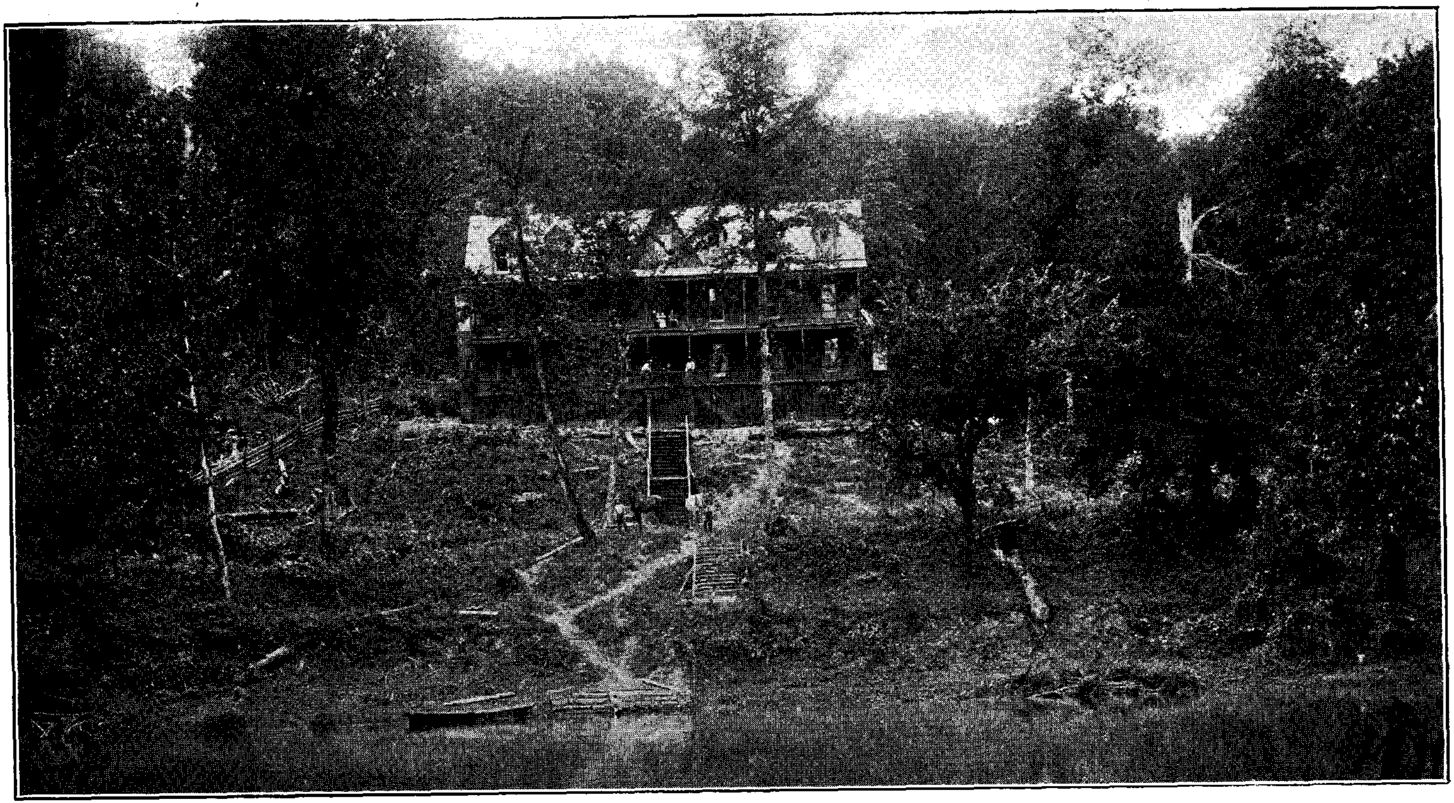
PLATE I.



HOTEL AT LASALLE SPRINGS, MARTIN COUNTY, INDIANA.

(See pp. 84, 85.)

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources.

TWENTY-SIXTH ANNUAL REPORT.

W. S. BLATCHLEY,

STATE GEOLOGIST.

1901

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.
1903.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
March 11, 1903.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, April 21, 1903.

The within report, so far as the same relates to moneys drawn from the State Treasury, contains no statement.

D. E. SHERRICK,
Auditor of State.

APRIL 21, 1903.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

GEO. B. LOCKWOOD,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana, April 21, 1903.

DANIEL E. STORMS,
Secretary of State.

Received the within report and delivered to the printer this 22d day of April, 190[illegible].

THOS. J. CARTER,
Clerk Printing Bureau.

State of Indiana, Department of Geology and Natural Resources.

INDIANAPOLIS, IND., January 28, 1902.

HON. W. T. DURBIN, *Governor of Indiana:*

DEAR SIR—In accordance with the provisions of the law under which the Department of Geology and Natural Resources was organized, I have the honor to submit to you herewith the manuscript of the Twenty-sixth Annual Report of the said Department. The contents of the report pertain very largely to the economic resources of the State and embrace the results of the work accomplished by the different divisions of the Department during the calendar year 1901.

Respectfully yours,

W. S. BLATCHLEY,
State Geologist.

ASSISTANTS.

E. M. KINDLE, Franklin	Field Assistant.
J. A. PRICE, Fort Wayne	Field Assistant.
L. E. DANIELS, LaPorte	Clerk and Field Assistant.
DR. ROBERT HESSLER, Logansport	Assistant.
J. F. NEWSOM, Palo Alto, Cal.	Field Assistant.
W. A. NOYES, Terre Haute	Chemist.
W. C. ZARING, Indianapolis	Supervisor of Oil Inspection.
J. C. LEACH, Kokomo	Supervisor of Natural Gas.
JAMES EPPERSON, Linton	Inspector of Mines.
CHARLES LONG, Coal Bluff	Assistant Inspector of Mines.
ANDREW DODDS, Oakland City	Assistant Inspector of Mines
ISADORE KESSLER, Indianapolis	Stenographer.

TABLE OF CONTENTS.

DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND.

W. S. BLATCHLEY, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

In return, Scientific Books, Fossils, etc., and Implements of the "Stone Age" are acceptable.

State Museum, Room 126, Third Floor, State House.
Open to the public from 8 A. M. to 5 P. M., except on Sundays and legal holidays. Admission free.

Office of State Geologist, Room 89, Third Floor, State House.

INTRODUCTORY.

The first paper included in this volume, entitled "The Mineral Waters of Indiana," gives the location and describes the character of the waters of more than 80 mineral wells and springs in different parts of the State. These mineral waters comprise one of the important Natural Resources of the State, which, in the future, will be much more appreciated than in the past. Those of two or three localities have already become so noted as to attract many thousands of visitors each year from all parts of the United States. A number of other springs and wells of the State have waters which are as valuable and worthy of increased public patronage as those of these better known resorts, and it is to be hoped that the present report will lead to their being brought more prominently to public notice.

The preparation of a paper on the "Medicinal Properties and Uses of Indiana Mineral Waters," was entrusted to Dr. Robert Hessler, of Logansport. Dr. Hessler is well qualified for the task, both by education and experience. He was for two years Assistant in Chemistry in the State University at Bloomington and is thoroughly acquainted with the chemistry of mineral waters. His intimate knowledge of pathology, of the science of the causation and nature of disease, is attested by the fact that for three years he was instructor of pathology in the Medical College of Indiana and pathologist to the Indianapolis City Hospital, and subsequently to the Central Indiana Hospital for Insane.

While on a recent tour through Europe, Dr. Hessler paid especial attention to the subject of health resorts, visiting many to see their location and surroundings and to note their methods of treating diseases. His remarks on foreign health resorts are, therefore, based on personal observation.

In his paper, Dr. Hessler treats the subject of the medical properties of our mineral waters and the indications for their use in an original manner, one that can not fail to be useful to any one interested in the question of what mineral waters will do and what they will not do. As the doctor himself has said: "The amount of ignorance displayed in regard to the requirements of the human body in health and in disease is something remarkable." It takes a medical man to occasionally show us how little we know about the body in health and in disease, and his advice to employ some good physician when we are ill, and be guided by his advice, is no doubt correct.

"A Geologic and Topographic Section Across Southern Indiana," is the title of an interesting and valuable paper by Prof. J. F. Newsom, formerly Assistant Professor of Geology in Indiana University. The paper and accompanying maps are based upon two seasons' field work done by Professor Newsom and a company of students. The section crosses the driftless area of the State, where the outcrops of the different formations can be easily studied. The region crossed embodies all the different formations represented in the State, and the section is the more interesting on that account.

A paper on "The Petroleum Industry in Indiana in 1901," gives in detail the developments of that growing industry in the State during the year. It is accompanied by statistical tables which, had their value not been impaired by delayed publication, would doubtless have been of much interest to a large number of citizens who are financially interested in the oil wells of the State.

The remaining papers comprise the Reports of the State Mine Inspector, the State Supervisor of Natural Gas, and the State Supervisor of Oil Inspection for the calendar year 1901.

THE MINERAL WATERS OF INDIANA.

THEIR LOCATION, ORIGIN AND CHARACTER.

By W. S. Blatchley.

Water a Mineral.—A mineral is any natural inorganic compound having a definite chemical composition. Quartz is an example of such a compound. It exists abundantly in nature, and its components are the two elements, silicon and oxygen, in the proportions of 53.3 parts of oxygen to 46.7 of silicon. According to the same definition, water is a mineral. It is very widely distributed in nature and in a pure state is composed of the elements hydrogen and oxygen in the proportions of 11.11 parts of the former to 88.89 of the latter. Pure water, however, is known only in the chemical laboratory, the purest form in nature being the vapor as it rises from ocean, stream or lake. When it condenses and falls as rain or snow, impurities, as carbon dioxide, ammonia, dust, etc., are absorbed from the atmosphere. The water which falls near the close of a long rain, especially in country regions, is almost free from these impurities. Some springs have also nearly pure water; but to separate all foreign matter from it, water must be distilled. Even then it may contain traces of ammonia or other substance which vaporizes at a lower temperature than the water itself.

Origin of Mineral Waters.—Water is the most universal of solvents. Its dissolving power upon rocks, minerals and soils is, however, largely increased by the carbon dioxide which it gathers unto itself while rising and falling through the atmosphere and by the humus acids which it absorbs from the soils. Carbon dioxide, or "carbonic acid," is given out in respiration by all animals and is one of the products of animal and vegetable decay. In this way the supply is constantly being renewed and it becomes distributed through the air and waters. Humus acids are also formed by animal and vegetable decay and occur in all damp soils where such decay is in progress. These acids, when absorbed by the falling or percolating waters, render the latter much more effective in dissolving the rocks with which they come in contact. As the acidulated water penetrates deeper and deeper, it gathers soda and potash from rocks containing feldspar; lime and magnesia from limestones; iron from shales and iron ores; sulphur from gypsum and pyrites, and many other substances from the component rocks with which the slowly percolating water comes in contact. When, therefore, the underground water finally comes to the surface through springs or artesian bores it contains many dissolved solids, gathered during its subterranean wanderings. Among the more common of these are calcium carbonate; salts of iron; magnesium, sodium and potassium carbonates, sulphates or chlorides; calcium chloride; and occasionally, though usually sparingly, aluminum sulphates and lithium salts. It also often contains gases, such as carbonic acid, hydrogen sulphide and nitrogen. The amount and kind of these solid and gaseous ingredients in the issuing water depends wholly upon the kinds of rocks and minerals over which the underground stream has flowed, or through which its component parts have slowly passed. As has been truly said, "the table of contents of a mineral spring is but an index of the various geological strata through which its waters have passed and of the mineral bodies with which they have come in contact." Whatever is soluble in the region through which the underground waters flow will, of course, be taken up by them, and many ingredients are soluble in minute proportions which are usually described as insoluble.

Definition of "Mineral Water."—As water is in itself a mineral, the term "mineral water" is seemingly tautological or redundant. It is a term in common use, but its definition depends largely upon the point of view of the person using it. By the Geologist, the term is usually applied to a water in which the dissolved salts are unusual in quantity or in kind; being present generally in sufficient amount to affect the taste. Since calcium carbonate or "carbonate of lime" is, for the most part, tasteless, the water of a spring or well may contain a large quantity of this common mineral, and yet be termed "pure water" or "hard water," without the prefix "mineral."

The physician and the general public usually give a more restricted definition to the term "mineral water," applying it only to those waters which *are or may be used in the treatment of diseases.* This definition is the one adopted in the present paper, and the waters of the springs and wells mentioned have by experience been proven to possess medicinal properties, or their chemical composition is such as to lead to the supposition that they will prove of value medicinally.

The waters of the majority of the springs described would be classed as "mineral waters" even by the Geologist, since they contain a high percentage of dissolved solids or gaseous materials. On the other hand, a number whose waters have gained much reputation for their curative effects have been found, when analyzed, to hold but a small percentage of mineral matter. Their medicinal value is, however recognized or believed in by the general public. They have come into recognition, probably, through the superior intelligence or energy of their proprietors, who call attention to them in all ways possible. As these owners have more or less capital invested and derive from the springs a revenue, the waters are treated in connection with those which are more highly mineralized. However, they are termed "neutral" or "indifferent" rather than "mineral" in the descriptions which follow.

THE VALUE OF MINERAL WATERS.—Since Dr. Hessler in his paper will give a full discussion of the medicinal value of our mineral waters, but little need be said on this subject. While the person of intelligence, be he physician or be he not, who may visit the various springs, resorts and sanitariums of the State, is soon favorably impressed with their number, the variety of their waters, and, in many instances, the picturesqueness of their surroundings, he at the same time soon comes to smile at the extravagant claims set forth by many of the spring owners and proprietors of sanitariums. The great majority of them assert that the water of their particular spring or well "has no equal in the State," and oftentimes "none on earth." It will cure more diseases than are recognized by the average physician. It is a veritable "fountain of youth"—worthy to be classed with the most famous sought for in the halcyon days of Ponce de Leon.

Such extravagant claims no doubt do much more harm than good. They appeal, for the most part, only to the ignorant. They repel the intelligent invalid and especially the physician who is seeking some spring or sanitarium whose waters and surroundings are especially suited to a case in hand. As Dr. Crook has well said in his excellent work,* "There exists among medical practitioners in the United States a wide-spread skepticism regarding the medicinal value of mineral waters. This incredulity is no doubt based, to a considerable extent, upon a somewhat justifiable prejudice; but may it not be due, in a much greater degree, to a want of correct information? We are all acquainted with the mineral spring advertising circular. It comes to us clothed in a respectable, even elegant dress; but it too frequently portrays the virtues of the alleged healing fluid which it represents in language of absurd hyperbole. When the intelligent practitioner reads that a certain water is positively curative in an imposing list of diseases, as set forth in divers pages of testi-

*"The Mineral Waters of the United States and Their Therapeutic Uses," p. 34.

monials from renovated statesmen, restored clergymen and rejuvenated old ladies, and then learns from the analysis that it contains two or three grains of lime-salts to the gallon, with the remaining ingredients requiring perhaps a third or fourth decimal figure to express, he can hardly be blamed for tossing the circular into his wastebasket, with an objurgation upon quacks generally and the mineral spring quack in particular; yet the conservative physician will find a safe and dignified position between that of the pretentious advertisement which claims everything and that of the medical skeptic who will believe nothing."

It is a well recognized fact among physicians that too little water is used by most persons. Pure water, when taken in quantity, is in itself beneficial. It flushes the channels of the body, and by increasing the liquid portion of the blood, aids materially in bearing the food particles to the absorbents and in carrying away the harmful products of the excretory organs. Especially is hot water valuable, not only by acting as a tonic, but by causing an increased activity of heart, lungs, skin and kidneys. This stimulation of the more important organs brings about better nutrition, which in turn causes more and better blood to be sent to all the organs. The beneficial action of pure or "neutral" waters upon the system as a whole is thus accounted for, and in general it may be said that a person can drink *ad libitum* of such waters, and receive only benefit therefrom.

When the water contains chemicals or mineral ingredients which are known to be remedies for certain diseases, its importance as a medicinal agent is thereby increased. Each of the common minerals found in solution in such waters has a distinct effect upon some organ of the body when taken in quantity. No one of them or no combination of them is a "cure all" as claimed by so many of the advertising circulars sent out. The average person knows but little concerning the medicinal or remedial effects of the mineral compounds found in such waters. He should, therefore, if suffering from a well-defined disease, always consult a reputable physician before using freely any strong mineral water, else the result may be in the highest degree harmful rather than beneficial. The physician can judge from the chemical analysis and from his general knowledge of medicine the curative value of any water for the disease in hand. For this reason an accurate chemical analysis is one of the best advertisements which the proprietor of any mineral water resort can place before the public. It is far better for such proprietor, after having such analysis made, to learn from a good physician the exact curative properties of the water, and then advertise them judiciously and truthfully, at the same time calling attention to the attractiveness of the surroundings and advantages for recreation, rather than claim, as is so often done, that the water is a universal panacea for all diseases to which humanity is subject.

It is the writer's opinion, based on personal experience, that the change of surroundings and diet, the increased amount of recreation and exercise, obtained by a few weeks spent at the sanitariums and resorts, have quite as much to do with bringing about a cure of many patients as does the water itself. There are many ordinary springs of pure water, i. e., water containing only a few grains of lime or iron salts per gallon, located near villages in this State, which are claimed by the inhabitants to possess remarkable curative properties. Old persons who seldom get ten rods from their homes, and business men who are kept indoors most of their time, begin to visit such springs, and once or twice a week walk or drive quite a distance to bring home a jug full of the water. The increased amount of exercise thus obtained, as well as the change of scenery, however limited, and perhaps the drinking of an extra amount of water each day, are the causes of the improved health rather than any curative properties possessed by the water. The psychic agency in the cure of disease is a powerful one and in no instance should it be neglected. A change of place, of surroundings, if possible of climate, is for a time, to the person "run down" in general health, almost always beneficial. Facilities for recreation, as bathing, fishing, bowling, etc., in connection with a sanitarium, lend much to its value by furnishing a means of exercise which will aid to keep the thoughts of the patient from dwelling too much upon himself and his ailments, fancied or real.

"Curæ vacuus hunc adeas locum
ut morborum vacuus abire queas"

was the inscription above the baths of Antoninus at Rome. "Come to this place free from care that you may leave it free from disease," is a maxim as much to be regarded at present as in the palmy days of the Roman empire.

Classification of Indiana Mineral Waters.—Many elaborate schemes of classification of mineral waters have, in the past, been put forward by different writers. One of the most simple, based upon the chemical ingredients of the water, is that of Dr. A. C. Peale, of the United States Geological Survey. According to this classification, the mineral waters of Indiana may be grouped under the following heads:

I.—Alkaline.
II.—Saline.
III.—Chalybeate.
IV.—Neutral or Indifferent.

Class I.—*The alkaline waters* include those whose principal mineral ingredients are the *carbonates* of one or more of the following elements: calcium, magnesium, potassium and sodium. The majority of the Indiana waters of this group contain calcium carbonate (carbonate of lime) or magnesium carbonate, as the principal salt. Oftentimes both are present in quantity. While frequent in the drift-covered area and along the outcrops of the limestone districts of southern, central and southeastern Indiana, the springs and wells containing the waters of this class are far less noted for their medicinal virtues than are those of the next group.

Class II.—*The saline waters* include the large majority of the mineral waters of Indiana now in use. In the waters of this class the *sulphates* or *chlorides* of calcium, magnesium, aluminum, potassium or sodium form the principal salts in solution. Sodium chloride (common salt) is the most common ingredient of this class of waters, though magnesium sulphate (Epsom salt) or sodium sulphate (Glauber's salt) occur in most of the waters of the group. Where these two salts occur in quantity such waters may be designated as *sulphated* and purgative. The springs of Clark, Floyd and Brown counties, described on subsequent pages, which issue from the New Providence shale at the base of the Knobstone formation, produce excellent examples of saline waters rich in the sulphates of magnesium and sodium. These waters resemble closely in chemical composition, taste and medicinal effect the celebrated Hungarian water, known as the Hunyadi Janos. Their salts are derived from the ingredients found in the New Providence shale. It is probable that many additional springs producing water similar to those described, exist in the counties where this shale outcrops.

Aluminum sulphate is found in a number of the "bitter springs" in the coal regions of southwestern Indiana, notably in Gibson, Pike and Warrick counties. It is derived from the shales overlying the coal veins or from the pyrites accompanying them. The sulphur of the pyrites or iron sulphide, when exposed to air or water, takes up oxygen and forms sulphuric acid. This in turn combines with the alumina of the shale to form aluminum sulphate. A portion of the sulphuric acid may also combine with the iron to form iron or ferric sulphate, which is also often one of the ingredients of these "bitter springs." When such sulphate is present the water may be termed a *saline-chalybeate* water.

When the carbonates of the metals mentioned in *Class I* are found in quantity in the same water with the sulphates or chlorides of *Class II*, the water may be termed *alkaline-saline.*

Class III.—*The chalybeate waters.* To this group belong the waters of all springs and wells having *salts of iron* in solution. Chalybeate or iron springs probably occur in every county in Indiana, though but few of them have been developed for commercial purposes. Iron carbonate, like carbonate of lime, is slightly soluble in rain water or water containing carbonic acid in solution. Iron carbonate is found throughout the clay deposits of the drift-covered area of the State and in many of the shales of the driftless area of the southern portion. The underground waters, when they come in contact with this carbonate, dissolve a small portion of it and form an iron bi-carbonate. On coming to the surface, either in springs or wells, this bi-carbonate gives up the carbonic acid and absorbs oxygen. It is thus changed into iron oxide, which precipitates or settles as a brownish yellow sediment. This is seen in and alongside the rills bearing water away from the springs, as well as in the springs themselves. In the country these are commonly called "sulphur springs," though their waters contain no sulphate or sulphide, nor have they the least trace of the odor of hydrogen sulphide.

According to Dr. Crook, "These bi-carbonated chalybeate waters ars usually most valuable for internal administration. Not only does carbonic acid increase the solubility of the iron, but it disguises its otherwise astringent and ferruginous taste, and aids in its speedy absorption and assimilation. These waters prove of great value in cases of anæmia or poverty of the blood. Clinical experience has shown that they cause an increase in the appetite, a return to the normal color, a gain in weight and strength, and a general improvement of the bodily functions. It matters not though the iron be present in small quantities, and few of the carbonated iron waters contain more than five or six grains per gallon. The blood contains normally about forty-five grains of iron, and this quantity can not be permanently increased by consuming large quantities. It is probable that the deficiency, no matter how produced, never exceeds fifteen or twenty grains. A chalybeate water containing not more than one grain to the gallon will speedily show its influence in the returning color and increased tone and vigor of the system."

While chalybeate springs are found in numbers in almost every county in the State, but few of them are mentioned in the present paper as the time at the disposal of the writer forbade him visiting only a few of those which are undeveloped. Their waters can be taken with freedom by most persons, since they are readily assimilated and comparatively devoid of taste. After a short use they are generally relished and preferred to the waters of the purer springs with which they are usually found associated. Many of the larger springs producing chalybeate waters will, in the future, doubtless be utilized as resorts and will well repay the capital invested in their development.

Class IV.—*Neutral* or *indifferent* waters have been already referred to. They contain such a small quantity of mineral matter as to be excluded from either of the above named classes, and yet have been utilized for medicinal purposes and are highly recommended by some physicians. Those so utilized and described in the present paper are mentioned specifically as "neutral" in the text. Many of the so-called "potable water" or "pure water" springs of the State are as worthy of development for medicinal purposes as those described. Proper advertising and the expenditure of some capital in furnishing means of recreation is about all that is necessary to make of them noted health resorts.

Hydrogen Sulphide as an Ingredient of Mineral Water.—Many of the more important mineral springs and artesian wells of Indiana emit with their water an ill-smelling gas known as hydrogen sulphide or sulphuretted hydrogen. It is usually mentioned as having the odor and taste of rotten eggs, since it is formed in quantity in such eggs during the process of decay. This gas is found in such quantity in some of the mineral waters as to destroy or disguise the taste of the other minerals present, and therefore to render the water nauseating or unpalatable. It is formed in the earth by a chemical process in which the sulphur of calcium sulphide or gypsum is replaced by the hydrogen of water according to the formula

$$CaS + H_2O = CaO + H_2S.$$

As the water issues through spring or well much of the gas escapes, permeating the surrounding atmosphere with its characteristic odor. When brought in contact with the oxygen of the air the gas is often disassociated or split up into its elements. The sulphur is deposited as a white or whitish-yellow sediment upon surrounding objects while the hydrogen joins with the oxygen to form water. The name "white-sulphur" is often given to the spring or well where such deposit is formed. Again, when salts of iron are present, this sulphur, when set free, may unite with the iron to form black flakes of iron sulphide, which settle slowly to the bottom of spring or rill.

Various opinions are held by physicians as to the medicinal value of hydrogen sulphide. It is poisonous when inhaled and when thus taken into the system in quantity is quickly fatal. Its medicinal virtues, when taken into the stomach, are fully discussed on a subsequent page by Dr. Hessler. On account of its gaseous form and its consequent rapid escape when exposed to air, the quantity in any mineral water is variable. The presence of the gas in sufficient quantity to make its presence known by odor or taste, usually causes the name "sulphur water" to be given locally to the water issuing from a spring or well. In the descriptions which follow the term "sulphuretted" is used to donate its presence. Thus "saline-sulphuretted" indicates a water belonging to Class II, which contains hydrogen sulphide. The waters of the springs of Orange and Martin counties, as well as those of the artesian wells at Shelbyville, Martinsville, Spencer, Montezuma, and many other places, are thus designated as "saline-sulphuretted."

Springs in General.—The mineral waters of Indiana are derived from both springs and wells. In early days that of the springs alone was used, but now artesian and other wells producing such water exceed in number the natural springs.

What is the cause of a spring? Why does water issue forth from a certain point on a hillside, or well up from a certain place in a valley? These are questions which every person interested in nature has probably asked many times. In answer it may be said that the water falling as rain on any land area in a given time may be divided into three parts, viz.: (a) That which rushes immediately down the slopes and causes the floods of streams and rivers. (b) That which sinks slowly into the earth, where for a time it does much work in dissolving rocks and forming soils; and then finally reappears as springs and forms the regular supply of streams and rivers. (c) That which sinks still deeper and never appears again on the surface, but finds its way by underground channels into the ocean, or else is added to the permanent supply of water which by deep borings we know exists at great depths below the land surface.

The amount of water which sinks below the surface to form springs depends largely upon the character of the surface. Where this is bare of trees and other vegetation that which flows directly off is much greater in quantity than where the soil is covered with vegetation. The roots of trees, shrubs and herbs, the stems of moss and grass, dead twigs, leaves and other rubbish, all retard the flow of water and so give time for more of it to enter the soil and sink slowly until it reaches an impervious stratum of clay or rock. It is a well known fact that while the annual rainfall in Indiana has been almost the same for the past forty years, the size of the springs and streams has slowly decreased. Many of the former, in existence a half century ago, have wholly disappeared, while the flow from others has diminished fully one-half. Since the water supply of streams, especially during times of drought, is dependent wholly upon springs, many streams which once had a large flow in summer are now wholly dry for several months. The cause of this is, without doubt, the clearing away of the forests which, with the artificial drainage of the cleared land, allows the rapid removal of the rainfall. The water, which formerly sank slowly beneath the surface and more slowly seeped out through many springs, is now carried away in a day or two in floods which often leave ruin and desolation in their wake.

Wherever underground water appears at the surface, on the side or at the foot of a hill, or bubbles up from a natural opening in a valley, such an appearance is termed a *spring*. The surface water, in sinking, penetrates the soil and the porous strata, as sand, gravel, sandstone, etc., beneath, until it reaches an impervious layer of clay, shale or limestone through which it can not pass. It flows along the surface of this impervious layer, sometimes for miles, until it finds an opening on the face or at the foot of a bluff, or in the bank of a lake or pool, from which it issues as a spring. The largest springs usually issue from fissures in the rock, or bubble up through a cavity in a valley or bed of a stream. Their water has passed along a porous stratum probably for a great distance, and has been prevented from rising by the overlying impervious stratum and from sinking by a similar underlying stratum. As it reaches a fissure it immediately rises, being forced up by the great hydrostatic pressure behind it, until it wells or bubbles out above the surface. In the limestone regions of southern Indiana there are numbers of these "fissure springs," some of which are large enough to be utilized for water power in running mills. One of the most noted of these is Harrison Spring, a few miles west of Corydon. This wells up in a valley with sufficient flow and force to run both a grist and a saw mill. Another, a few miles east of Mitchell, Lawrence County, issues from a cave with great force and was long utilized for power in a grist mill and a distillery.

As already noted, the subterranean water dissolves, during its flow, portions of the rocks with which it comes in contact. If these be of the proper character and the distance in underground flow be great enough, it will issue as "mineral water," and the spring be termed a "mineral spring." Since for ages the water bearing the salts dissolved from the different rocks in the solid crust of the earth has been flowing into the ocean, the latter may be termed the great mineral spring of the world. About three and a quarter per cent. of its waters consist of soluble salts thus derived from the rocks of the land. These salts are, for the most part, the same as exist in many of the noted "mineral springs" now in existence; namely, sodium chloride, magnesium sulphate, sodium sulphate, calcium carbonate, etc. However, many more varieties of salts exist in the ocean than in any other mineral spring on earth.

If the different strata through which the slowly sinking water flows be principally sand, gravel, limestone or sandstone, the issuing water will be "pure" or "potable," since the materials mentioned contain little soluble matter other than carbonate of lime or salts of iron. The great majority of springs in the northern part of the State where the drift area exists are of this nature. Many of them contain iron bi-carbonate in sufficient quantity to be termed "chalybeate springs," and it is possible that analyses would show their waters to be similar to those of many of the "iron springs" of noted health resorts.

Occurrence of Mineral Water in Deep Wells.—But a few deep bores were sunk in Indiana previous to 1886, when natural gas in commercial quantities was first discovered in the State. Several of the bores put down before that date, notably those at Reelsville, Putnam County; Terre Haute, Vigo County; Lodi, Fountain County, and at two or three localities in Crawford County, had developed artesian flows of mineral water, but at only one of these wells was this water used to any extent for medicinal purposes, notwithstanding that the analyses of the water from most of the wells were made and published in the older reports of this Department, and were copied quite extensively in the medical journals and works on mineral waters.

Since 1886 more than 14,000 deep bores have been sunk for oil and gas in different parts of the State. Of these a number developed flowing water; while in a still larger number the water rose within easy pumping distance of the surface. In the different strata encountered above the Trenton limestone, especially outside of the main oil and gas fields as at present defined, large supplies of excellent potable water were often found. In most instances this occurred in the Niagara limestone; was cased off, and the bore sunk to the Trenton limestone, where salt water was found. By plugging the well between the potable and the salt water the former has been made available as a source of water supply for many cities and towns or for manufacturing and other industries.

The output of a number of the flowing wells in central and western Indiana proved to be a saline-sulphuretted mineral water of high value as a medicinal agent. Such water is now being utilized in sanitariums at Greenwood, Martinsville, Columbus, Gosport, Spencer, Terre Haute, Montezuma and other localities; while in a number of places wells are producing a water as valuable, but which is being used only locally. In many of the deep bores, two or three different veins of mineral water were struck. The Niagara limestone furnishes most of the saline-sulphuretted water now in use. The water of the Trenton limestone and the underlying St. Peter's sandstone is, in most instances, too brackish, i. e., contains too large a percentage of common salt for medicinal use; though in a few cases a fair quality of "blue lick" water, containing magnesium sulphate in quantity and also much sulphuretted hydrogen, is found in the St. Peter's sandstone.

In general it may be said that the waters of the deep wells contain a much larger percentage of mineral matter than those of the springs and shallow wells. This is due to the fact that the deeper subterranean waters are in direct contact with the rocks which yield them the salts a much longer time, since the water is not so soon renewed as that in springs which have a constant flow. It is probable, also, that more or less sea water was left in the Niagara and Trenton limestones and in the St. Peter's and Potsdam sandstones, at the time of the recession of the ocean, from the area now occupied by these formations. The mineral contents of this sea water have there remained for ages, and only when furnished a vent by artificial boring does the hydrostatic pressure behind force it upward as an artesian flow of so-called "mineral water." As impervious strata of rock, shale, etc., usually exist between the surface and the source of the mineral water in the deep bores, it follows that the supply of water can not be renewed by percolation as in ordinary springs. Dr. Edward Orton, of Ohio, proved that the hydrostatic pressure behind the salt water, gas and oil of the Trenton limestone of Indiana is caused by the waters of Lake Superior. The level of this lake is 600 feet above tide level, and by adding this height to the number of feet at which the Trenton lies below tide level and calculating the pressure on this basis he found that it corresponded closely with the original rock pressure of gas, oil or salt water. The ultimate source of the mineral water which rises from great depths in the different artesian bores of the State is probably accounted for in the same manner, i. e., it comes from lakes which lie far distant from the point at which it wells forth. During its long journey it has plenty of time to gain, both by solution and chemical action, the large percentage of mineral salts which it holds.

Chemical Analyses.—The means at command forbade the making of but few analyses of mineral waters especially for this paper. The analyses incorporated are, for the most part, those which had already been made for the owners of the various springs and wells. A number of these have already been published in former reports of this Department. In every case, but one or two, the name of the chemist making the analysis is known and given.

The results of the analyses, as furnished, were expressed in many different ways. These have been reduced to a common standard, viz., grains per U. S. gallon of 231 cubic inches, as that was thought to be the most intelligible to the greatest number of people. "Everyone is acquainted with the familiar gallon measure, which equals eight wine pints. With the quantitative analysis before us and a knowledge of the capacity of the vessel from which the patient drinks, we can make, under any circumstances, a fairly close estimate of the amount of mineral water which he is taking. With the exception of a few very strong springs, concerning which specific instructions should always be given, it is not necessary to be absolutely exact in the dosage of mineral waters, and if the patient should imbibe a gill or two more or less than the amount prescribed, no harm is done." The gases, hydrogen sulphide and carbon dioxide, when expressed in grains, have also been reduced to cubic inches.

The conversions from the form as furnished into grains per U. S. gallon, or into cubic inches, of the gases mentioned, was made according to the following table:

Parts per 100,000 × .583 = Grains per U. S. gallon.
Parts per 1,000,000 × .058 = Grains per U. S. gallon.
Grains per imperial gallon × .833 = Grains per U. S. gallon.
One grain of hydrogen sulphide = 2.596 cubic inches.
One grain of carbon dioxide = 2.006 cubic inches.

ALLEN COUNTY.

ABBOTT MAGNETIC MINERAL WELL.

Water = *Alkaline-saline-sulphuretted.*

Location.—Two miles southeast of the courthouse at Fort Wayne, a city of 47,000 population, situated at the junction of the St. Joseph, Maumee and St. Mary's rivers; 148 miles east of Chicago, 117 miles northeast of Indianapolis, and 94 miles southwest of Toledo. Seven railways enter the city, furnishing ample transportation facilities in all directions.

Origin and Character of the Water.—The well which yields the mineral water was sunk for gas in 1888. It is located rather unfortunately, being one mile distant from street car lines, and near railroad yards. The total depth of the well was 1,900 feet. The mineral water was found in the Trenton limestone and rose only to within 900 feet of the surface. The water was analyzed by Dr. Charles R. Dryer, with the following result:

ANALYSIS OF WATER FROM ABBOTT WELL, FORT WAYNE, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride ($NaCl$)	2,993.793
Magnesium chloride ($MgCl_2$)	148.825
Magnesium sulphate ($MgSO_4$)	143.283
Calcium sulphate ($CaSO_4$)	20.71
Calcium carbonate ($CaCO_3$)	597.401
Potassium bromide (KBr)	5.469
Ferrous carbonate ($FeCO_3$)	21.119
Silica, alumina and organic matter	43.755
Nitrates and phosphates	traces
Total solids	3,974.355
Gases.	*Cu. In. per Gal.*
Carbon dioxide (CO_2)	2.31
Hydrogen sulphide (H_2S)	2.3677

A sanitarium and bath house for the utilization of the water was erected and for a few years was well patronized, and the water achieved quite a renown in the cure of rheumatism, skin diseases and nervous troubles. In time, however, difficulties arose in pumping the water from so great a depth, and the place was abandoned. It has recently come into the possession of Louis Fox, a wealthy citizen of Fort Wayne, who proposes to reopen it as a sanitarium on a larger scale. The water is said to possess magnetic qualities to such an extent that a knife held in it for a few seconds will pick up a nail or other article of iron or steel. Hence the name "Magnetic Mineral Well."

BARTHOLOMEW COUNTY.

THE COLUMBUS SANITARIUM CO.

Water = *Saline-sulphuretted.*

Location.—In the environs of Columbus, the county seat, a city of 8,500 population, situated 40 miles south of Indianapolis, and 69 miles north of Louisville.

The city possesses all modern improvements and is reached by three branches of the Pennsylvania Railway, and from Cincinnati and points east by the Columbus and Greensburg Division of the "Big Four" Railway. Electric street cars pass within one block of the sanitarium. A rich agricultural region surrounds the city, affording facilities for pleasant country driving.

ORIGIN AND CHARACTER OF WATER.—The water used in the sanitarium of this company is from an artesian well located near the northern limits of the city of Columbus. This well was sunk in 1893 to a depth of 1,700 feet. The water now in use was struck, according to Dr. M. N. Elrod, in the Waldron shale at a depth of about 180 feet. The sulphur in the water is probably derived from iron pyrites in this shale. The water was cased off until after the well was proven barren of both gas and oil, when it was allowed to flow. The well is in a strip of low ground 300 feet northwest of the main building of the sanitarium. In November, 1901, the flow was but about two gallons a minute to a height of about three feet above the surface. It has been demonstrated by the city engineer of Columbus that the water can be forced by the artesian pressure 200 feet above its source. For use in the sanitarium the water is pumped into tanks located above the boiler house near the sanitarium, and from these tanks flows into the bath rooms. The water has a constant temperature of 56° F. as it issues from the well. The odor of hydrogen sulphide is distinct but not strong. The water has a rather agreeable, sweetish-saline taste and when fresh from the well is clear and sparkling.

Its analysis by Dr. J. N. Hurty, of Indianapolis, resulted as follows:

ANALYSIS OF MINERAL WATER FROM ARTESIAN WELL, COLUMBUS, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	6.786
Magnesium carbonate ($MgCO_3$)	8.447
Sodium chloride ($NaCl$)	37.947
Calcium sulphate ($CaSO_4$)	3.501
Sodium sulphate (Na_2SO_4)	5.136
Magnesium chloride ($MgCl_2$)	0.437
Alumina (Al_2O_3)	2.203
Silica (SiO_2)	0.443
Total solids	64.900

Hydrogen sulphide (H_2S) 4.031 cubic inches per gallon.

For the depth from which the water is obtained the percentage of solid ingredients is not large, but the water is well suited for sanitary baths, the use to which it is principally put. It is claimed by the proprietors to be especially efficacious in diseases of the skin and kidneys, rheumatism, gout, neurasthenia, etc. It is bottled and sold on the market, but as yet the sale has been limited. It is a mild saline water and may be used freely.

IMPROVEMENTS.—The sanitarium in which the Columbus artesian water is principally used, was first opened in August, 1894, and until 1900 was operated only as a sanitarium and bath house without hotel accommodations. In the latter year a twenty-room hotel was constructed on the same lot. The sanitarium is open during the entire year and is well equipped for giving mineral and vapor baths, there being ten bath rooms with attendants. Competent consulting physicians reside in the building and furnish advice to all patients.

THE AZALIA MINERAL SPRING.

WATER = *Chalybeate.*

LOCATION.—Quite a number of chalybeate or iron springs exist in Bartholomew County. The best known is the "Azalia Mineral Spring," located six miles southeast of Columbus, on the land of Nathan H. Newsom, southeast quarter Section 16 (8 N., 6 E.), near the junction of Brush and Little Sand Creeks. The nearest railway station is Elizabethtown, on the Madison Branch of the Pennsylvania Railway, two miles east.

ORIGIN AND CHARACTER OF WATER.—The water bubbles up at the rate of about two gallons per minute through the sand, and probably through a fissure in the underlying rock. The temperature is 53° F. The water has a very decided taste of iron which probably issues as the bi-carbonate and is changed to the peroxide on contact with air. Lime and magnesia are also present in the form of bi-carbonates, but not in larger quantity than in most other spring and well waters of the vicinity. The spring is surrounded by a fine growth of elm and other forest trees, and is a noted resort for picnic and pleasure parties. There is little doubt but that a successful sanitarium for invalids afflicted with diseases for which chalybeate water is beneficial, could be established at this place.

Another chalybeate spring of more than local repute, and possessing a much larger flow of water, wells up through a fissure in the limestone just below the Anderson Falls on Fall Fork Creek.

BROWN COUNTY.

McCARTY'S MINERAL SPRING.

WATER = *Saline-sulphated* (Purgative).

LOCATION.—The spring which yields the mineral water sold under the name of "Blue Mountain Laxine" is located near the postoffice of Mount Moriah, in the northeastern part of Brown County, near the Bartholomew County line. It is on the land of W. H. McCarty, southeast quarter Section 5 (9 N., 4 E.), about 12 miles northwest of Columbus and half way between Edinburg, Johnson County, and Nashville, Brown County. The nearest railway station is Taylorsville, nine miles east on the Louisville Division of the Pennsylvania Railway, 35 miles south of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—The spring is located at the base of a hill or bluff of Knobstone about 35 rods from the postoffice of Mount Moriah. The water comes up through a dark blue mud and has an estimated flow of about eight gallons per hour. The spring is walled up with sawed stone, but no other improvements have been made.

The water was used locally by the owner and his neighbors for stomach and kidney troubles for some years and about 1887 was placed on sale at Franklin and other towns. It gained slowly in reputation until 1900, when Dr. J. L. Morris, of the Columbus, Indiana, sanitarium leased the spring for ten years and had an analysis of the water made by T. W. Smith, of Indianapolis, which resulted as follows:

ANALYSIS OF "BLUE MOUNTAIN LAXINE WATER" FROM MOUNT MORIAH, BROWN COUNTY, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride ($NaCl$)	15.28
Calcium sulphate ($CaSO_4$)	8.40
Magnesium sulphate ($MgSO_4$)	325.30
Sodium sulphate (Na_2SO_4)	319.92
Silica (SiO_2)	55.29
Iron	trace
Total solids	724.19

The water is clear and sparkling and has no odor, but possesses the bitter taste characteristic of its two main constituents—Epsom salt and Glauber's salt. In composition and taste it closely resembles the saline waters of Clark County, described on subsequent pages, and probably gains its chemical constituents from the same source, viz., the New Providence shale, which forms the base of the Knobstone. It is an aperient or cathartic, depending on the dose. The percentage of free silicia is surprisingly large. The water is now being hauled overland to the Columbus sanitarium, where it is used and where it is also bottled and placed on the market. About twenty barrels were sold in 1901 at an average price of 30 cents a gallon.

NASHVILLE ARTESIAN WELLS.

WATER = *Saline-sulphuretted* (?).

LOCATION.—In the northwest quarter of the northwest quarter of Section 19 (9 N., 3 E.), within the corporate limits of Nashville, the county seat, a town of 400 population, situated near the center of the county.

ORIGIN AND CHARACTER OF THE WATER.—Two wells drilled in 1899; one on the public square, a short distance southwest of the court house, to a depth of 500 feet, yielded for a time a good flow of water, which ceased when the second well was drilled. The latter, two squares south of the court house, was drilled to a depth of 530 feet, and when turned on full-force, flows about ten gallons of mineral water per minute, which has a temperature of 56° F.

The water is clear and sparkling with hydrogen sulphide and carbonic acid gases. It has an agreeable saline-sulphur taste, and is much used by the citizens of Nashville and vicinity. It is diuretic and laxative in effect and, when taken in quantity, purgative. No analysis has been made.

IMPROVEMENTS.—A frame hotel and bath house, known as the "Nashville Sanitarium," containing 24 rooms, was erected in 1900, and is open to guests from June to November of each year. The water is piped into the house, and is used for both drinking and bathing, there being six well equipped bath rooms. Up to the present, the guests have been mostly from Brown and adjacent counties. With better means of transportation afforded, there is little doubt but that the number of guests would largely increase, as the water appears to be of excellent quality.

CARROLL COUNTY.

DELPHI ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—Two squares south of the court house at Delphi, a city of 2,300 inhabitants, located at the junction of the C., I. & L. (Monon) and Wabash railways, 72 miles northwest of Indianapolis and 112 miles southeast of Chicago. Delphi is picturesquely located on the high banks of Deer Creek, near the junction of that stream and the Wabash River. It is situated in a region replete with fine roads and romantic scenery, so that the facilities for driving and enjoyment of out of door exercise are excellent.

ORIGIN AND CHARACTER OF THE WATER.—The well which yields the artesian flow of mineral water was one of several put down in and around Delphi about 1890, in search of oil and gas. It was sunk on the north bank of Deer Creek to a depth of 912 feet. It developed a strong vein of mineral water, a slight flow of gas and a trace of oil. It was shot with nitroglycerin in an endeavor to increase the flow of gas, but failed to do so. However, gas has continued to issue with the water and in August, 1901, when set on fire, would burn steadily with a flame reaching a foot or two from the end of the escape pipe.

The water was analyzed by Dr. J. N. Hurty, of Indianapolis, who reported on it as follows:

ANALYSIS OF WATER FROM ARTESIAN WELL AT DELPHI, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	0.708
Magnesium chloride ($MgCl_2$)	1.678
Sodium chloride (NaCl)	30.885
Potassium chloride (KCl)	0.023
Calcium sulphate ($CaSO_4$)	0.004
Iron and aluminum oxides (Fe_2O_3&Al_2O_3)	0.058
Total	33.356

Sulphuretted hydrogen (H_2S), 7.76 cubic inches per gallon.

"This water may be classed with the best known salt sulphur mineral waters. In rheumatism and all indigestion troubles and all strumous diseases, it will be found a sovereign remedy. It will be found best for drinking if diluted with an equal amount of pure water, but for baths it may be used without dilution, although in some instances dilution would be advantageous."—*Hurty.*

The water flows at the rate of about six gallons per minute and has a temperature of 57° F. It has the distinctive odor and taste of hydrogen sulphide, with just enough of that of common salt to make it palatable.

A sanitarium and bath house was established in connection with the well in 1893, and ran for several years. Litigation involving the title of the property and poor management, finally caused its closing. The water was also shipped quite extensively for a time. At present it is free to everybody and is much used by the residents of Delphi. The Commercial Club of the city believe strongly in the medical virtues of the water and will encourage and lend assistance to any one who will undertake the erection of a new sanitarium.

A second well, producing a smaller flow of the same water, is located on the south side of Deer Creek, within a few hundred yards of the one above described.

CASS COUNTY.

LOGANSPORT ARTESIAN WELLS.

WATER = *Saline-sulphuretted.*

LOCATION.—Two wells, one the "West End well," near the crossing of the Vandalia and Pennsylvania railways, one and a fourth miles southwest of the court house; the other, the "Water Works well," on the south bank of Eel River near the city water works. Logansport is a city of 17,000 population, located 120 miles southeast of Chicago, on the Pennsylvania, Vandalia and Wabash railways.

ORIGIN AND CHARACTER OF THE WATER.—Two wells sunk for gas struck mineral water in the Trenton limestone at about 1,100 feet. The West End well produced quite a flow of water for a number of years, but was finally plugged. The flow can be renewed at any time by removing the plug. An analysis of the water from this well was made some years ago by Floyd Davis, Iowa State Chemist, who reported on it as follows:

ANALYSIS OF WATER FROM WEST END ARTESIAN WELL, LOGANSPORT, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride (NaCl)	792.716
Magnesium chloride (MgCl)	78.570
Magnesium sulphate ($MgSO_4$)	46.884
Calcium sulphate ($CaSO_4$)	104.494
Calcium carbonate ($CaCO_3$)	107.109
Silica (SiO_2)	4.460
Total	1134.233

"Besides the above, traces of potassium chloride and alumina were present. This is a very strong saline water, its active constituents being sodium chloride, magnesium chloride and magnesium sulphate."

The sodium chloride promotes tissue changes generally and is of use in dyspepsia with deficient acidity; the magnesium salts are aperient, in sufficient doses laxative or cathartic, and are useful in eliminating waste products and in keeping the bowels regular. The calcium carbonate is an antacid, serviceable in excessive acidity of the stomach, and it also acts as a diuretic.

This water is especially indicated in uric acid, gouty and rheumatic conditions.

The Water Works well, in 1901, was flowing about three gallons per minute of a clear water, which had the odor and taste of hydrogen sulphide, combined with the bitter taste of magnesium sulphate. The water rises four feet above the surface and flows from a small discharge pipe, with a temperature of 56° F. It is used to some extent locally. No analysis was available.

CLARK COUNTY.

KING'S MINERAL SPRING.

WATER = *Saline-sulphated* (Purgative).

LOCATION.—On the southwest quarter of Section 233, Illinois Grant, near the northeast corner of Carr Township, Clark County, one and a half miles north of Wilson's Switch, the nearest railway station, on the C., I. & L. (Monon) Railway, 18 miles north of Louisville, 305 miles south of Chicago. Postoffice, Dallas.

ORIGIN AND CHARACTER OF THE WATER.—A spring, which in its natural state issued from the side of a bluff of shale, has been dug out to a depth of six feet and walled with stone. It has an output of about 15 gallons per hour, of a clear water, without odor, but with a very bitter taste, the water being strongly impregnated with mineral salts derived by leaching through the New Providence shale. This shale is one of the lower members of the Knobstone formation, which comprises a large portion of the surface of Clark, Scott, Jackson and other counties of this portion of Indiana. It is a fine, greenish-gray, marly shale that pulverizes when dry without difficulty. This shale is the source of all but one of the springs of mineral water described from Clark County, as well as the one from Floyd County.

An analysis of the water from King's Spring was made by Dr. W. A. Noyes for this paper. He reports on it as follows:

ANALYSIS OF WATER FROM KING'S MINERAL SPRING, NEAR DALLAS, CLARK COUNTY, INDIANA.

Bases and Acid Radicals.

Bases and Acid Radicals.	*Parts per 1,000,000.*	*Grains per U. S. Gallon*
Calcium (Ca)	456.4	26.624
Magnesium (Mg)	1599.3	93.295
Potassium (K)	76.3	4.451
Sodium (Na)	2177.6	127.030
Chlorine (Cl)	1740.0	101.503
Sulphate (SO_4)	9360.0	546.015
Carbonate (CO_3)	261.6	15.260
Silica (SiO_2)	11.2	.653
Total	15,682.4	914.831

Besides the above there were present traces of alumina, iron, barium, bromine, and phosphoric acid, and small amounts of manganese, nickel, zinc, strontium, lithium and boric acid.

The elements and acid radicals present may be considered as combined as follows:

	Grains per U. S. Gallon.
Calcium sulphate ($CaSO_4$)	55.937
Calcium carbonate ($CaCO_3$)	25.434
Magnesium sulphate ($MgSO_4$)	466.475
Potassium sulphate (K_2SO_4)	9.935
Sodium chloride (NaCl)	167.264
Sodium sulphate (Na_2SO_4)	189.133
Silica (SiO_2)	0.653
Total	914.831

The analysis shows a water strongly impregnated with Epsom and Glauber's salts. It is an active cathartic when taken in quantity, while in smaller doses it is valuable in stomach, liver and intestinal troubles. It is also advertised as an excellent remedy for scrofulous diseases and dyspepsia. Miss Jennie King, the owner of the spring, reports the sale of 700 gallons of the water in 1901, at a price of 10 cents per gallon, which did not include the cost of receptacles.

PAYNE'S MINERAL SPRINGS.

WATER = *Saline-sulphated* (Purgative).

LOCATION.—One mile northwest of Blue Lick Postoffice, Clark County, on the northwest quarter of Section 251, Clark's Grant. Three and one-half miles northwest of Memphis, a station on the Louisville Division of the Pennsylvania Railway, 17 miles north of Louisville; 93 miles south of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—Three springs or seeps, issuing on the slope of a hill which rises 30 to 40 feet above them, have been improved by digging wells 20 feet in depth. In these the water stands eight to ten feet deep and is raised with pumps or with rope and bucket. The springs issue from crevices in the New Providence shale and the water is of the same character as that described from King's Mineral Spring. It has a bitter taste, due to the large quantity of sulphates present, and a temperature, when drawn fresh from the well, of 57½° F.

An analysis made by Prof. E. T. Cox in 1876, resulted as follows:

ANALYSIS OF MINERAL WATER FROM PAYNE'S SPRINGS, CLARK COUNTY, INDIANA.

Bases.	*Grains per U. S. Gallon.*
Lime	117.098
Soda	158.632
Potash	50.117
Magnesia	3.149
Alumina	2.916
Acid Radicals.	
Chlorine	23.353
Carbonic acid	32.327
Sulphuric acid	334.863
Total	722.455

These constituents are probably combined as follows:

	Grains per U. S. Gallon.
Calcium sulphate ($CaSO_4$)	184.446
Sodium sulphate (Na_2SO_4)	303.008
Potassium sulphate (K_2SO_4)	92.672
Magnesium sulphate ($MgSO_4$)	9.440
Aluminum sulphate ($Al_2(SO_4)_3$)	9.720
Calcium carbonate ($CaCO_3$)	73.471
Sodium chloride ($NaCl$)	49.698
Total	722.455

"The precipated matter which was filtered out contained silica, oxide of iron, lime and alumina. The quantity of water received was not sufficient to admit of the determination of bromine and iodine, but traces were detected.

"This is a strong and valuable saline sulphur water, a small quantity of which will act as cathartic and diuretic."—*Cox.*

In the circular sent out by Parady Payne, the owner, the following claims are made for the water: "It is an excellent purgative tonic. It causes no pain or griping whatever and requires only a small quantity to keep the system in proper condition. It is not unpleasant to drink, emits no odor, will keep any length of time in clean vessels, air-tight or not, there being no loss of virtue by being exposed to the air. It acts on the stomach, liver, kidneys and bowels, imparts clearness and beauty to the complexion, removes pimples from the skin and cleanses the system of all poisons and impurities. It is a good appetizer and materially aids digestion."

Much of this statement is doubtless true not only of the waters of Payne's Springs, but also of those of all others in the county derived from the New Providence shale. They are, however, so strong in cathartic constituents, that they should not be used indiscriminately, but always upon the advice of a physician.

The water from Payne's Springs has been sold many years in Louisville, Jeffersonville, New Albany and Indianapolis. It brings $5.00 per barrel, $3.00 per half barrel or 20 cents per gallon in jugs, f. o. b. at Memphis. A limited number of guests have, in the past, been accommodated at the farm house of Mr. Payne. It is his intention to enlarge his house during the coming season so that he can take care of all who may apply.

INDIANA BLUE LICK SPRING.

WATER = *Saline-sulphated* (Purgative).

LOCATION.—One-half mile west of Blue Lick Postoffice, and three miles northwest of Memphis, Clark County, on Section 250, Clark's Grant. One mile southwest of Payne's Mineral Springs above described.

ORIGIN AND CHARACTER OF THE WATER.—A well sunk to a depth of 11 feet is at the foot of a slope where the water formerly seeped forth from crevices in the shale. In this well the water stands six feet deep and is raised with a rope and bucket. At the residence of the owner, Mr. L. D. Townsend, 30 rods from the well, on the crest of the slope above the latter, cistern water is used for household purposes. It is also used at all other residences in the vicinity, as the bitter mineral water is struck as soon as a well reaches the underlying or New Providence shale. The water of the Townsend well is clear and odorless, has the bitter taste of Epsom and Glauber's salts and a temperature of 58° F. No analysis was available. It possesses, doubtless, the same mineral salts as the Payne and King waters above described and is useful for the same diseases. About 20 barrels per year have been shipped, chiefly to Bedford and Jeffersonville, Ind.

SAMSON KING MINERAL WELL.

WATER = *Saline-sulphated* (Purgative).

LOCATION.—On the northwest quarter of Section 233, Clark's Grant, four miles west of Memphis, on the Louisville Division of the Pennsylvania Railway. Three miles from Wilson's Switch on the C., I. & L. Railway. Postoffice, Blue Lick.

ORIGIN AND CHARACTER OF THE WATER.—The well which formerly produced the Samson King Mineral Water, is situated on top of a hill which rises 40 feet above the valley of Blue Lick Creek. This was the first well or spring in Clark County from which water from the New Providence shale was sold or used to any extent for medicinal purposes. It was dug about 1870 in search of fresh water by Samson King. He passed through five feet of soil, 27 feet of soapstone and 33 feet of "blue rock" (Knobstone). At the depth of 65 feet a fissure was struck in the rock, through which the mineral water entered and filled the well to a depth of 33 feet. An analysis of the water was made by Prof. E. T. Cox, who reported on it as follows:

ANALYSIS OF MINERAL WATER FROM SAMSON KING WELL, CLARK COUNTY, INDIANA.

	Grains per U. S. Gallon.
Calcium sulphate ($CaSO_4$)	59.814
Magnesium sulphate ($MgSO_4$)	357.907
Sodium chloride ($NaCl$)	238.313
Sodium and potassium sulphates	170.265
Total	826.299

Mr. King built a large frame hotel and bath room, advertised freely, and the water had quite a patronage until his death. The place was then transferred to a Mrs. McCabe who carried on the business for some time, selling the water as "Silver King Mineral Water." The well in time partially caved in and no use has been made of the water since 1898.

In 1900 a new spring was discovered about one-eighth of a mile northwest, on the same tract of land, seeping from the side of a slope, 40 feet lower than the surface of the old well. This was dug out to a depth of 12 feet, and in it, in October, 1901, the water was eight feet deep. The output is about ten gallons per hour, of a very clear water, having a temperature of 58° F. The taste is quite bitter and the medicinal virtues are doubtless the same as the waters of the neighboring springs of the same horizon. The new spring is owned by Catherine King, and the water will, in the future, be sold.

* * *

Besides the above, other springs and wells producing a saline water of the same character, have been located in Clark County, on the land of Augustus Reid, Section 27 (1 N., 6 E.); on Sections 4 and 5 (1 S., 6 E.); two miles north of Henryville, on the land of John Stewart, southwest quarter of Section 31 (2 N., 7 E.), and one mile east of the same town on the northeast quarter of Section 241, Clark's Grant. Wherever seeps or springs issue from the New Providence shale, or where wells are sunk to that formation, the chances are that the water will be found heavily charged with the mineral salts mentioned above as occurring in the King, Payne and other waters.

CHARLESTOWN "BLUE LICK SPRING."

WATER = *Saline-sulphuretted* (?).

LOCATION.—One mile northeast of the town of Charlestown, Clark County, on the northwest quarter of Section 97, Clark's Grant. The Louisville Division of the B. & O. S.-W. Railway passes through Charlestown, which is 17 miles northeast of Louisville.

ORIGIN AND CHARACTER OF THE WATER.—The spring issues from the side of a low bluff of Corniferous limestone, and flows into "Lick Run," a small stream a short distance away. The flow, at the time of my visit, in June, 1901, was weak, not over one-half gallon per minute. A white coating of sulphur covered the sides of the rock about the outlet and a distinct but slight odor of hydrogen sulphide was present. The water was clear, cool, and had an agreeable sweetish saline taste, very different from that of the bitter blue lick "sulphated" waters of the northwestern part of the county.

The spring is located in a very pretty woodland, much visited by picnic parties and citizens of the town. It would be an admirable spot for a sanitarium were the supply of water greater. No analysis of the water has ever been made. It is said to be laxative in effect, and is often used by the citizens of Charlestown for skin diseases and rheumatism.

CRAWFORD COUNTY.

WHITE SULPHUR WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—At Sulphur Postoffice, southeast quarter Section 35, (3 S., 1 W.), 12 miles southwest of English, the nearest railway station, on the St. Louis Division of the Southern Railway; eight miles west of Leavenworth and six miles and a half north of Otisco—steamer landings on the Ohio River. A daily stage, carrying mail, express and baggage, runs between English and the well. A livery stable and a stage line are operated in connection with the hotel at the well.

ORIGIN AND CHARACTER OF THE WATER.—The artesian well, from which the water at present flows at the rate of about 10 gallons per minute, is in a wooded grove on the banks of the west fork of the Little Blue River. It was started in search of oil in 1862, but at a depth of 284 feet near the base of the St. Louis limestone a heavy flow of mineral water was struck which stopped farther drilling. According to Professor Collett, the section of the bore above the vein of water was as follows:*

SECTION OF EATON'S WHITE SULPHUR WELL, CRAWFORD COUNTY, INDIANA.

	Ft.
Soil, level of Kaskaskia limestone	21
Chester sandstone and shale	175
Chester and St. Louis limestone with many clay partings	88
Total	284

When the vein of water was reached it "rushed up the well with tremendous force, carrying with it the tools, and put a stop to further boring. An ineffectual attempt was made to test the height to which the well would throw water. A wooden tube, 45 feet long, was placed in the mouth of the bore, and the water flowed over the top, but the hydrostatic pressure was so great that it burst the bottom of the tube, and water was forced through the earth for many feet around."†

An analysis of the water was made in the laboratory of the State Geological Survey by Dr. G. M. Levette, the chemist of the Department, and published in the report for 1878, p. 515. This showed the mineral ingredients to be as follows:‡

*Geological Survey of Indiana, 1878, p. 443.

†Geological Survey of Indiana, 1872, p. 155.

‡In the report cited, the result of analysis was given in grains per imperial gallon. This has been reduced to grains per U. S. gallon.

ANALYSIS OF WHITE SULPHUR WATER, CRAWFORD COUNTY, INDIANA.

Elements and Acid Radicals.	*Grains per U. S. Gallon.*
Ferrous oxide	1.233
Lime	22.702
Magnesia	19.900
Potash	2.916
Soda	4.748
Sodium	49.305
Sulphuric acid	44.726
Carbon dioxide	41.329
Chlorine	76.089
Total	262.949

The above constituents are probably combined as follows:

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	47.498
Magnesium carbonate ($MgCO_3$)	16.793
Calcium sulphate ($CaSO_4$)	11.449
Magnesium sulphate ($MgSO_4$)	43.962
Sodium sulphate (Na_2SO_4)	10.950
Potassium sulphate (K_2SO_4)	5.397
Sodium chloride (NaCl)	125.394
Carbonate of iron (Fe_2CO_3)	1.989
Total	263.432

The amount of hydrogen sulphide was not determined by Dr. Levette at the well, but in the samples taken to the laboratory he found 1.96 cubic inches per U. S. gallon. That much more exists is proven by the odor and the bubbles of gas escaping. Part of the gas, however, is undoubtedly carbon dioxide. The analysis shows the water to be saline-sulphuretted in character and to possess valuable medicinal salts. The circulars issued by the company contain numerous testimonials of people who claim to have been highly benefited by its use, especially where taken for stomach diseases, rheumatism, eczema and skin troubles in general.

As it flows from the well the temperature of the water is 58° F. and it is very clear and sparkling. The taste is slightly bitter, due to the sulphates present. The water at present rises about seven feet above the surface in a four-inch closed pipe from which three pipes lead to the bath rooms and bottling works near by. By an arrangement of a wire and pulley the water is taken from the well up to the hotel in a bucket. When this is lowered it fills itself automatically in the stone basin at the base of the outlet pipe in the well.

Besides its use at the hotel and in the bath rooms, large quantities of the water are bottled and shipped, the principal markets being the cities along the "Air-Line" Railway and the Ohio River. A concentrated form produced by boiling 16 gallons down to one, is also bottled and sold under the name "16 to 1 White Sulphur Water."

IMPROVEMENTS.—A three-story hotel and annex has been built on a natural terrace 85 feet above the well. A flight of steps leads down to the well, while a gradual incline skirts the hill, giving an easy path to the infirm and leisurely inclined. The hotel is surrounded by a fine natural grove of beech, oak, walnut and other native forest trees. Wide verandas, swings, music and dancing halls and bowling alleys afford abundant means of recreation. The climb from well to hotel affords also a method of exercise which, while not compulsive, is highly exhilarating. The bath house is located in the valley close to the well and has facilities for hot and cold baths. The hotel is open to guests from April to November. The fresh water used in it is piped by gravity from a spring 1,600 feet distant and located on a hillside 40 feet above the hotel. It is of the purest quality and the supply is abundant even in the driest season. As a place of peaceful quiet, far removed from all nerve-jarring sounds of commerce and travel; surrounded by romantic scenery and pure air, and blessed with an abundance of water, both mineral and pure, the "White Sulphur" resort of Crawford County is highly recommended.

Thirteen miles east of White Sulphur Well, near Great Blue River, the dividing line between Crawford and Harrison counties, is Wyandotte Cave, one of the largest and most beautiful caverns in the United States, furnishing, as it does, at least 12 miles of underground travel if one visits all of its passages. While Wyandotte does not equal Mammoth Cave, Kentucky, in size, it far surpasses it in the grandeur of its scenery. One view alone, that of "Rothrock's Cathedral by Moonlight," is well worthy a journey of hundreds of miles to see. The situation of Wyandotte among the rugged hills which form the breaks of the Ohio River, in a country as yet primitive in character, where game is plentiful, and fishing in the clear waters of Blue River exceptionally good, make it a most inviting spot for a summer's outing.

Around the hotel, situated close to the cave, on a commanding eminence in a natural wooded grove, grow numerous forms of plant life which are strangers to central and northern Indiana, while in the cave dwell many sightless animals whose habits of life are yet unknown; so that the botanist and zoölogist may add to the study of the cavern itself the pursuit of their favorite subjects.

An electric railway could be readily constructed from Corydon, the county seat of Harrison County, 11 miles, to Wyandotte Cave, and from there by way of Leavenworth to White Sulphur Well. Blue River possesses the best undeveloped water power in the State of Indiana, and by the construction of a dam or two it will easily furnish ten times the power necessary for operating the railway and lighting the cave. Stone suitable in every way for building the dams and ballasting the road exists in inexhaustible quantities just where needed. The best of railway ties can be secured at 25 cents apiece, or even less, as thousands are gotten out and floated down Blue River to the Ohio each season.

If thought best, the railway could be constructed along the New Albany and Corydon Pike between New Albany and Corydon. It would thus furnish direct transportation by electric line to the citizens of Louisville, Jeffersonville and New Albany to and from the cave and well. The line, as proposed, would pass, for the most of the way, through a good farming region, and would furnish freight facilities, now lacking, to one of the best fruit raising districts of southern Indiana. A company with the necessary capital, and with men of energy in control, could, without doubt, make of such a road a paying investment. Its construction would make easy of access to the public two of the most worthy and attractive pleasure and health resorts in the United States which are now known only to a few, because of their inaccessibility.

TAR SPRINGS.

WATER = *Alkaline-saline.*

LOCATION.—Three and a half miles northwest of White Sulphur Well, on the southeast quarter of Section 15 (3 S., 1 W.), and seven miles southwest of English, the nearest railway station, on the St. Louis Division of the Southern Railway.

ORIGIN AND CHARACTER OF THE WATER.—These springs were not visited, but I was reliably informed that the conditions are practically the same as in 1878, when Professor Collett wrote of them as follows: "Two weak springs have outlets from beneath the Kaskaskia limestone, just below a bed of Conglomerate, in a deep, wild valley. The west spring discharges with its waters coal tar and carburetted hydrogen; the outlet is in a basin trough, built up on the rocks, of earth cemented with the deposited asphaltum. The east spring, thirteen feet distant from the last, discharges water and petroleum, with a small quantity of carburetted hydrogen gas. Both are strong flowing fountains during rainy weather, but are weak during dry seasons.

"Some instinct of nature, or reason, attracts all domestic animals to these springs; in malarial seasons hogs and cattle will break from enclosures and go miles to obtain the water, while pure spring and brook water is plentiful nearer by. There is no saline taste perceptible, but we may infer that there is some remedial effect experienced by the animals after drinking it. I am informed by Mr. T. Roberson that domestic animals not only drink the water greedily, but when foot and mouth diseases are prevalent they manifest a desire to bathe the diseased parts in the oily fluid. It is probable that this spring and other "oil seeps" induced the boring of the six wells which were put down during the "oil fever" of 1862-66.*"

The analysis of the water, made by Dr. Levette and published on page 516 of the report cited, showed the mineral ingredients to be as follows:

ANALYSIS OF WATER FROM THE "TAR SPRING," CRAWFORD COUNTY, INDIANA.

Elements and Acid Radicals.	*Grains per U. S. Gallon.*
Ferric oxide	2.332
Lime	8.397
Magnesia	3.649
Potash	0.916
Soda	1.541
Sulphuric acid	8.765
Carbonic acid	16.053
Total	41.653

The above constituents are probably combined as follows:

	Grains.
Calcium carbonate ($CaCO_3$)	21.596
Magnesium carbonate ($MgCO_3$)	2.078
Magnesium sulphate ($MgSO_4$)	8.995
Sodium sulphate (Na_2SO_4)	3.529
Potassium sulphate (K_2SO_4)	1.696
Carbonate of iron ($FeCO_3$)	3.758
Total	41.652

"This water has a slight odor of petroleum, with a few globules of oily matter floating on the surface. It contained no hydro-sulphuric acid or chlorine."

*Geological Survey of Indiana, 1878, p. 445.

HAZLEWOOD SULPHUR WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—On the land of Dr. George R. Hazlewood, along the west bank of Little Blue River, south half of section 13 (2 S., 1 W.), one-half mile north of the station of the St. Louis Division of the Southern Railway, at English.

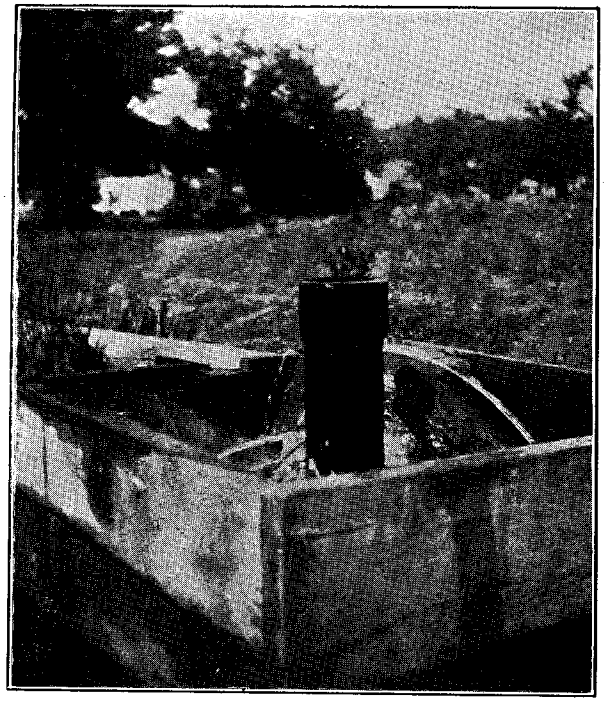
ORIGIN AND CHARACTER OF THE WATER.—The water at present flows from an artesian boring 32 feet deep, at the rate of about two gallons per minute. Prior to 1890 it issued from several springs in a basin which has been excavated and cemented close to the bank of the creek. In the first settlement of the country these springs were known as "Elk Springs" or "Elk Lick," as elk and other wild beasts used to frequent the place, probably for the salt which the water held in solution, and that which was left in the surrounding soil by evaporation. A large hotel and sanitarium, which was run under the name of the "Hartford Sulphur Spring," was erected in 1885, but burned in 1889. The water at that time had a wide reputation and many patients and visitors patronized the resort. When the bore was sunk 10 rods northwest of the spring, so as to have the water nearer the dwelling erected on the site of the hotel, the flow of the spring grew less and finally ceased.

Dr. Levette, in 1878, analyzed the water, finding its mineral ingredients to be as follows:

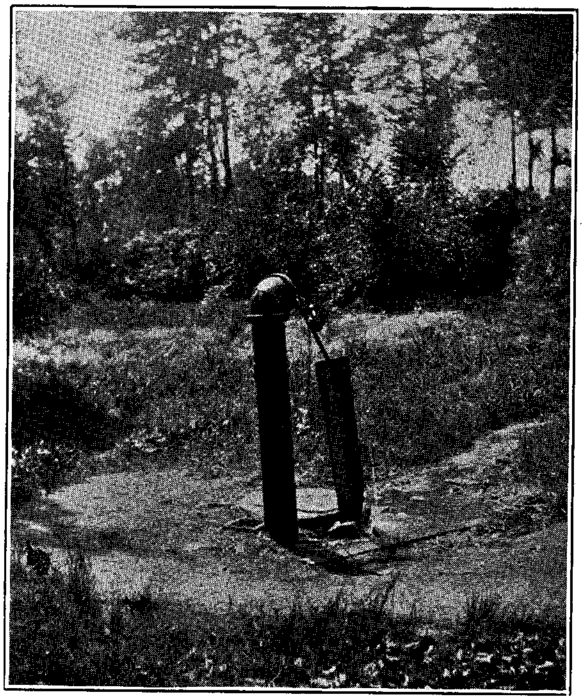
ANALYSIS OF WATER FROM HAZLEWOOD SULPHUR WELL, CRAWFORD COUNTY, INDIANA.

Elements and Acid Radicals.	*Grains per U. S. Gallon.*
Ferric oxide	1.166
Lime	10.413
Magnesia	7.064
Potash	0.708
Soda	3.515
Sodium	23.864
Sulphuric acid	16.786
Carbonic acid	19.776
Chlorine	36.827
Total	120.119

*Geological Survey of Indiana, 1878, p. 518.



ARTESIAN MINERAL WELL IN ENGLISH PARK, ENGLISH, CRAWFORD COUNTY, INDIANA.



ARTESIAN MINERAL WELL IN CITY PARK, KOKOMO, INDIANA.

(See p. 64.)

The above constituents are probably combined as follows:

	Grains.
Calcium carbonate ($CaCO_3$)	20.568
Magnesium carbonate ($MgCO_3$)	9.459
Calcium sulphate ($CaSO_4$)	5.866
Magnesium sulphate ($MgSO_4$)	12.296
Sodium sulphate (Na_2SO_4)	8.051
Potassium sulphate (K_2SO_4)	1.310
Sodium chloride ($NaCl$)	60.691
Total	120.119

In August, 1901, the water flowed from a pipe three feet above the ground. Both odor and taste of hydrogen sulphide were distinct, but not strong. The temperature was 65° F. The characteristic white sulphur deposit lined the receiving basin and coated the sides of the rill bearing away the overflow. Dr. Hazlewood, the owner, claims the water to be anti-acid and diuretic rather than purgative; and stated that when the sanitarium was in operation it was the custom to secretly sink a bag of Epsom salts in one of the springs during the night in order to increase the purgative properties of the water. At present only local use is made of the water, and that has decreased largely since the flowing wells have been developed in English Park.

ENGLISH ARTESIAN WELLS.

WATER = *Saline-sulphuretted* (?).

LOCATION.—In a public park four squares northwest of the court house and three squares west of the railway station at English, the county seat, a town of 800 inhabitants, located on the St. Louis Division of the Southern Railway ("Air Line"), 46 miles northwest of Louisville and 228 miles east of St. Louis.

ORIGIN AND CHARACTER OF THE WATER.—These wells, two in number, were sunk in 1899 to depths of 817 and 860 feet, respectively, in search of oil or gas. They lacked 1,000 feet or more, however, of reaching the Trenton limestone, the main oil and gas horizon of the State. The wells are 100 yards apart in English Park, a rather low tract of land lying in the angle between the junction of Little Blue River and Camp Creek, and along the north side of the "Air-Line" Railway.

The mineral water in both was struck at a depth of approximately 700 feet. A pure water was struck at a higher level and cased off, but is said to now mingle with the mineral water before reaching the surface, thereby weakening the latter. Only the northernmost of the two wells at present flows, though the water in the other, which was the first drilled, stands eight inches above the surface in the protruding iron casing, and would flow were the casing removed. When the flow of one is stopped the other immediately begins, and the pipes and levels could be so arranged as to cause a good flow from each. In August, 1901, the water was rushing forth from the drive-pipe of the flowing well, three feet above the surface, at the rate of 15 or more gallons per minute. It was clear and sparkling; had a temperature of 56° F.; a slightly bitter taste and a weak odor of hydrogen sulphide. This gas was, however, sufficient in quantity to coat with a deposit of sulphur the nearby objects. No analysis of the water was available. It is much used locally in bilious diseases, and is said to be a strong purgative.

DAVIESS COUNTY.

CABLE & CO., No. 4 MINERAL WELL.

WATER = *Saline-sulphated.*

LOCATION.—About one and one-half miles south of Washington, the county seat, a city of 9,000 population, situated on the B. & O. S.-W. Railway, 173 miles west of Cincinnati and 168 miles east of St. Louis; and on the E. & I. Railway, 58 miles north of Evansville, and 80 miles southeast of Terre Haute.

ORIGIN AND CHARACTER OF THE WATER.—This well was drilled 800 feet deep in search of coal. It is on the southwest quarter of Section 3 (2 N., 7 W.), near the No. 4 Mine of Cable & Co. At the bottom of the well, in a grayish shale, a strong vein of mineral water was encountered, which flowed four feet above the surface for some years. The well was finally plugged, as the water ran into the mine in too great quantity. The plug can, however, be removed at any time, and the water be rendered once more available.

An analysis made for the owners by Werner & Simonson, of Cincinnati, showed the presence of the following mineral salts:

ANALYSIS OF WATER FROM CABLE & CO.'S NO. 4 WELL, WASHINGTON, INDIANA.

	Grains per U. S. Gallon.
Calcium sulphate ($CaSO_4$)	75.712
Calcium carbonate ($CaCO_3$)	9.256
Magnesium chloride ($MgCl_2$)	88.480
Magnesium bromide ($MgBr_2$)	0.605
Potassium sulphate (K_2SO_4)	7.168
Sodium sulphate (Na_2SO_4)	488.088
Sodium chloride ($NaCl$)	1014.336
Total	1683.645

A small quantity of lithium was found. The water was wholly free from nitrogenous organic matter.

When last seen by the writer, in 1895, the flow was about 15 gallons per minute. The water was without odor, but was quite salty in taste. Large quantities were being carried away daily in jugs and kegs by the citizens of Washington and vicinity. It was claimed to be especially valuable in skin and kidney diseases and for rheumatism.

DEARBORN COUNTY.

AURORA ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—In the western portion of Aurora, a city of 3,700 inhabitants, located on the Ohio River, 26 miles below Cincinnati. Accessible by steamers on the Ohio; by the B. & O. S.-W. and Big Four railways, and by the Cincinnati, Lawrenceburg and Aurora Electric Railway.

ORIGIN AND CHARACTER OF THE WATER.—The artesian well at Aurora is on the bank of South Hogan Creek, within a few rods of the station of the B. & O. S.-W. Railway. It was sunk about 1890 in search of natural gas, to a depth of 366 feet; the water being found about 10 feet below the top of the Trenton limestone. In July, 1901, the water was flowing from a two-inch pipe, four feet above the ground, at the rate of about seven gallons per minute.

A partial analysis was made a number of years ago by Dr. W. Dickore, of Cincinnati, who reported on it as follows:

ANALYSIS OF AURORA ARTESIAN WATER.

Total solids, 564.16 grains to the U. S. gallon. These are present in the following forms:
Sodium chloride (three-quarters of the whole amount).
Magnesium sulphate or chloride.
Calcium carbonate and sulphate.
Potassium sulphate or chloride.
Iron carbonate.
Silicic acid (trace).
Lithia (trace).
Magnesium bromide (trace).
Magnesium iodide (trace).
The free gases present are sulphuretted hydrogen and carbonic acid gas.

The water is known locally as "Blue Lick" and has an agreeable sweetish-saline taste. The amount of hydrogen sulphide present is not great, but sufficient to give its distinctive odor to the air a rod or two away from the well. It is said that the water will hold its gas for several days without becoming "flat." It is recommended by the physicians of Aurora for catarrh and skin diseases, especially eczema and ivy poisoning. It is also said to be very helpful in recovering from the effects of intoxication, and one mud-covered disciple of Bacchus whom I found at 5 o'clock in the morning quaffing long and deep of the water, assured me that "it destroys all feeling of sickness at stomach and headache. One can drink any amount of it after being on a drunk and it will help him every time." Many citizens carry it home in jugs for use as a mild laxative and diuretic. Quantities are also shipped, though no person, as far as could be learned, controls this shipment. The well is owned by a local stock company and the water is free to all users. It offers excellent advantages to a party with capital who desires to erect a sanitarium and bath house, as there is no similar water so readily accessible in southeastern Indiana.

CHEEK'S SPRING.

WATER = *Saline-sulphuretted* (?).

LOCATION.—In the city of Aurora, one-third of a mile north of the artesian well above described.

ORIGIN AND CHARACTER OF THE WATER.—The spring issues from the base of a low bluff a few rods north of the B. & O. S.-W. Railway track. The flow is small, probably not over 20 gallons per hour, into a pond lying between the railway track and the spring.

No analysis was available. The water has a bitter taste, indicating the presence of sulphates of magnesia and soda. It is said to smell strongly of sulphuretted hydrogen at times, and the water of cisterns near by has been so affected by the same gas as to be useless. Before the drilling of the artesian well the water of Cheek's Spring was much used locally for rheumatism, and as a purgative and diuretic.

DUBOIS COUNTY.

JASPER ARTESIAN WELL.

WATER = *Saline-sulphuretted* (?).

LOCATION.—One-third of a mile southeast of the court house at Jasper, the county seat, a town of 2,000 inhabitants, on the St. Louis Division of the Southern Railway, 82 miles west of Louisville and 206 miles east of St. Louis.

ORIGIN AND CHARACTER OF THE WATER.—The artesian well is located on a terrace just west of the Patoka River, near the east line of Section 35 (1 S., 5 W.). It was sunk in 1889, in search of oil or gas, to a depth of 1,009 feet, but lacked several hundred feet of reaching Trenton limestone. At 720 feet the drill pierced a soft blue limestone, from which issued a water strongly charged with hydrogen sulphide. This was so offensive to the nostrils of the citizens that the well was filled up to 713 feet, at which depth the present issuing mineral water had been found.

No analysis of the water was available. In September, 1901, it was flowing at the rate of four gallons per minute. The temperature at the end of the discharge pipe, 40 feet from the well, was 62° F. The water had an agreeable, slightly saline taste. The odor of hydrogen sulphide was present, but weak. Enough gas, probably carburetted hydrogen, was issuing from the pipe to burn when ignited, with a small but constant flame. It is said that at times for a few days the water becomes murky, much more bitter, and strongly impregnated with hydrogen sulphide, after which it clears up and remains clear for several weeks. It may be that this change is caused by an accumulation of gas forcing some of the stronger mineral water up from the lower vein and causing a mixture of the two waters. The water is used by many of the citizens of Jasper as a laxative and diuretic. In appearance and properties, as far as could be judged without an analysis, it is fully equal to many similar waters which are used in sanitariums with excellent curative results.

TOUSSAINT DUBOIS SPRING.

WATER = *Neutral.*

LOCATION.—On the farm of Fritz Mann, northeast quarter Section 3 (1 S., 5 W.), Boone Township, five miles northwest of Jasper.

ORIGIN AND CHARACTER OF THE WATER.—This spring bubbles up in an artesian flow about 50 feet from Mill Creek. According to Prof. Geo. R. Wilson "it flows a strong stream and its waters are noted for their purity. An analysis of its waters by Dr. John Hurty, of Indianapolis, shows its ingredients to be as follows: Thirty-two grains of chalk (carbonate of lime) and the slightest trace of iron in one gallon."*

*"History and Art Souvenir of Dubois County," 1896, p. 9.

ELKHART COUNTY.

LAMBERT MINERAL WELL.

WATER = *Saline-carbonated.*

LOCATION.—In the south part of the city of Elkhart, one-half mile from the center, and about the same distance from the southern limits. Elkhart is a city of 16,000 population, located 101 miles east of Chicago on the Lake Shore and Michigan Southern Railway, and 157 miles north of Indianapolis, on the Michigan Division of the Big Four Railway. The Indiana Electric Railway, operating between South Bend and Goshen, also runs its cars within three blocks of the well.

ORIGIN AND CHARACTER OF THE WATER.—The well which produces the water in question was started some years ago in search of oil or gas. At a depth of 290 feet a strong vein of mineral water was found, which arose to within 14 feet of the surface.

An analysis of the water by Dr. W. A. Noyes, of Terre Haute, resulted as follows:

ANALYSIS OF LAMBERT MINERAL WATER, ELKHART, INDIANA.

Elements and Acid Radicals.	*Parts to 1,000,000.*
Calcium	380.0
Magnesium	132.7
Sodium	4660.0
Potassium	72.4
Chlorine	8137.0
Carbon dioxide	127.0
Silica	7.4
Alumina	.8
Iron	.3
Total	13517.6

The substances in the water may be considered as combined essentially as follows:

	Grains per U. S. Gallon.
Calcium chloride ($CaCl_2$)	54.520
Calcium carbonate ($CaCO_3$)	6.300
Magnesium chloride ($MgCl_2$)	30.643
Sodium chloride (NaCl)	686.077
Potassium chloride (KCl)	8.050
Silica (SiO_2)	.432
Alumina (Al_2O_3)	.047
Ferrous carbonate ($FeCo_3$)	.035
Total	786.104

Carbon dioxide, free and as bi-carbonate—10,088 cu. in. per gallon.

Besides the above, a trace each of strontium chloride, lithium chloride, sodium bromide and sodium borate were present. The water is remarkable for the absence of sulphates.

This is a water strongly impregnated with common salt, and when pumped has a temperature of 54° F. It is very clear, and sparkles with the carbonic acid gas which it holds in solution. It is without odor and has a salty but not disagreeable taste. The minerals present are held in such chemical affinity that they do not precipitate readily. The water can thus be shipped or carried a distance and still retain its natural properties. As yet it has had only a local use, being furnished free to all who apply.

The well is located on high and spacious grounds. The buildings already in use can be readily converted into a sanitarium, and, as no other similar water is known to occur in northern Indiana, an excellent location for a medical sanitarium is presented.

FLOYD COUNTY.

BRIGGS MINERAL SPRING.

WATER = *Saline-sulphated.*

LOCATION.—One mile northwest of the court house at New Albany, the county seat, a city of 21,000 population; situated on the Ohio River, opposite Louisville, Kentucky. Accessible by steamer on the Ohio and by the C., I. & L. (Monon), Pennsylvania, Big Four, and the St. Louis Division of the Southern railways; also by electric lines from Louisville.

ORIGIN AND CHARACTER OF THE WATER.—The Briggs Mineral Spring issues from the base of a wooded bluff which slopes up to a height of 75 or more feet, just outside the city limits. This bluff is composed, for the most part, of New Providence shale, a fine grained, greenish-gray material, containing many nodules and bands of siderite or iron carbonate. This shale is the source of the water of all the mineral springs of Clark County, described on a preceding page. The lower slope of the bluff in the immediate vicinity of the Briggs Spring has been much eroded and cut up into gullies, and the weathered shale is in many places wholly devoid of vegetation. On account of disuse, the visible flow of water from the spring is at present small, being not over 12 gallons per hour.

An analysis of the water by Prof. J. F. Elsom, made in 1883, when it was extensively used, showed its mineral ingredients to be as follows:

ANALYSIS OF WATER FROM BRIGGS SPRING, FLOYD COUNTY, INDIANA.

	Grains per U. S. Gallon.
Magnesium carbonate ($MgCO_3$)	2.936
Calcium carbonate ($CaCO_3$)	29.728
Sodium chloride ($NaCl$)	18.536
Potassium sulphate (K_2SO_4)	4.072
Magnesium sulphate ($MgSO_4$)	263.280
Ferrous carbonate ($FeCO_3$)	.1416
Calcium sulphate ($CaSO_4$)	31.896
Total	350.5896

When visited, in September, 1901, the temperature of the water was 57° F. The taste is quite bitter, due to the large percentage of sulphates present. For a number of years the water was bottled and sold quite extensively in Louisville and New Albany. It was also delivered to customers in New Albany at 15 cents a gallon. The ownership changed hands and the sale was gradually abandoned. The water contains the same constituents as the Clark County mineral waters and is in every way as valuable as they.

FOUNTAIN COUNTY.

LODI ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—On the east bank of the old Wabash and Erie Canal, one mile northwest of Silverwood, a station on the T., St. L. & W. (Clover Leaf) Railway, 191 miles east of St. Louis and 263 miles southwest of Toledo, Ohio. From Cayuga, the crossing of the "Clover Leaf" and C. & E. I. railways, the well is distant three and a half miles east, the Wabash River intervening. The distance by rail to Cayuga from Terre Haute is 37 miles; from Chicago 141 miles.

ORIGIN AND CHARACTER OF THE WATER.—This well, which furnishes one of the best, if not the best, undeveloped sites for a mineral water sanitarium in the State, was drilled in 1865 to a depth of 1,155 feet in search of oil. It is located near the center of the northern half of Section 35 (18 N., 9 W.), on a farm belonging to Mrs. Mary F. Safely, of Rockville, Ind. Several veins of salt water were struck in the bore and at 1,057 feet, in a magnesian limestone, a strong vein of mineral water was developed, which burst forth with great violence.

An analysis of the water was made, a year or two after it was struck, by Dr. J. C. Pohle, of New York City, and another in 1884 by Dr. C. F. Chandler, of the same city. These analyses are both given herewith:

ANALYSES OF WATER FROM THE LODI ARTESIAN WELL.

	POHLE.	CHANDLER.
	Grains per	*U. S. Gallon.*
Sodium chloride ($NaCl$)	502.464	523.058
Calcium chloride ($CaCl_2$)	47.928	21.774
Magnesium chloride ($MgCl_2$)	53.540	57.895
Calcium sulphate ($CaSo_4$)	55.553	40.240
Potassium sulphate (K_2SO_4)	.804	13.598
Magnesium sulphate ($MgSO_4$)	3.260	.....
Sodium sulphate (Na_2SO_4)	2.135	1.412
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	2.904	53.593
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	1.104	.....
Magnesium bromide	.880	.....
Sodium bromide	.....	1.409
Silicic acid (H_4SiO_2)	.520	.472
Calcium phosphate (Ca_3PO_4)	1.200	.065
Lithium chloride ($LiCl$)	.....	.749
Totals	672.292	714.265
Hydrogen sulphide, cu. in. per gal	7.94	4.64

It will be noted that the two analyses differ materially in the amounts of calcium chloride, potassium sulphate and calcium bi-carbonate present, and to a less extent in the amounts of a number of the other salts. The comparison could have been much more exact if the percentage of each of the elements and acid radicals present had been shown in each instance, but these were not furnished by the chemists.

It is said that the flow has decreased little, if any, in the 37 years since the well was drilled. In August, 1901, the water was bubbling with great force over the top of a four-inch wooden pipe eight feet above the surface, the estimated output being 30,000 barrels per day. Iron pipes are eaten through in a year or two, so are not used. The temperature of the water as it left the well was 69° F. The odor of hydrogen sulphide was very strong, and free sulphur from this gas had coated a yellowish white all objects within 20 feet of the well. The taste of the water is a bitter-saline, somewhat disagreeable at first, but relished after a time. According to Dr. George T. Deverter, of Silverwood, it is slightly laxative and a most excellent remedy for all skin troubles, such as eczema, eruptions due to heat, and for kidney troubles. At present it is much used locally, and to some extent is shipped, bringing $4.00 per barrel on board the cars at Silverwood, or 50 cents per gallon in jugs.

IMPROVEMENTS.—A large residence and hotel, erected about 1880 by the former owner, Mr. J. J. Safely, was burned a few years later and has not been rebuilt. A bath house, with cement-lined pool. 60x20 feet, and averaging four and a half feet in depth, is connected with the well, and is open during the summer months. There are no facilities for heating the water. A fine grove of timber lies adjacent to the well and bath house, and is much frequented by campers and picnic parties during the warm season. Taking into consideration the quality and quantity of the water, the railway facilities and the natural surroundings, this well offers a most excellent site for parties who wish to erect a large sanitarium and resort for invalids.

ATTICA ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—Near the southern limits of Attica, a city of 3,100 population, situated on the Wabash River in the northern portion of the county. The Wabash Railway and the Brazil division of the C. & E. I. Railway cross in the city, thus furnishing easy transportation in all directions. The distance from Chicago is 118 miles; from Indianapolis, via the Big Four to Covington, 87 miles; from St. Louis, 211 miles; from Lafayette, 21 miles.

ORIGIN AND CHARACTER OF THE WATER.—The mineral water at Attica does not come from a spring, as commonly advertised, but from an artesian well, which was sunk in 1889 to a depth of 865 feet. A strong flow of saline-sulphur water was struck at a depth of 600 feet, which has since continued unabated.

An analysis of the water by Prof. H. A. Huston, of Purdue University, proved the presence of the following ingredients:

ANALYSIS OF WATER FROM ATTICA ARTESIAN WELL.

	Grains per U. S. Gallon.
Calcium sulphate ($CaSO_4$)	4.10
Sodium chloride ($NaCl$)	338.82
Potassium chloride (KCl)	trace
Lithium chloride ($LiCl$)	1.16
Magnesium chloride ($MgCl_2$)	14.72
Calcium chloride ($CaCl_2$)	10.13
Calcium carbonate ($CaCO_3$)	21.65
Alumina and iron oxide (Al_2O_3&Fe_2O_3)	.08
Total	390.66

The flow of water is said to be about 320 gallons per minute. It has an agreeable saline taste, a temperature of 55° F., and a distinct odor of hydrogen sulphide.

IMPROVEMENTS.—The "Lithia Springs Hotel," a large two-story building with accommodations for 80 guests, equipped with modern improvements, and with excellent facilities for giving mineral and Turkish baths, was erected at the site of the well in 1898. Mud baths, for persons afflicted with rheumatism or skin diseases, are also given if desired. The grounds about the hotel are spacious, and it promises to grow in popularity as a resort as the water becomes better known.

WALLACE MINERAL SPRING.

WATER = *Chalybeate.*

LOCATION.—One-fourth of a mile west of Wallace, a village situated in Section 19 (18 N., 6 W.), in the southwest corner of the county. The nearest railway station is Yeddo, seven miles northwest on the Brazil Division of the C. & E. I. Railway.

ORIGIN AND CHARACTER OF THE WATER.—This is one of the strongest flowing chalybeate springs in western Indiana. It issues from a bank of glacial gravel on the roadside, and is in part piped to a watering trough, where it has an extensive local usage by both man and beast. The flow varies slightly with the season, and is between 2,000 and 3,000 gallons per hour. The water contains quite a percentage of iron salts, probably the carbonate, as is shown by the reddish-brown deposit of iron oxide on the watering trough and about the orifice of the spring. No analysis has been made.

There are a number of similar but smaller springs south along Sugar Mill Creek, and one, heavily charged with iron and free carbon dioxide gas, is located three-quarters of a mile west of Wallace. It bubbles up in the bed of a small stream in the middle of the road.

FULTON COUNTY.

FEECE'S MINERAL WELL.

WATER = *Chalybeate.*

LOCATION.—On the southeast quarter Section 24 (30 N., 3 E.), four miles southeast of Rochester, the county seat, a town of 3,500 population, situated on the L. E. & W. and Chicago and Erie Railways, 101 miles southeast of Chicago; 98 miles north of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—A well 30 feet deep, sunk in drift (clay and gravel), developed a vein of chalybeate water which rose to within 12 feet of the surface. A trench was dug and an inch pipe put down, which conveys the water 60 or more feet to the side of a bluff, where it emerges as a flowing stream. This passes through a small building, in which a boiler and engine, now out of repair, was used to heat the water. The output from the well is about five gallons per minute. No analysis was available, but the taste and appearance suggest the presence of iron and calcium carbonates and calcium sulphate.

IMPROVEMENTS.—For some years this water had a local reputation. A small bath house and hotel was erected, and the place had, from time to time, a number of guests. The patronage was not sufficient to pay expenses, and for several years no use has been made of the water or buildings.

GIBSON COUNTY.

McCULLOUGH'S SPRING.

WATER = *Alkaline-saline-chalybeate.*

LOCATION.—On the land of D. C. McCullough, a mile and a quarter south of Oakland City, a town of 2,000 inhabitants; situated at the crossing of the E. & I. and Southern Railways, 99 miles west of Louisville, 175 miles east of St. Louis and 28 miles northeast of Evansville.

ORIGIN AND CHARACTER OF THE WATER.—This spring issues by the roadside from the base of a knoll, which rises 15 feet above the lower land, along which the overflow escapes. The surface of the knoll is of the yellow silty soil peculiar to the county. At the bottom of the spring a stiff blue clay occurs, which is probably a decomposed shale from which the water derives its iron and sulphates. A well-like receptacle for the spring water has been dug and walled up with brick. In this the water stands eight feet deep. An open well-house has been erected over the spring, and a large tile put in above the brick wall. Several springs of similar water, though flowing a smaller quantity, exude along the same bank a few rods to the west. No one of these has been improved.

According to the owner, an analysis of the water was made in 1880 or 1883, by a chemist in Indianapolis, whose name has been forgotten. This resulted as follows:

ANALYSIS OF WATER FROM M'CULLOUGH'S SPRING, OAKLAND CITY, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	36.339
Ferrous carbonate ($FeCO_3$)	57.920
Ferric sulphate ($Fe_2(SO_4)_3$)	96.226
Magnesium sulphate ($MgSO_4$)	87.355
Aluminum sulphate ($Al_2(SO_4)_3$)	36.407
Sodium chloride (NaCl)	1.784
Potassium chloride (KCl)	trace
Total	316.031

The analysis shows an alum-copperas water of excellent quality. It is clear, has a temperature of 65° F. and a very bitter taste. It has been much used locally, and is said to have excellent results in stomach and kidney troubles and malaria, and especially for chronic diarrhea. It is a decided purgative if taken in quantity. The owner ships it to whoever applies, at 25 cents a gallon, but the demand, as yet, is not large.

OWENSVILLE ARTESIAN WELL.

WATER = *Chalybeate.*

LOCATION.—On the land of Warrick Smith, northwest of the public square and about 200 yards from the corporate limits of Owensville, a town of 1,100 population, situated in the southwestern part of Gibson County, on the Mt. Vernon Branch of the E. & T. H. Railway, 30 miles north of Mt. Vernon and 13 miles southwest of Princeton.

ORIGIN AND CHARACTER OF THE WATER.—This well is a prospect bore put down for coal on the southeast quarter Section 1 (3 N., 12 W.), in 1872 to a depth of 217 feet. The water was struck in a bed of fire-clay and gray shale at the bottom of the well. It has been flowing steadily since. The water has a distinct taste of iron, but is said to contain no sulphur. No analysis has been made. It is used extensively by the citizens of Owensville for drinking purposes. It acts as a laxative when used freely.

GREENE COUNTY.

WORTHINGTON ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—In the south part of Worthington, a town of 1,500 inhabitants, located one-half mile southwest of the junction of Eel River and the west fork of White River, at the crossing of the I. & V. and E. & I. Railways. Distance from Indianapolis, 71 miles; from Vincennes, 46 miles; from Evansville, 98 miles; from Terre Haute, 40 miles.

ORIGIN AND CHARACTER OF THE WATER.—This well was drilled for oil or gas in 1890 to a depth of 1,670 feet. At 1,430 feet, in a limestone, probably the Niagara, a strong flow of mineral water was developed. A test showed that this water would rise 65 feet above the surface in a two-inch pipe. It is piped to a public fountain in the center of town, one-third of a mile north of the well.

An incomplete analysis only was available. It was made by Albert H. Prescott, of the University of Michigan, who reported the presence of the following:

ANALYSIS OF WATER FROM WORTHINGTON ARTESIAN WELL.

Hydro-sulphuric acid sulphides.
Chlorides.
Sulphates (in traces).
Bromides (in traces).
Magnesium salts.
Calcium salts.
Sodium salts.
Potassium salts (in traces).

These constituents are chemically united, chiefly as follows:

Sodium sulphide (Na_2S).
Calcium sulphide (CaS).
Magnesium chloride ($MgCl_2$).
Calcium chloride ($CaCl_2$).
Potassium bromide (KBr)
The total quantity of solids is 252 grains per U. S. gallon.

In September, 1901, the flow at the fountain was probably 1,200 gallons per hour. At the well, where but a small escape pipe was open, the temperature was 71° F. From this pipe gas enough was issuing with the water to burn steadily with a flame six inches high when ignited. The odor of hydrogen sulphide was strong, and the escaping gas was probably a mixture of this and carburetted hydrogen. The water was very clear at the well, but at the fountain was somewhat turbid. The taste is slightly bitter and saline, but less so than many other sulphuretted waters. The citizens partake freely of it at the fountain. As a remedial agent it is used quite extensively for skin diseases and as a diuretic.

The locality about Worthington, especially along the river, is picturesque. Excellent facilities for boating and fishing are present. A sanitarium and resort could, without doubt, be established which would prove successful under the proper management.

HANCOCK COUNTY.

HALSALL SPRING.

WATER = *Alkaline.*

LOCATION.—On the farm of Maggie L. Halsall, east half of the southeast quarter of Section 12 (16 N., 6 E.), three miles northwest of Greenfield, the county seat, and one and a half miles from Maxwell, a station on the Peoria Division of the Big Four Railway, 22 miles east of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—A strong flowing spring wells up through the drift on a comparatively level plain. The output is 10 gallons per minute of a remarkably clear water, sparkling with numerous bubbles of carbonic acid gas. A large quantity of travertine or calcareous tufa has been deposited by this spring about its mouth and along the rill bearing away the overflow. This is formed of calcium carbonate, which the waters of the spring have dissolved while percolating through beds of gravel and other drift material in the vicinity. As soon as the water charged with this calcium carbonate reaches the surface, the gaseous carbon dioxide is liberated and the calcium carbonate deposited as calcareous tufa. No analysis of the water of this spring has been made.

SPRING LAKE PARK MINERAL WELL.

WATER = *Alkaline-chalybeate.*

LOCATION.—In Spring Lake Park, a tract of 35 acres of woodland, located 17 miles east of Indianapolis, on the line of the Indianapolis & Greenfield Rapid Transit Company, the cars of which run into the park. One-half mile southwest from Philadelphia, a station on the Columbus & Indianapolis Division of the Pennsylvania Railway.

ORIGIN AND CHARACTER OF THE WATER.—A well, 17 feet in depth, is situated on a ridge eight feet above the level of a large pond. The bottom of the well is in a bed of gravel, and yields a large supply of water, which is raised by a pump. It is clear and odorless, but tastes strongly of iron oxide. An analysis by T. W. Smith, of Indianapolis, showed the mineral ingredients to be as follows:

ANALYSIS OF WATER FROM SPRING LAKE PARK, HANCOCK COUNTY, INDIANA.

	Grains per U. S. Gallon.
Silica (SiO_2)	0.64
Calcium sulphate ($CaSO_4$)	1.75
Calcium carbonate ($CaCO_3$)	0.40
Magnesium carbonate ($MgCO_3$)	12.42
Sodium chloride ($NaCl$)	1.00
Ferrous oxide (FeO)	16.27
Total solids	32.48

The analysis shows a water strongly chalybeate in character, and therefore useful in anemic conditions. It is used extensively by visitors to the park, of which there are many during the summer months. The lake in the park is fed by a number of natural springs, whose waters are also of a chalybeate nature.

HARRISON COUNTY.

CORYDON SULPHUR WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—One and a fourth miles east of Corydon, by the side of the New Albany and Corydon Turnpike. Corydon, the first capital of Indiana and the present county seat of Harrison County, is situated in one of the most picturesque regions of southern Indiana. It is a town of 1,650 population, located on the Louisville, New Albany & Corydon Railway, 31 miles west of Louisville.

ORIGIN AND CHARACTER OF THE WATER.—In 1871 sulphur water was found oozing out of the bank at the site of the present well on the north side of Little Indian Creek. The owner, Mr. Amos Zenor, began investigations, and finally dug a well 28 feet in depth to a thick stratum of St. Louis limestone, through a crevice of which the water welled up in a strong flow. The well was walled with brick, and the water rose within five feet of the top and then found its way into the nearby creek.

An incomplete analysis by Dr. T. E. Jenkins, of Louisville, showed the presence of the following salts:

ANALYSIS OF WATER FROM CORYDON SULPHUR WELL.

Sodium bi-carbonate ($NaHCO_3$).
Magnesium bi-carbonate ($MgH_2(CO_3)_2$).
Sodium sulphate (Na_2SO_4).
Magnesium sulphate ($MgSO_4$).
Calcium sulphate ($CaSO_4$).
Sodium chloride ($NaCl$).
Magnesium chloride ($MgCl_2$).
Calcium chloride ($CaCl_2$).
Silica (SiO_2).
Total solids in one U. S. gallon, 450.88.
Gases in solution, carbonic acid and hydrogen sulphide.

The underbrush and fallen timber about the well was cleared up a number of years ago, leaving a beautiful grove of oak, cedar, beech, buckeye, butternut, sycamore, mulberry, black willow and other natural forest trees. This wooded tract of 11 acres still exists in all its pristine beauty, furnishing a natural park far surpassing that found about any other mineral well or spring of Indiana, French Lick excepted. At the time of my visit, in October, 1901, I walked in early morn from the center of Corydon, nestled among her hills and shaded by rows of great spreading elms, out to the sulphur well, and was forcibly impressed by the quiet beauty of the place. The old stone State House and the "legislative elm;" Indian Creek rippling gently over her rocky bed; the hills rising on every side, their slopes covered with forest trees whose foliage had been painted a varied hue by that prince of painters, Jack Frost; the autumn sunshine flooding all with glory, combined to make a picture most entrancing to at least one beholder's eye.

On my way I met an old man and boy, each of whom had been to the well for a jug of water. The former said that he was 76 years of age, and for 25 years he had gone three times a week for the water, and that he had to take no medicine as long as he drank it. It is said that, from April to November, 50 or more people a day visit the well with jugs. A rude sanitarium and natatorium was at one time connected with the well, but it was before the railway entered Corydon, and the facilities for reaching the place were too poor to make it a permanent paying venture. The water had then a high reputation for cures of dyspepsia, rheumatism, chronic neuralgia, scrofula, sore eyes and skin diseases.

At present two old frame buildings, in a bad state of decay, are on the grounds, one of which shelters the well. The water has a distinct, though not strong, odor of hydrogen sulphide. The taste is a combination of bitter, saline and sulphur; the temperature, 63° F. The well is two feet eight inches in diameter, and when cleaned out, a short time before my visit, filled at the rate of four feet in twenty minutes. The grounds and well are owned by three citizens of Corydon, who purchased them a few years ago for $1,600. As noted on page 40, this well is so situated that it could be readily connected with Wyandotte Cave and the White Sulphur Well of Crawford County by electric railway, and a combination of health and pleasure resorts thus effected, which would be unexcelled by any in America.

HENDRICKS COUNTY.

CARTERSBURG MINERAL SPRINGS.

WATER = *Neutral.*

LOCATION.—One mile north of Cartersburg, a town in the south-eastern part of Hendricks County, situated on the Terre Haute and Indianapolis (Vandalia) Railway, 17 miles west of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—These springs, which in recent years have gained quite a renown for the purity of their waters and the attractiveness of their surroundings, are six in number. They issue within a few yards of each other, from the base of a gentle slope, facing southward, and lying along the north bank of the West Fork of White Lick Creek. The grounds surrounding the springs are prettily wooded with native sycamore, elm, willow and maple trees, besides a number of cedars and other evergreens. According to tradition, the springs were well known to the Indians, who had one of their villages on the high ground a short distance to the eastward.

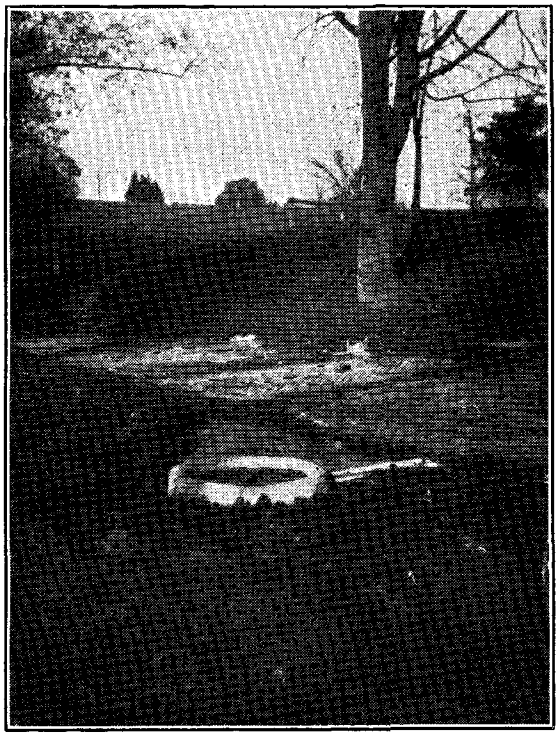
A qualitative analysis of the water from the principal spring has been made by Dr. J. N. Hurty, of Indianapolis, who reported on it as follows:

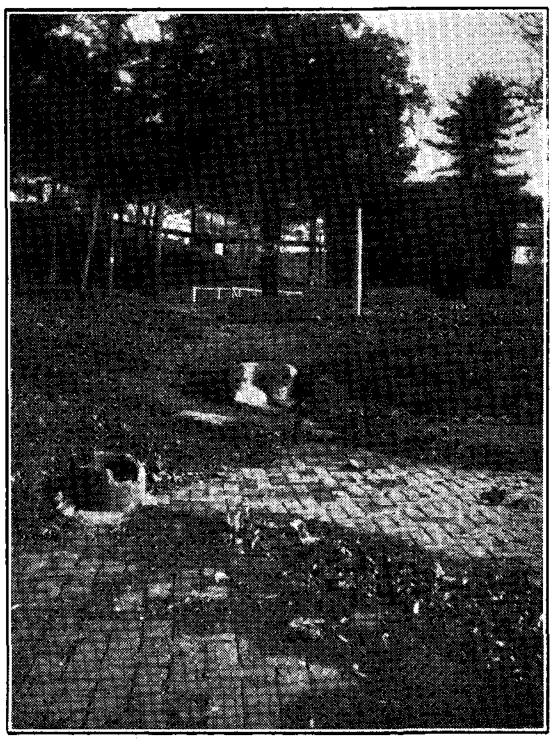
QUALITATIVE ANALYSIS OF MINERAL WATER FROM SPRING NO. 2, CARTERSBURG, INDIANA.

Bases.	*Acids.*
Magnesium.	Hydrochloric.
Calcium.	Sulphuric.
Iron.	Carbonic.
Sodium.	

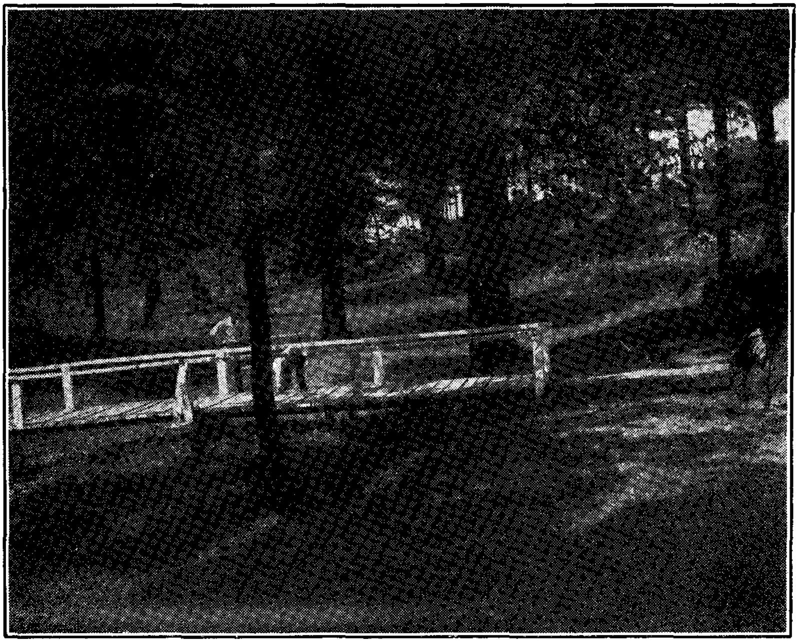
Total mineral matter, 29.04 grains per U. S. gallon.

PLATE III.

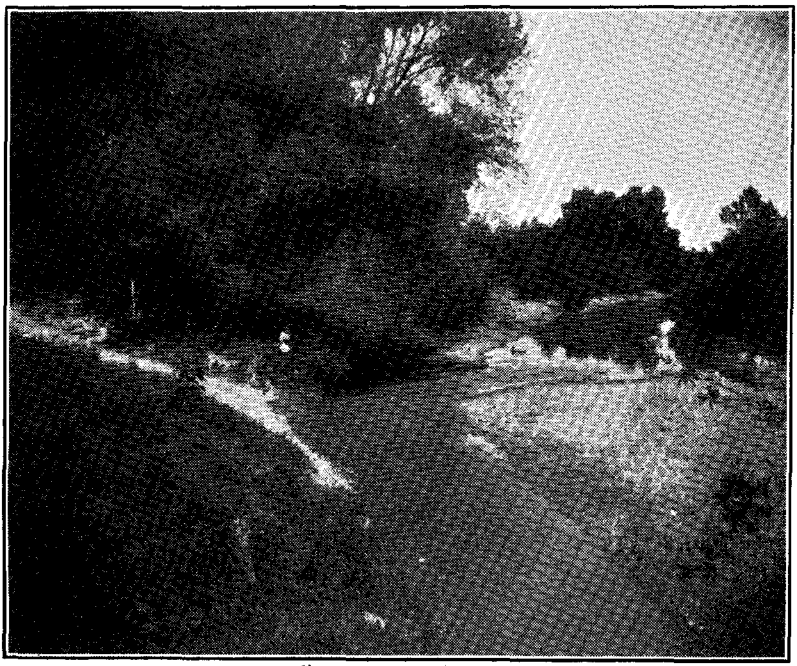




VIEWS OF THE CARTERSBURG MINERAL SPRINGS.



PORTION OF GROUNDS, CARTERSBURG MINERAL SPRINGS.



LOOKING UP WHITE LICK CREEK FROM CARTERSBURG MINERAL SPRINGS.

"The above bases and acids are combined as chlorides, sulphates and carbonates. The iron exists as carbonate, being rendered soluble by virtue of the presence of a large amount of carbonic acid gas. This gives life and piquancy to the water, and is a valuable medicinal agent, as it makes it grateful to the stomach, relieving nausea and all tenderness. The iron is in very small quantity, which is a matter of unusual moment, because it is found that iron, when taken very dilute, is absorbed and appropriated by the economy, most effectually."—*Hurty.*

In November, 1901, the flow from the three leading springs was about one gallon each per minute. The water was very clear, odorless and tasteless, with a temperature of 53½° F. In and about one of the springs was a thin deposit of the reddish-brown precipitate of oxide of iron. The water from this spring is probably more truly a chalybeate water than any of the others. The water of a second spring is said to possess magnetic properties. The circular issued by the proprietors claims that the water is a specific for dyspepsia, rheumatism, nervous prostration, general debility, etc.

IMPROVEMENTS.—A company, composed of four prominent citizens of the county, has recently secured control of the springs and 50 acres of surrounding ground. The president of the company, W. R. McClelland, of Danville, is in charge during the season, which is from May 1st to October 1st. About $10,000 have been invested in improvements. These consist of a hotel, comprising three separate buildings, and containing in all 53 well-furnished rooms and a bath house with ten tubs, steam heat, etc. A bowling alley and billiard room furnish facilities for indoor exercise and recreation, while the spacious grounds and the fine roads of the surrounding country afford special advantages for walking and driving.

MARTHA HADLEY MINERAL WELL.

WATER = *Alkaline-saline.*

LOCATION.—On the Martha Hadley farm, northwest quarter Section 25 (15 N., 2 W.), three miles northeast of Amo, a station on the Vandalia Railway, 25 miles west of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—A well drilled in the fall of 1902, in search of water for domestic use, was sunk to a depth of 705 feet. In a bluish shale at this depth a strong vein of mineral water was developed, which is said to quickly rust everything made of iron with which it comes in contact. An analysis of the water made by Dr. W. A. Noyes, of Terre Haute, showed its mineral constituents to be as follows:

ANALYSIS OF WATER FROM THE MARTHA HADLEY WELL, NEAR AMO, INDIANA.

Elements and Acid Radicals.	*Grains per U. S. Gallon.*
Silica (SiO_2)	0.525
Calcium (Ca)	3.442
Magnesium (Mg)	1.283
Sodium (Na)	151.788
Potassium (K)	1.808
Chlorine (Cl)	230.481
Sulphate (SO_4)	0.525
Carbonate (CO_2) (combined)	9.042
Carbonic acid (H_2CO_3) (free)	1.108
Carbonic acid (semi-combined)	9.334
Total	409.336

These substances in the water may be considered as being combined as follows:

	Grains per U. S. Gallon.
Silica (SiO_2)	0.525
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	13.942
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	7.817
Sodium chloride (NaCl)	381.744
Potassium chloride (KCl)	0.992
Potassium sulphate (K_2SO_4)	0.933
Potassium bi-carbonate ($KHCO_3$)	2.275
Carbonic acid (H_2CO_3) (free)	1.108
Total	409.336

Besides the above, there were present traces of iron bi-carbonate, barium and strontium sulphates, calcium phosphate, borax, and lithium chloride.

The water is seen to contain quite a large amount of common salt (sodium chloride) and smaller amounts of carbonates of magnesium and lime. It has a salty and somewhat bitter taste, but contains nothing harmful and not much that is very beneficial as a medicinal agent. It is on one of the farms donated by Addison and Martha Hadley to the Women's Christian Temperance Union.

HENRY COUNTY.

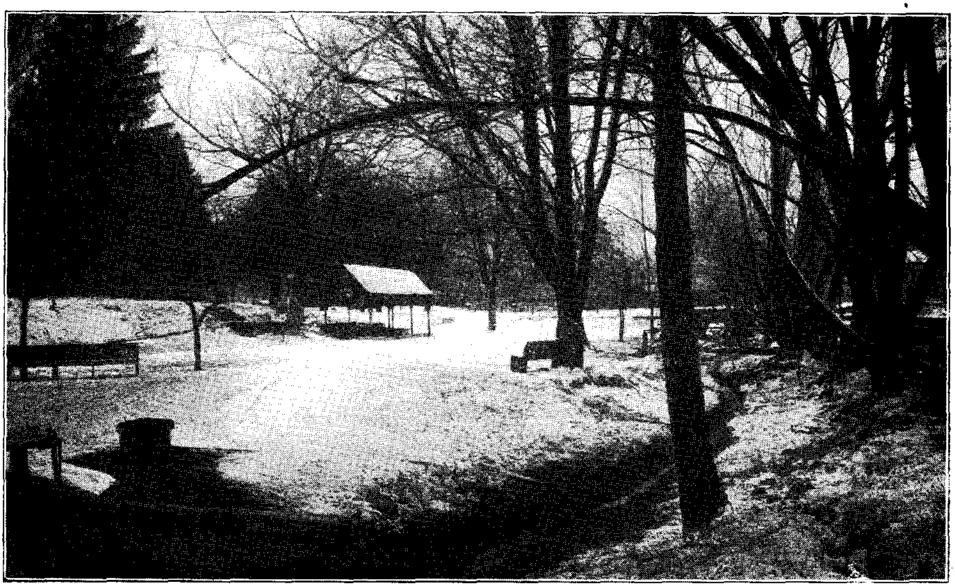
SPICELAND MINERAL SPRINGS.

WATER = *Chalybeate.*

LOCATION.—Near the west environs of Spiceland, a town of 600 population, located in the south part of Henry County, on the Ft. Wayne, Cincinnati and Louisville Railway, 29 miles south of Muncie, and two and one-half miles north of Dunreith, a station on the

PLATE V.

SPICELAND SANITARIUM.



AT THE SANITARIUM, WHERE BROOK BEZOR FLOWS.

Pennsylvania Railway, 40 miles east of Indianapolis and 30 miles west of Richmond.

ORIGIN AND CHARACTER OF THE WATER.—Three springs issue a few yards apart from the base of a gentle slope on the eastern side of the three-acre tract owned by the Spiceland Sanitarium Company. A partial analysis of the water has been made by Dr. J. N. Hurty, of Indianapolis, who reported on it as follows: "A qualitative analysis of water from the Mineral Springs at Spiceland, Indiana, shows the presence of the following bases and acids:

Bases.	*Acids.*
Calcium.	Carbonic.
Iron.	Hydrochloric.
Magnesium.	Sulphuric.
Sodium.	

"These bases and acids are combined as carbonates, sulphates and chlorides. This is a chalybeate water, and is very pure, being absolutely free from organic matter.

"The great virtue of the Waukesha water lies in its purity, and not in any mineral matter it contains.

"The Spiceland water has the purity, and also contains iron as a ferrous carbonate, which is considered the most desirable form. This water will be found valuable for all sanitarium purposes."

In September, 1901, the springs had an average flow of three gallons per minute each. The temperature was 54° F. and is said to be the same the year round. The water possesses the characteristic taste of iron carbonate water. No odor of hydrogen sulphide is present. The water is used principally in the sanitarium, both internally and externally. It is claimed to be excellent for rheumatism, stomach, bowel and kidney diseases, and may be used freely.

IMPROVEMENTS.—A sanitarium was erected on the grounds connected with the springs in 1893, and has been open since. Until 1899 the patients were obliged to secure board in private residences of the town, but in that year a hotel, accommodating 30 or more guests, was built, which is open the year round. Facilities for giving mineral water and mud baths are excellent, there being 10 neatly equipped bath rooms. The mud used is a mixture of muck and marl secured from a low spot a short distance south of the sanitarium. The grounds are spacious and well shaded, while pleasant walks and beautiful drives abound in the vicinity.

HOWARD COUNTY.

KOKOMO ARTESIAN WELLS.

WATERS = *Saline-sulphuretted,*
and
Chalybeate.

LOCATION.—In the city park, one mile south of Kokomo, the county seat, a city of 11,000 population, 54 miles north of Indianapolis, on the L. E. & W. Railway. The T., St. L. & W. and the Richmond Division of the Pennsylvania Railway also pass through Kokomo, so that the city is easy of access from all directions. Electric cars run direct to the park.

ORIGIN AND CHARACTER OF THE WATER.—The city park in which the wells are located comprises 42 acres of woodland lying on both sides of Kokomo Creek. It is one of the prettiest small parks in the State, being handsomely laid out and planted with shrubbery and flowers. A large number of natural forest trees and a plentiful water supply add much to its value and beauty. There are said to be five wells in the park which flow under favorable circumstances. Two of them were dry when I was there in August. One I did not find. The main well is located on the north bank of the creek, near the northern end of the park. A five-inch iron casing rises four feet above the surface, and from near its top a flow of mineral water, estimated at four gallons per minute, was escaping from a small pipe. Only a part of the output of the well is allowed to escape at this vent, a portion being piped across the stream to another drinking place.

The water has an agreeable, sweetish saline-sulphur taste, and a distinct odor of hydrogen sulphide. In the rill bearing the overflow into the nearby stream there is a large quantity of the black flakes of iron sulphide, which denote the presence of hydrogen sulphide and iron.

The well is 108 feet in depth, but the mineral water, according to Dr. J. M. Moulder, was struck at 40 feet in a shale. No analysis was available. The water is said to be mildly laxative and an excellent diuretic. It is much used by the citizens of Kokomo.

A second well, flowing about five gallons per minute, of a very pure chalybeate water, is located in a picturesque spot about 200 yards southeast of the one above described. The water bubbles up through an iron pipe into a basin hollowed out in a large boulder, and then flows out through a notch cut in the rim of the basin. It has coated the stone receptacle with the reddish-yellow hue of ferrous oxide, thus proving its chalybeate properties, which are also denoted by the taste. The flow is said to be the same at all seasons.

A third well, 36 feet in depth, located near the south end of the park, is said to yield a copious supply of "lithia" water, but I was unable to secure an analysis from the park commissioners.

The city of Kokomo is to be highly congratulated on having such an excellent and varied supply of mineral waters in its public park, since they are free, and easy of access to all classes of its citizens.

JACKSON COUNTY.

SEYMOUR ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—In the southwestern portion of Seymour, a city of 7,000 population, located on the B. & O. S.-W.; Louisville Division of Pennsylvania, and Southern Indiana railways, 46 miles north of Louisville, 64 miles south of Indianapolis, and 88 miles east of Cincinnati.

ORIGIN AND CHARACTER OF THE WATER.—A well sunk for gas on the property of the Seymour Woolen Mills Company, to a depth of 1,140 feet, developed a vein of mineral water in the Niagara limestone at 395 feet. The flow of gas found in Trenton limestone was very small, and was shut off with a plug. The upper casing was left in the well to keep out the surface water, and the mineral water rose and overflowed the top of the casing in a small stream three feet above the surface. A qualitative analysis of it, made by C. T. Fennel, of Cincinnati, showed the presence of sodium chloride, calcium chloride, potassium chloride and calcium carbonate. Hydrogen sulphide is present, but not in such quantity as to make the odor or taste objectionable. The temperature of the water is 55° F. The supply is plentiful, never having been noticeably reduced by pumping. It is much used by the residents of Seymour, both as a beverage and as a remedy for skin and stomach diseases, etc.

IMPROVEMENTS.—A small bath house, equipped with four tubs and with facilities for giving Turkish, Russian and shampoo baths, has been erected near the well. It is open the entire year and is well patronized.

JASPER COUNTY.*

RENSSELAER MINERAL WELLS.

WATER = *Saline-sulphuretted* (?).

LOCATION.—In or near Rensselaer, the county seat, a city of 2,700 population, situated on the C. I. & L. (Monon) Railway, 73 miles south of Chicago.

ORIGIN AND CHARACTER OF THE WATER.—Three wells sunk respectively to depths of 245, 630 and 1,427 feet, have developed veins of mineral water which rises above the surface.

The S. P. Thompson artesian well was sunk in 1868 to a depth of 630 feet. It is located two blocks southwest of the court house. The output, in December, 1901, was three gallons per minute of a clear water, with a distinct odor of hydrogen sulphide and a temperature of 52° F. A white deposit of free sulphur coats objects near the well.

City Water Works Wells.—Two wells, located four blocks northwest of the court house, produce the same quality of water as does the Thompson well. One of these was sunk in 1886, in search of gas, to a depth of 1,427 feet; the other in 1898, to a depth of 245 feet. The output of the two wells, in December, 1901, was about 20 gallons per minute. When pumped, the supply is as large from one as from the other. It is very probable that the water in all three wells comes from a depth of 180 to 210 feet. No analysis of the water has been made.

Besides the above, several shallow wells have been sunk in or near Rensselaer, which produce flowing water containing more or less hydrogen sulphide. These range in depth from 30 to 45 feet, entering the rock at six to fifteen feet. The water comes from the Lockport limestone which underlies the drift.

The Wm. Washburne well, eight blocks west of the court house, has a depth of 36 feet and flows about 75 gallons an hour. The J. D. Babcock well, one-half mile west of the court house, is 45 feet in depth and flows 25 gallons per hour. Both have sufficient hydrogen sulphide in the water to cause a deposit of free sulphur over surrounding objects.

Several springs in the vicinity of Rensselaer produce a similar water. One on the J. D. Babcock farm, one-half mile west, flows 40 gallons per hour, of a water having a temperature of 43° F. Another on the bank of the Iroquois River, 300 feet distant, wells

*For much of the data regarding the mineral waters of this county I am indebted to the kindness of Prof. W. O. Hiatt, of Rensselaer.

up in a larger flow through an old barrel which has been sunk about its orifice. Both yield quite an amount of hydrogen sulphide gas, which is doubtless derived by percolation through the limestone above mentioned.

Other springs whose waters are charged with hydrogen sulphide and possibly metallic salts occur in Jasper County as follows: One at Pleasant Ridge, four miles east of Rensselaer; one near McCoysburg, five miles east of Rensselaer; four or five, six miles south, and one four miles northwest. The water of none of these has been analyzed. All are used more or less locally.

Besides hydrogen sulphide, the waters of the wells and springs near Rensselaer doubtless contain other minerals, which only chemical analyses can determine. Such analyses will probably show them to possess medicinal properties of sufficient importance to justify their use in sanitariums.

JEFFERSON COUNTY.

AUSTIN MINERAL WATER WELL.

WATER = *Saline.*

LOCATION.—On the farm of Dr. F. H. Austin, near North Madison, a station on the Madison Branch of the Pennsylvania Railway, two miles north of Madison, and 84 miles southeast of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—The well which yields the water was bored for oil or gas in 1890 to a depth of 1,500 feet. At about 1,450 feet mineral water was struck, which rose to within 200 feet of the surface. A qualitative analysis by Prof. A. H. Young, of Hanover, showed the presence of the following acids and bases:

ANALYSIS OF MINERAL WATER FROM NORTH MADISON GAS WELL.

Bases.	*Acids.*
Calcium (plentiful).	Sulphuric acid (plentiful).
Magnesium (considerable amount).	Carbonic acid (not excessive, but enough to form bi-carbonates of calcium, magnesium and iron).
Iron (small amount).	Hydrochloric acid (plentiful).
Potassium (small amount).	Phosphoric acid (very small amount).
Sodium (very plentiful).	Silicic acid (small amount).
Lithium (faint traces).	
Magnesium (trace).	

The water is used locally, but not extensively.

JOHNSON COUNTY.

GREENWOOD MINERAL WELL.

WATER =*Saline-sulphuretted* (?).

LOCATION.—Near the eastern limits of Greenwood, a town of 1,600 population, situated on the Louisville and Indianapolis Division of the Pennsylvania Railway, 11 miles south of Indianapolis. The well is located within one block of the railway station and four blocks east of the line of the Indianapolis, Greenwood and Franklin Electric Railway.

ORIGIN AND CHARACTER OF THE WATER.—The well producing the mineral water was sunk in 1894 to a depth of 1,725 feet. The bore passed entirely through the Trenton limestone and about 25 feet into the St. Peter's sandstone. Here a vein of water was struck which arose to within 325 feet of the surface. This water resembles very closely that found at Shelbyville in the same formation. Only a qualitative analysis, by Dr. J. N. Hurty, of Indianapolis, has been made. He reports the presence of the following elements:

Bases.	*Acid Radicals.*
Sodium.	Hydrochloric.
Magnesium.	Sulphuric.
Calcium.	Carbonic.
Iron.	Silicic.
Aluminum.	Hydro-sulphuric.

The water, as raised by steam pump, is quite black with flakes of iron sulphide. The odor of sulphuretted hydrogen is present, but weak. The taste is quite saline, but not bitter, and when diluted one-half with pure water, is very agreeable. The temperature of the water as pumped is 56° F.

IMPROVEMENTS.—A short time after the well was completed a two-story frame sanitarium and bath house was erected by the Greenwood Sanitarium Company, composed of citizens of the town and vicinity. It is located just northwest of the well, on a tract of six acres, which has been planted to shade trees and shrubbery. The building is steam heated and contains, besides reception rooms and offices, 20 bath rooms equipped with porcelain-lined tubs, and also facilities for giving vapor and shower baths. The well opens into a brick building adjoining, in which are engines and pumps; also tanks, in which the water is held and from which it is piped into the sanitarum. The town of Greenwood is situated in a fine agricultural community, with good roads radiating in all directions.

BRADLEY MINERAL SPRING.

WATER = *Chalybeate.*

LOCATION.—On the Forest Ridge farm, about seven miles south of Franklin, the county seat.

ORIGIN AND CHARACTER OF THE WATER.—A spring emerges from the black Devonian shale on the south side of Sugar Creek, about midway between the State Road and the railway. It flows about 75 gallons an hour, of a clear, cold water, which tastes strongly of iron oxide. The spring has built up a large mound of ferruginous, carbonaceous material below its original outlet, and flows over the top of this mound, the size of which is slowly increasing by deposits from the water. No analysis has been made. The water has quite a large local use.

* * *

In the report of this department for 1883, page 133, Rev. David S. McCaslin makes the following mention of another group of mineral springs which I did not find time to visit:

"The finest and most noted mineral springs (in Johnson County) are found in Section 7, Nineveh Township. They are known as the 'Vickerman Springs,' after the name of the original owner of the land. They are three in number, all close together and issuing from the base of a boldly escarped bluff of bowlder drift. The springs flow out at the top of the sandstone strata at the base of the clay. They are quite similar in character, though the one farthest to the west exhibits the most decided mineral character. Its analysis was not obtained. The water is said to have medicinal properties, and many have testified as to its efficacy in certain disorders. It has a pleasant taste. The rocks over which it flows are colored bluish black, as is the whole bed of the stream into which it flows, for some distance below. Bubbles issuing occasionally, indicate the presence of a free gas."

KOSCIUSKO COUNTY.

WINONA MINERAL SPRINGS.

WATER = *Alkaline.*

LOCATION.—In the west half of Section 15 (32 N., 6 E.), just east of the Winona Assembly grounds, on the eastern shore of Eagle or Winona Lake. Two miles east of Warsaw, the county seat, a city of 4,000 population, situated at the crossing of the Pittsburg, Ft. Wayne and Chicago and the Michigan Division of the Big Four railways, 109 miles east of Chicago, 122 miles north of Indianapolis.

Origin and Character of the Water.—A number of springs issue along the base of a low range of wooded hills composed of drift material, which form the eastern rim of the basin in which the waters of Eagle Lake are held. The lake is in part fed by the waters of these springs.

The water as it issues is clear, cold and sparkling; odorless and tasteless. An analysis by Dr. R. E. Lyons, of Bloomington, Indiana, showed the mineral ingredients present to be as follows:

ANALYSIS OF WATER FROM WINONA SPRINGS.

	Grains per U. S. Gallon.
Potassium chloride (KCl)	.0495
Sodium chloride (NaCl)	.3411
Sodium nitrate ($NaNO_3$)	.0350
Sodium sulphate (Na_2SO_4)	.3224
Calcium sulphate ($CaSO_4$)	3.6493
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	15.5420
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	8.4868
Ferrous carbonate ($FeCO_3$)	.1294
Alumina (Al_2O_3)	.0524
Silica (SiO_2)	.7523
Total solids	29.3602

The analysis shows a very pure, slightly alkaline or neutral water. It has been used many years by persons living in the vicinity, and since the Winona Association secured control of the grounds, by thousands of summer visitors. That association has ceded for 20 years the right to bottle and ship this water to a company known as the Winona Springs Company. A bottling works, with a capacity for bottling and charging with carbon-dioxide 26,000 gallons of water daily, was erected in 1901. To a part of the water lithium oxide is also added, and the water is sold under the name of "Winona Lithia Water." The purity and sparkling qualities of the water will recommend it highly for table use.

LAKE COUNTY.

HAMMOND ARTESIAN WELLS.

Water = *Alkaline-saline.*

Location.—In and near the boundaries of the city of Hammond, located within three miles of the south shore of Lake Michigan, in the northwestern corner of the county, 21 miles southeast of Chicago. Seven railways furnish outlet in all directions. Population in 1900, 12,376.

Origin and Character of the Water.—Six wells sunk to depths of 1,840 to 1,875 feet, have in the past furnished an artesian flow of mineral water at Hammond. For a time this water was used for domestic purposes, and at several of the larger factories, but its use has in recent years been displaced by the public water supply from Lake Michigan. In October, 1901, most of the wells had ceased flowing, having been stopped up, it was claimed, by an accumulation of mineral salts; but if necessity required, they could be easily opened, thus renewing the flow. Two of them were located on the grounds of the Western Starch Association. A chemical analysis of the water from one of these, which will probably hold good for that formerly flowing from the other five, showed the presence of the following solids:

ANALYSIS OF ARTESIAN WATER FROM WESTERN STARCH ASSOCIATION WELL, HAMMOND, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	10.003
Magnesium carbonate ($MgCO_3$)	9.283
Sodium sulphate (Na_2SO_4)	29.894
Sodium chloride ($NaCl$)	20.913
Sodium carbonate (Na_2CO_3)	3.260
Calcium sulphate ($CaSO_4$)	38.308
Silica (SiO_2)	1.022
Oxide of iron and alumina ($Fe_2O_3+Al_2O_3$)	.058
Total solids	112.741

WILLOWDALE SPRINGS.

Water = *Alkaline.*

Location.—On the Willowdale Stock Farm, owned by W. J. Davis, one-half mile north of Crown Point, the county seat, a town of 2,500 population, situated 36 miles southeast from Chicago on the Chicago and Erie and the P., C., C. & St. L. railways.

Origin and Character of the Water.—Two springs issue a few rods apart from the base of a knoll, the surface of which is eight or ten feet higher than the surrounding land.

An analysis made for the owner by Dr. T. C. Van Nuys, formerly chemist at the State University, showed the mineral constituents to be as follows:

ANALYSIS OF WATER FROM WILLOWDALE SPRINGS, NEAR CROWN POINT, INDIANA.

	Grains per U. S. Gallon.
Potassium sulphate (K_2SO_4)	.799
Sodium sulphate (Na_2SO_4)	.113
Sodium carbonate (Na_2CO_3)	1.398
Sodium chloride (NaCl)	.183
Aluminum sulphate ($Al_2(SO_4)_3$)	.652
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	19.290
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	11.650
Silicic acid ($Si(OH)_4$)	1.664
Total solids	35.749

The analysis shows this to be an alkaline water of excellent quality. It is clear and sparkling. The flow at the two springs combined is about 12 gallons per minute. It has not, as yet, been used to any extent for medicinal purposes.

* * *

At East Chicago, a city of 3,500 inhabitants, in the northern part of Lake County, there is an artesian well 1,830 feet in depth, which yields a copious supply of an excellent chalybeate water. The natural pressure is sufficient to raise the water 40 feet above the surface.

LAPORTE COUNTY.

MICHIGAN CITY ARTESIAN WELLS.

LOCATION.—Three wells yielding an artesian flow of mineral water are found in the immediate vicinity of Michigan City. One is located on the grounds of the Northern Penitentiary, one mile southwest of the city; a second well is on the lake front, between the penitentiary and Lake Michigan, while the third is two miles southwest of the city, in the edge of Porter County.

Michigan City has a population of 15,000. It is located on a good harbor on the southeastern border of Lake Michigan, 56 miles east of Chicago and 161 miles northwest of Indianapolis. The Michigan Central, Monon and L. E. & W. railways furnish easy access from all directions.

(a) NORTHERN PENITENTIARY WELL.

WATER = *Alkaline-saline-sulphuretted* (?).

ORIGIN AND CHARACTER OF THE WATER.—The first of these flowing wells was put down to a depth of 541½ feet within the walls of the penitentiary 30 years or more ago. Dr. G. M. Levette, in the report of this department for 1873, p. 470, gives the following account of this well, which I quote verbatim, as no later information is available. "The bore terminates in a porous (Niagara) limestone rock, from which flows a stream of mineral water, strongly impregnated with sulphuretted hydrogen. The water rises twenty-two feet above the surface of the ground, discharges at the rate of about 300 gallons per minute and has a temperature of 57° F.

"A qualitative analysis of the water was made, by a chemist in Chicago, at the request of the prison authorities, which indicated the presence of the following constituents:

Carbonate of lime.
Bi-carbonate of magnesia.
Bi-carbonate of soda.
Bi-carbonate of potash.
Sulphate of soda.
Chloride of sodium.
Chloride of potassium.

"The water gives an alkaline reaction and is strongly charged with sulphuretted hydrogen and carbonic acid gas. It is a decided alterative and may prove remedial in diseases of the liver, kidneys and skin."

Since the above was in press, I have learned from Warden Reid that the well is now plugged, but the plug can be easily removed and the flow renewed at any time.

(b) Zorn Artesian Well.

Waters = *Alkaline-saline,*
and
Saline-sulphuretted.

Origin and Character of the Water.—This well, located on the lake front, southwest of the city, and owned by Mr. Philip Zorn, was sunk in 1899 to a depth of 950 feet. At 292 feet, in a Devonian shale, a flow of strong "blue lick" sulphur water was encountered. At 387 feet, in the Niagara limestone, a second vein of so-called "white sulphur" water was developed, while at a depth of 630 feet a third vein of more strongly saline water was found. The three veins of water flow through separate pipes from the surface, the total output approximating 70 gallons per minute.

An analysis of the water from the lower vein, made for the owner by Frank Gazzolo, a Chicago chemist, resulted as follows:

ANALYSIS OF WATER FROM ZORN ARTESIAN WELL, MICHIGAN CITY, INDIANA.

	Grains per U. S. Gallon.
Potassium nitrate (KNO_3)	.16
Potassium chloride (KCl)	12.31
Sodium chloride ($NaCl$)	356.68
Ammonium chloride (NH_4Cl)	1.41
Magnesium chloride ($MgCl_2$)	87.28
Calcium chloride ($CaCl_2$)	82.50
Calcium sulphate ($CaSO_4$)	134.71
Calcium carbonate ($CaCO_3$)	1.98
Oxide of iron and alumina (Fe_2O_3&Al_2O_3)	.20
Silica (SiO_2)	.17
Total solids	677.40

This is a true saline water, free from the odor and taste of hydrogen sulphide. The upper two veins, of which no analyses have been made, both contain gaseous hydrogen sulphide in sufficient quantity to emit a strong odor. The flow from the uppermost (292 feet) is much the stronger and has a temperature of 56° F. The well is located in a beautiful natural park, one and a half miles from the center of the city. Pine and oak trees cover the high sand dunes, which in themselves are objects of interest to many persons from a distance. The site is an ideal one for a great sanitarium, the proximity of the lake furnishing bathing and fishing facilities not often present in connection with good mineral waters.

The water from the well is free to all who apply, and is used extensively by the residents of Michigan City, with beneficial results for kidney and liver complaints and for skin diseases.

(c) Blair Artesian Well.

WATER = *Alkaline-saline-sulphuretted.*

ORIGIN AND CHARACTER OF THE WATER.—This well was sunk about 1875 to a depth of 858 feet. It is located in the extreme northeastern corner of Porter County, north half of Section 1 (37 N., 5 W.), two miles southwest of Michigan City. A strong vein of mineral water was developed in the Niagara limestone, which has continued to flow with unabated force. An analysis, made by Dr. P. S. Hays, of the Chicago College of Pharmacy, showed the presence of the following mineral salts:

ANALYSIS OF ARTESIAN WATER FROM BLAIR WELL, NEAR MICHIGAN CITY, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride ($NaCl$)	360.4794
Magnesium chloride ($MgCl_2$)	45.6550
Potassium sulphate (K_2SO_4)	17.9968
Magnesium sulphate ($MgSO_4$)	31.9730
Calcium sulphate ($CaSO_4$)	84.4024
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	147.8503
Silica (SiO_2)	1.7523
Total solids	690.1092

A bath house and sanitarium were erected soon after the well was finished. For a number of years the place was well patronized, and the majority of the guests were highly benefited by the use of the water. Since the death of the owner, the use of the water has been practically abandoned and the improvements have fallen into decay.

The water rushes forth at the rate of 180 gallons per minute. It has a strong odor of hydrogen sulphide and the characteristic white deposit of sulphur from this gas coats many objects near the orifice of the well. Taking into consideration the excellent qualities of the water and its location so near the shores of Lake Michigan, it would seem that under the proper management a summer resort and sanitarium could be so combined as to make a valuable and paying property of this well.

LAWRENCE COUNTY.

AVOCA MINERAL SPRING.

WATER = *Saline-sulphuretted.*

LOCATION.—In the town of Avoca, five miles northwest of Bedford, on the Switz City Branch of the Monon Railway. Bedford, the county seat, from which the spring can be easily reached by hack or private carriage, is a city of 6,500 inhabitants, on the Monon, Southern Indiana and branch of the B. & O. S.-W. railways, 134 miles east of Cincinnati and 77 miles north of Louisville.

ORIGIN AND CHARACTER OF THE WATER.—The spring which yields the mineral water at Avoca emerges from the base of a stratum of Harrodsburg limestone on the east branch of Goose Creek, Section 31 (6 N., 1 W.). It is located at the rear of the general merchandise store of D. E. Bennett, to whom it belongs. A basin 24x18 inches in size and 18 inches deep has been excavated in the stone, and then cemented. When emptied, this is said to fill in 30 minutes, making the flow about 70 gallons per hour. The water is clear and sparkling, and has a temperature of 62° F. The flow and temperature are said to be the same at all seasons. The water emits a strong odor of hydrogen sulphide and has a slightly bitter taste. A white precipitate of sulphur occurs in the rill bearing away the overflow, and the spring is, for that reason, known locally as the "White Sulphur" Spring. No analysis of its waters has been made. It has quite a local reputation for diseases of the skin, sore eyes, and for kidney and bladder diseases. At the time of my visit the surroundings were in bad condition.

According to Hayden Bridwell, a prominent and intelligent citizen of Avoca, a number of similar springs, though with a smaller flow, emerge along Goose Creek both above and below the town.

FELDUN FIELDS MINERAL WELLS.

WATER = *Alkaline-saline-sulphuretted.*

LOCATION.—About four miles northwest of Bedford and three-quarters of a mile west of Avoca, on the land of the Misses Fell, of Bedford.

ORIGIN AND CHARACTER OF THE WATER.—A few years ago, while core drilling for oolitic stone, Hon. Moses Dunn, of Bedford, developed flowing mineral water in three wells on the land mentioned. One of the wells is 45 feet deep and the water rises about six feet above the surface. The other two are respectively 75 feet and 100 feet in depth. They are located about 1,000 feet apart. The water was found at the base of the blue oolitic limestone, probably in the Harrodsburg limestone, which is the source of a similar water at the Avoca "White Sulphur" Spring.

An analysis of the water from one of the Feldun Field wells was made by Dr. Robert E. Lyons, Professor of Chemistry at Indiana University, who reported on it as follows:

ANALYSIS OF MINERAL WATER FROM WELL NO. 5, FELDUN FIELDS, LAWRENCE COUNTY, INDIANA.

The following is the number of parts of each constituent in 10,000 parts of water:

Sulphur as free sulphuretted hydrogen	0.0846
Sulphur as hyposulphites	0.0150
Sulphur as sulphates	0.6361

Sulphur as sulphides	0.1665
Silica (SiO_2)	0.1230
Chlorine (Cl)	1.3647
Potassium oxide (K_2O)	0.0483
Sodium oxide (Na_2O)	1.5462
Ferric oxide (Fe_2O_3)	0.0471
Aluminum oxide (Al_2O_3)	0.0222
Calcium oxide (CaO)	0.9584
Magnesium oxide (MgO)	0.8390
Carbon dioxide (CO_2)	3.9685
Lithium oxide (Li_2O)	trace

The constituents are probably in the following combinations:

	Grains per U. S. Gallon.
Potassium hyposulphite ($K_2S_2O_3$)	.266
Potassium sulphide (K_2S)	.170
Sodium sulphide (Na_2S)	2.247
Sodium chloride (NaCl)	12.387
Magnesium sulphate ($MgSO_4$)	13.910
Magnesium chloride ($MgCl_2$)	.640
Calcium bi-carbonate ($Ca(HCO_3)_2$)	16.160
Ferrous bi-carbonate ($Fe(HCO_3)_2$)	7.048
Aluminum silicate ($Al_2(SIO_3)_3$)	.353
Silica (SiO_2)	.567
Lithium carbonate (Li_2CO_3)	trace
Total solids	53.748

Gases.	*Cu. In.*
Carbon di-oxide (free) (CO_2)	21.43
Sulphuretted hydrogen (free) (H_2S)	1.56

"The water is clear, colorless, and has a strong odor and taste of sulphuretted hydrogen gas. Its temperature is 52.1° F.

"By standing in contact with the air the water becomes cloudy and finally slightly yellow in color, owing to the separation of sulphur and the formation of higher sulphides of the alkali metals.

"By boiling, the water becomes turbid from the decomposition of the bi-carbonates of calcium and magnesium. The water after boiling has a bitter saline taste. This is to be explained by the fact that the sulphuretted hydrogen and the free and loosely combined carbon dioxide are separated and expelled during the process of boiling. This saline water will prove diuretic, laxative, alterative and resolvent."—*Lyons.*

* * *

Several other springs occur in Lawrence County whose waters are quite similar to those above mentioned. One on the estate of Dr.

Denson, one mile southwest of Bedford, is strongly charged with hydrogen sulphide, and is used extensively by the citizens of Bedford. The flow, however, is weak, probably 10 gallons an hour.

A number of others bubble up in the bed of Indian Creek in the southeast quarter Section 17 (5 N., 2 W.), near the old Gray's mill.

MARION COUNTY.

MT. JACKSON SANITARIUM.

WATER = *Saline-sulphuretted.*

LOCATION.—At Nos. 3127-3129 West Washington Street, Indianapolis, Indiana, three miles west of the center of the city. The West Washington Street electric cars pass the door every ten minutes, and connect at the Indianapolis Union Station with trains in all directions.

ORIGIN AND CHARACTER OF THE WATER.—A six-inch bore sunk in 1899 to a depth of 1,541 feet, developed, in the St. Peter's sandstone, a strong vein of mineral water, which filled the bore to within 150 feet of the top. The supply is inexhaustible, and is raised by a steam pump and piped through the adjacent sanitarium. An analysis of the water by T. W. Smith, of Indianapolis, shows its mineral constituents to be as follows:

ANALYSIS OF WATER FROM THE MT. JACKSON MINERAL WELL.

	Grains per U. S. Gallon.
Silica (SiO_2)	0.980
Sodium chloride ($NaCl$) Potassium chloride (KCl)	646.800
Calcium sulphate ($CaSO_4$)	1.300
Calcium carbonate ($CaCO_3$)	20.000
Calcium chloride ($CaCl_2$)	102.600
Magnesium carbonate ($MgCO_3$)	24.200
Magnesium chloride ($MgCl_2$)	140.000
Total	935.880
	Cu. In.
Hydrogen sulphide gas (H_2S)	4.270

The water has a very pleasant, sweetish-saline taste. When first pumped it is often dark-colored or milky, owing to the compounds of sulphur present, but after standing a short time becomes clear and limpid. The hydrogen sulphide gas is not present in sufficient quantity to render either the odor or the taste disagreeable. The specific gravity is, according to Smith, 1.011, and the temperature 60° F. In the sanitarium it is used extensively for bathing purposes and also internally for stomach troubles. It is claimed to be a sovereign remedy for rheumatism and skin diseases, and an excellent blood purifier. Many of the leading physicians of Indianapolis send patients to the sanitarium for the baths and hundreds of citizens are regular patrons at all seasons.

The water is bottled and shipped in small quantities, being sold at $1.80 per dozen quarts, or 25 cents per gallon in jugs.

IMPROVEMENTS.—A two-story brick and stone building is used as a sanitarium and bath house. It is steam-heated and contains 20 neatly furnished rooms for guests and 17 well-equipped bath rooms. The location, within ten minutes' ride of the theaters and other amusement centers of the city, will allow the necessary recreation for guests from a distance.

NEWHAVEN WELL.

WATER = *Neutral.*

LOCATION.—One and a quarter miles northeast of Lawrence, a station on the lines of the Cleveland Division of the Big Four Railway and the Union Traction Company of Indiana, eight miles northeast of Indianapolis. Both lines of railway run alongside the grove in which the well is located.

ORIGIN AND CHARACTER OF THE WATER.—A well dug, in 1898, to a depth of 29 feet in the drift, yields a plentiful supply of clear, odorless water, which has a slightly bitter taste and a temperature of 50° F. A partial analysis of the water, made by T. W. Smith, of Indianapolis, developed the presence of very small amounts of calcium and magnesium sulphates, and traces only of potassium, iron and chlorine. The water is, therefore, to be classed as neutral and pure. The well is located on the east side of a very pretty walnut and hickory grove and the water is raised to the surface by a wooden pump.

MARTIN COUNTY.

TRINITY SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—On the northwest quarter Section 28 (4 N., 3 W.), seven miles northeast of Shoals, the county seat, and three miles southeast of Indian Springs, a station on the Southern Indiana Railway. The property on which the springs are located, consisting of 280 acres, has recently been acquired by John R. Walsh, of Chicago, the owner of the Southern Indiana, who proposes building a branch to within a short distance of the springs. Postoffice, Trinity Springs.

ORIGIN AND CHARACTER OF THE WATER.—"Trinity Springs," so called from their number, are among the oldest and best known "sulphur springs" of the State. Three springs well up from rifts or crevices in the Mansfield sandstone rock. A ridge, finely wooded with native forest trees, rises 30 or more feet above the springs to the east. Two of these springs are but eight feet apart; the other about 20 feet south. The middle spring produces about 50 gallons of water per minute; the one to the north about 10 gallons, while the output of the southern one approximates 30 gallons per minute. The water is clear; the odor of hydrogen sulphide strong; the taste not disagreeable, being but slightly bitter and sulphuretted. In the rivulets bearing away the overflow there are heavy precipitates of black sulphide of iron and whitish free sulphur. The temperature of the water is 56½° F. at all seasons.

Three analyses have been made of the waters of these springs. One, by Mr. John F. Elsom, in 1883, was published in Dr. Peale's paper.* A second, made by Dr. T. C. Van Nuys, of Bloomington, in 1890, has since been incorporated in circulars sent out by the proprietors. A third was made in 1899 by Mariner & Hoskins, analytical chemists, at 81 South Clark Street, Chicago. Of these analyses, that of Dr. Van Nuys is the only one which shows the percentage of the bases and acid radicals present. These, as given by him, were expressed in "parts of mineral matter per 1,000 parts of water," as follows:

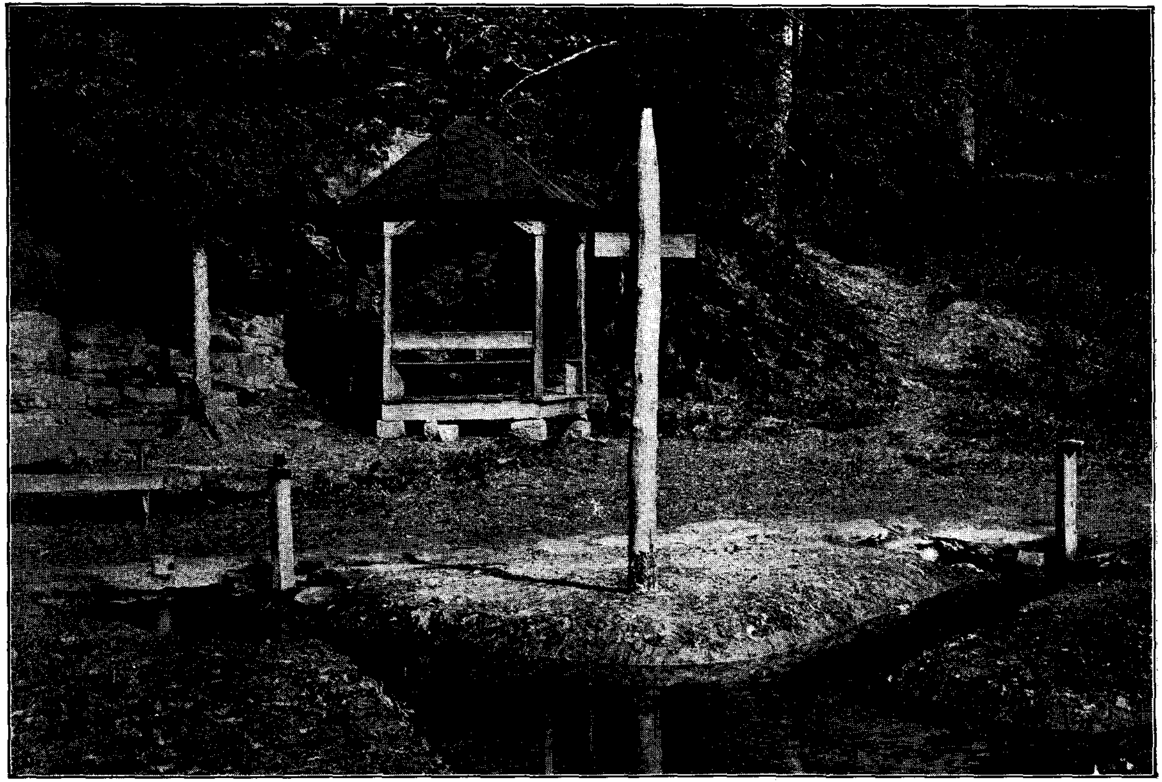
ANALYSIS OF WATER FROM TRINITY SPRINGS, BY DR. T. C. VAN NUYS.

Sulphur combined as sulphuretted hydrogen	0.0103840
Sulphur combined as hyposulphites	0.0060864
Sulphur combined as metallic sulphides	0.0003344
Sulphur combined as sulphates of metals	0.5103608
Carbon dioxide	0.1635000
Chlorine	0.1575600
Silica	0.0114000
Calcium oxide	0.7057000
Magnesium oxide	0.2028828
Potassium oxide	0.0443617
Sodium oxide	0.1535128

The compounds of mineral salts present, according to the views of each of the three chemists, are shown in the following table:

*Bulletin 32, U. S. Geological Survey, 1886, p. 139.

PLATE VI.



TRINITY SPRINGS, MARTIN COUNTY, INDIANA.

ANALYSES OF WATERS FROM TRINITY SPRINGS, INDIANA.

	ELSOM.	VAN NUYS.	MARINER & HOSKINS.
	Grains per U. S. Gallon.		
Potassium hyposulphite	.....	1.054	.....
Potassium sulphide	.....	.067	.....
Sodium chloride	8.338	15.140	.....
Sodium silicate	.....	1.352	.....
Calcium sulphate	1.26	99.934	71.07
Magnesium sulphate	4.165	23.430	14.71
Sodium bi-carbonate	.116	.655	.....
Potassium bi-carbonate	.067	4.273	.....
Magnesium carbonate	4.107	8.450	.....
Calcium carbonate	5.589	.....	5.84
Magnesium chloride	1.099	.....	14.83
Sodium sulphate	.350	.....	32.82
Potassium sulphate	.097	.....	.....
Calcium chloride	.708	.....	.....
Silica	.825	.....	.....
Totals	26.721	154.355	139.27
Gases.		*Cu. In.*	*Cu. In.*
Hydrogen sulphide	.....	1.721	1.09
Carbon dioxide	.....	5.78	.....

The analysis of Mr. Elsom differs so widely from the other two that it is manifestly wrong.

The percentages of bases and acid radicals as found by Messrs. Mariner & Hoskins probably differed but little from those found by Dr. Van Nuys. A difference of opinion as to the character of the resulting compounds accounts for the difference in analyses as shown in the table. Dr. Van Nuys added the following remarks to his analysis as given: "This is a saline sulphuretted water and in the amount of sulphur contained in it compares favorably with many of the noted sulphur springs of Germany, the amount of sulphuretted hydrogen contained being above the average. The absence of aluminum, iron and the nitrates is to be noted. The specific gravity of the water is 1.0019."

IMPROVEMENTS.—Trinity Springs were first opened to the public about 60 years ago. A large hotel, which was built for the accommodation of the visitors, was burned in 1863. Since then the patrons have found accommodations in the hotels and private houses of Harrisonville, a small town a third of a mile west. A fine grove occupies a portion of the terrace or second bottom of Indian Creek, which lies between the springs and that stream. This grove is used as a park and as a place for tennis courts, croquet grounds, etc. A portion of it is also utilized by campers, many of whom visit the springs each year. A small bath house is located at the eastern edge of the grove, where private baths can be taken in water piped from the spring. It is understood that Mr. Walsh, the new owner, will spend a large sum in improvements. The quantity and quality of the water; the picturesqueness and quiet of the surroundings, will, without doubt, bring to these springs a host of visitors as soon as the long needed accommodations and means of access have been provided.

INDIAN SPRINGS.

WATER = *Alkaline-saline-sulphuretted.*

LOCATION.—Eight miles north of Shoals, the county seat, and one mile southeast of Indian Springs, a station on the Southern Indiana Railway, 66 miles southeast of Terre Haute.

ORIGIN AND CHARACTER OF THE WATER.—Mineral water from a vein a few feet below the surface, wells up at four different places within a few yards of one another on the west bank of Sulphur Creek, west half of Section 17 (4 N., 3 W.). In October, 1901, these springs were being improved by sinking sections of sewer pipe about their orifices. One iron pipe, 12 feet in length and four feet in diameter, had been sunk about the main spring and in this pipe the water was standing within a few inches of the surface. In the others the old sycamore gums, sunk 30 years ago, were still present. There was no perceptible flow from any of the springs, the water standing at a certain height in the pipe or gums. When dipped out, however, it is said to be renewed from below at the rate of about eight gallons per minute in the main spring, down to two gallons in the smaller ones. The water in each comes from the same source or vein, and there is no difference in its appearance or component mineral parts. The temperature of each spring was 57° F. The odor of hydrogen sulphide was perceptible but not strong. The taste is slightly bitter and plainly sulphuretted.

Three analyses of the water from these springs have been made in the past; one by E. T. Cox in 1870*; a second by T. C. Van Nuys in 1892, and a third by Mariner & Hoskins, of Chicago, in 1899. Professor Cox gave the percentage composition of the bases and acid radicals present as follows:

*Geological Survey of Indiana, 1870, p. 108.

PLATE VII.

INDIAN SPRINGS, MARTIN COUNTY, INDIANA.

ANALYSIS OF WATER FROM INDIAN SPRINGS, BY E. T. COX.

	Grains per U. S. Gallon.
Silicic acid	.4399
Ferrous oxide	.0035
Lime	22.9279
Soda	27.5356
Potash	2.0658
Magnesia	20.0663
Alumina	.1763
Chlorine	18.5360
Carbonic acid	31.2783
Sulphuric acid	40.5842
Total	163.6138

The probable compounds present, according to the views of each chemist, are as follows:

	COX.	MARINER & HOSKINS.	VAN NUYS.
	Grains per U. S. Gallon.		
Sodium sulphate (Na_2SO_4)	11.828	18.65	.....
Potassium sulphate (K_2SO_4)	2.402	.....	.212
Magnesium sulphate ($MgSO_4$)	30.385	25.46	23.808
Aluminum sulphate ($Al_2(SO_4)_3$)	.829	.....	1.195
Ferrous sulphate ($FeSO_4$)	20.230	.....	.....
Calcium sulphate ($CaSO_4$)	.....	24.82	35.085
Calcium carbonate ($CaCO_3$)	33.102	8.76	12.435
Sodium carbonate (Na_2CO_3)	3.612	.....	.....
Potassium carbonate (K_2CO_3)	2.407	.....	.....
Magnesium carbonate ($MgCO_3$)	18.944	trace	3.218
Manganese carbonate ($MnCO_3$)	.....	.....	.233
Sodium chloride (NaCl)	39.366	.....	1.364
Magnesium chloride ($MgCl_2$)	.056	1.40	1.074
Potassium chloride (KCl)	.....	.....	1.737
Lithium chloride (LiCl)	.....	.....	.020
Calcium chloride ($CaCl_2$)	.....	.....	1.294
Sodium sulphide (Na_2S)	.....	.....	2.555
Sodium silicate (Na_2SiO_3)	.....	.....	1.078
Sodium phosphate (Na_3PO_4)	.....	.....	.127
Silica (SiO_2)	.4399	.....	.....
Ferrous oxide (FeO)	.0035	.....	.003
Total solids	163.6044	79.09	85.438
Gases.	*Cu. In.*	*Cu. In.*	*Cu. In.*
Carbonic acid	9.58	.....	.....
Hydrogen sulphide	3.33	1.66	2.03

How Professor Cox could have only .0035 grains of ferrous oxide in his table of elementary substances, the same amount in his table of compounds and yet have, in addition, in the latter, 20.230 grains of ferrous sulphate, passeth understanding.

History and Improvements.—The water of Indian Springs has, in the past, gained a high reputation for its medicinal virtues. These springs are said to have been in high repute among the Indians, and to have been opened to the public as a health resort in 1814. For a long time a large two-story frame hotel stood on the crest of the hill which rises 86 feet above the springs on the east. This was torn down in 1900 to make room for a more pretentious structure which Mr. Walsh, the new owner, proposes building. The site is a fine one, overlooking a wide and picturesque valley to the east and south. The slope which leads gradually from the hotel site down to the springs, is finely wooded with beech, oak, maple, locust, cedar and other trees. A railway switch in course of construction from the Southern Indiana, will bring passengers right to the springs. Since Mr. Walsh has gained control of Trinity Springs to the southeast and the intervening wooded territory, a combined resort, unexcelled in the State, will probably be established.

LA SALLE SPRING.

Water = *Alkaline-saline-sulphuretted.*

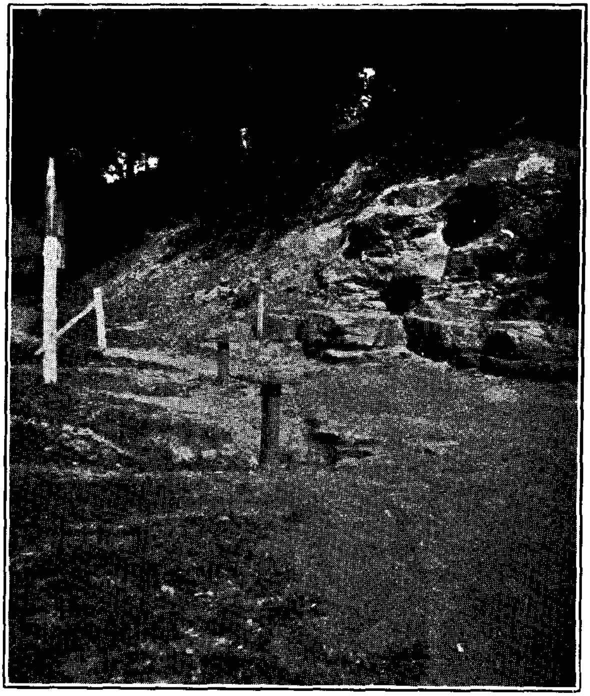
Location.—On the north bank of the east fork of White River, northeast quarter Section 22 (4 N., 3 W.), two miles northeast of Trinity Springs. Five miles from Indian Springs and three miles from Mt. Olive, stations on the Southern Indiana Railway; four miles from Huron and 10 miles from Shoals on the B. & O. S.-W. Railway. Telephonic connection with Shoals and Bedford. Postoffice, Mt. Olive.

Origin and Character of the Water.—A strong flowing spring of "white sulphur" water issues from the foot of the river bluff, about 15 feet above low water mark, and flows over limestone rocks about 30 feet into the river. At high water the river covers these rocks and reaches the mouth of the spring. An analysis of the water by Dr. Louis Schmidt, of the Cincinnati Department of Health, shows its composition to be as follows:

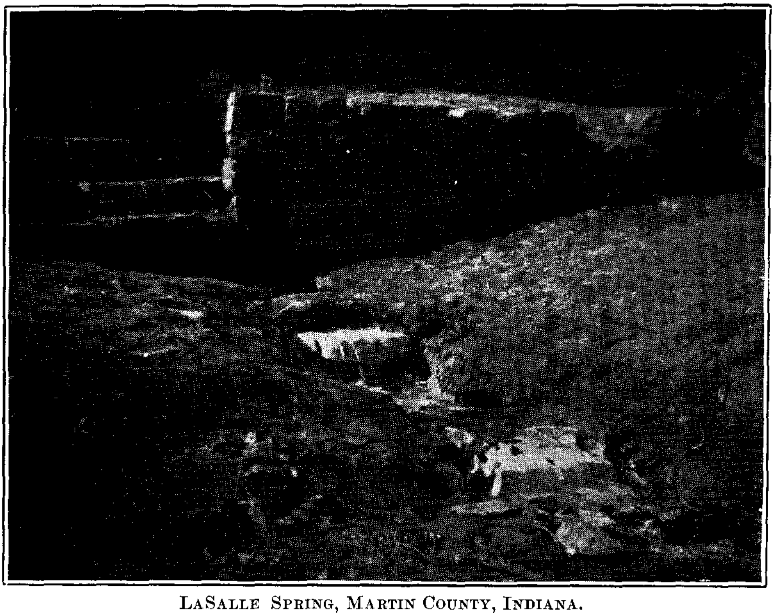
ANALYSIS OF WATER FROM LASALLE SPRING, MARTIN COUNTY, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	36.680
Ferrous carbonate ($FeCO_3$)	.232
Calcium sulphate ($CaSO_4$)	46.408
Magnesium sulphate ($MgSO_4$)	31.472

PLATE VIII.



TRINITY SPRINGS, MARTIN COUNTY, INDIANA.



LASALLE SPRING, MARTIN COUNTY, INDIANA.

	Cu. In. per U. S. Gallon.
Sodium sulphate (Na_2SO_4)	3.512
Potassium sulphate (K_2SO_4)	.184
Aluminum sulphate ($Al_2(SO_4)_3$)	.056
Sodium chloride (NaCl)	1.440
Magnesium chloride ($MgCl_3$)	5.616
Silica (SiO_2)	.728
Total solids	126.328
	Cu. In.
Sulphuretted hydrogen	10.32

Free sulphur has coated white the rocks on each side of the rill, between the spring and the river. The water of the spring is very clear and sparkling with bubbles of escaping gas. It has a temperature of 56° F., and the output is about 75 gallons per minute. The taste is slightly bitter, but not enough so to be disagreeable. It is recommended in circulars sent out by the owner, Frank Brassine, as especially efficacious in diseases of the kidneys, such as diabetes, chronic inflammation, etc., also in dyspepsia and other stomach troubles.

IMPROVEMENTS.—A two-story frame hotel of 22 rooms, stands on a terrace of the river bluff, 50 feet above the spring. A bath house with four tubs is located on a level spot just above the spring. The scenery about is wild and picturesque. White River furnishes facilities for boating and good fishing, bass, white perch, catfish and crappies being plentiful. Game is said to be abundant in the proper season. There is need of better roads between the railway stations and the spring. If these were provided, the amount of patronage would increase, for it is a place well worthy of visitation.

ELLIOTT SPRINGS.

WATER = *Saline-chalybeate.*

LOCATION.—On the southeast quarter Section 10 (3 N., 3 W.), five miles east of Shoals, and three-quarters of a mile north of Willow Valley, the nearest station on the B. & O. S.-W. Railway.

ORIGIN AND CHARACTER OF THE WATER.—Four springs bubble up through a vein of fire-clay near the top of a high wooded slope. The flow from each is about two gallons per minute of an acidulous chalybeate water, with a bitter astringent taste. A partial analysis by Dr. Adolph Gehrman, 103 State Street, Chicago, showed the presence of the following:

Bases.	*Acid Radicals.*
Iron.	Sulphuric.
Calcium.	Nitric.
Magnesium.	Hydrochloric.
Sodium.	Phosphatic.
Aluminum (trace).	

Total solids present—241.3 grs. per U. S. gallon.

"The solids present are such as would indicate a purgative water, the sulphates of sodium, calcium and magnesium predominating."

Dr. T. B. Ritter, of Orleans, Indiana, the owner, states that the water is especially valuable for diseases of the mucous membranes; also for skin diseases, ulcers, etc. It can be kept bottled for a long time and not lose its cathartic and diuretic properties. It is shipped to some extent, bringing $5.00 per barrel, or 20 cents per gallon. There are no improvements. A limited number of visitors can find accommodations at the farm house on the land. A well near this farm house, 16 feet in depth, contains eight feet of water of the same character.

SHOALS ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—Just east of Shoals, the county seat of Martin County, a town of 750 population, situated on the B. & O. S.-W. Railway, 150 miles west of Cincinnati, and 191 east of St. Louis.

ORIGIN AND CHARACTER OF THE WATER.—This well was sunk in 1887 by a local company, to a depth of 960 feet in search of oil or gas. It lacked about 700 feet of reaching Trenton limestone, the main reservoir of those bitumens in Indiana. At 900 feet a vein of mineral water was struck which filled the bore and issues in a weak artesian flow. The rill escaping contains a thick sediment of the blackish flakes of iron sulphide. The odor of hydrogen sulphide, while strong, is not enough so to be disagreeable. The water is very saline in taste, and for use it should be diluted freely with pure water.

An analysis by Karl Langenbeck, of Cincinnati, Ohio, Professor of Chemistry in Miami Medical College, proved the presence of the following mineral salts:

ANALYSIS OF WATER FROM SHOALS ARTESIAN WELL.

	Grains per U. S. Gallon.
Silica (SiO_2)	2.7184
Alumina (Al_2O_3)	.6352
Sulphide of iron (FeS)	1.3776
Sodium chloride (NaCl)	1303.4400
Potassium chloride (KCl)	47.3040

	Grains per U. S. Gallon.
Potassium nitrate (KNO_3)	7.8640
Lithium chloride ($LiCl$)	2.9352
Magnesium chloride ($MgCl_2$)	9.6832
Magnesium bromide ($MgBr_2$)	2.2376
Magnesium iodide (MgI_2)	.0040
Calcium sulphate ($CaSO_4$)	203.0160
Calcium chloride ($CaCl_2$)	2.6512
Calcium carbonate ($CaCO_3$)	32.5256
Calcium sulphide (CaS)	24.4288
Calcium disulphide (CaS_2)	18.8856
Calcium hyposulphite (CaS_2O_3)	133.0720
Ammonium chloride (NH_4Cl)	8.3480
Total solids	1801.2264
	Cu. In. per U. S. Gallon.
Sulphuretted hydrogen (H_2S)	32.4312
Carbonic acid gas (CO_2)	10.8584

"The water is strongly sulphurous in odor, and of a salty-alkaline-bitterish taste. It is faintly tinged greenish-yellow, by the contained bi-sulphide of calcium and has always a small black deposit of sulphide of iron. Protected from the atmosphere it keeps perfectly, remaining clear and unchanged in color. But if the containing bottle remain uncorked, the water becomes gradually of a deep greenish-yellow color, then becomes turbid, depositing white sulphur, while the supernatant water becomes clear and colorless. Ultimately all the sulphur disappears, through oxidation, the water containing the equivalents in sulphates and hyposulphites.

"It may be doubted if the water contains hyposulphite of lime as it issues from the earth. This may be purely a product of oxidation incident to the collection of the water in bottling. However this may be, this factor which is so important in the water, as analyzed, will always be present as an important factor, as the patient would get it. The analysis is, therefore, of the bottled water, of the product which interests the physician and not that of the water collected with extreme precautions to exclude atmospheric influence.

"The water instantly blues red litmus paper, showing its alkaline character, and turns a deep violet color on addition of sodium nitroprusside, showing that its sulphur is largely combined as sulphides. The presence of these is, from a chemical point of view, the most characteristic feature of the water."—*Langenbeck.*

The water from the Shoals well has been shipped extensively to customers in Louisville, Cincinnati and a number of the larger towns of southern Indiana. It is held in high esteem by the citizens of Shoals as an alterative and as a remedy in skin diseases, catarrh, etc.

MONROE COUNTY.

KETCHAM'S SULPHUR SPRING.

WATER = *Saline-sulphuretted.*

LOCATION.—In the northwest quarter of Section 7 (7 N., 1 W.), about three miles southwest of Smithville, a town on the C., I. & L. (Monon) Railway, 228 miles south of Chicago, 95 miles north of Louisville. A loop of the same railway runs within a short distance of the spring. The latter is distant seven and a half miles southwest of Bloomington, the county seat.

ORIGIN AND CHARACTER OF THE WATER.—A spring, flowing a small stream of water, wells up through a rift in the Harrodsburg limestone in the bed of Clear Creek. A cavity has been drilled in the limestone about the outlet of the spring, and a pump inserted which is reached by a raised platform. The water of the spring is heavier than that of the stream, and by means of the pump can be secured when the creek overflows the spring. No analysis of the water has been made. It has a strong odor of hydrogen sulphide and the bitter taste of that gas combined with sulphates, probably magnesium or sodium. It has been used with good effect locally for such diseases as are benefited by the common saline sulphuretted waters of this region of the State. The scenery about the spring is varied and picturesque, especially that along the bluffs of Clear Creek.

ORCHARD'S SULPHUR SPRING.

WATER = *Saline.*

LOCATION.—On the northwest quarter of Section 19 (8 N., 1 E.), about five miles southeast of Bloomington.

ORIGIN AND CHARACTER OF THE WATER.—A spring flowing about 20 gallons an hour, emerges from the base of a bluff of Knobstone shale. The water is strongly impregnated with sulphates derived by leaching through the shale, and for that reason has a very bitter taste. An analysis will probably show it to be quite like the Clark County mineral waters, which emerge from a similar shale. The water of some wells in the vicinity possess also a slight saline taste from the same source.

* * *

A third spring producing a saline-sulphuretted water, wells up in the bed of Salt Creek about a mile north of Guthrie and very near the Monroe-Lawrence county line. It is on the west side of the creek, about five feet from the bank and is covered during high water. A keg has been sunk about the orifice and the water, almost black with flakes of iron sulphide, presents a strong contrast to the muddy waters of Salt Creek, being plainly visible to passengers on the Monon Railway, which runs along the brink of the stream.

MONTGOMERY COUNTY.

VAN CLEVE'S SPRINGS.

WATER = *Alkaline-chalybeate.*

LOCATION. — Near the northern limits of Crawfordsville, the county seat, a city of 7,000 population, situated on the C., I. & L. (Monon); the Peoria Division of the Big Four and the Michigan Division of the Vandalia railways; 44 miles west of Indianapolis; 148 miles south of Chicago.

ORIGIN AND CHARACTER OF THE WATER.—A group of five springs, now owned and utilized by the Crawfordsville Water Company, issue from gravel at the base of a bluff 40 feet in height. Several six-inch driven wells, flowing water of the same character, have been sunk near the springs to a depth of 80 feet.

An analysis of the water of these springs made by Dr. Thad. M. Stevens, of Indianapolis, and published in the report of this Department for 1875, is as follows:

ANALYSIS OF WATER FROM VAN CLEVE'S SPRINGS, CRAWFORDSVILLE, INDIANA.

Potassium carbonate (K_2CO_3)	.144
Sodium carbonate (Na_2CO_3)	.168
Magnesium carbonate ($MgCO_3$)	3.824
Ferrous carbonate ($FeCO_3$)	.616
Calcium carbonate ($CaCO_3$)	9.800
Sodium chloride (NaCl)	.704
Sodium sulphate (Na_2SO_4)	.200
Magnesium sulphate ($MgSO_4$)	7.320
Silicic acid (H_4SiO_2)	.072
Total	22.848

"Carbonic acid and oxygen gases are held in solution, which render the water agreeable to the taste. The water acts as a laxative, febrifuge and tonic invigorator." It is very feebly mineralized and may be used freely. The iron will be found of service in anemic conditions. The water is collected in an impounding reservoir and from there pumped to a stand pipe.

GARLAND DELLS MINERAL SPRINGS.

WATER = *Neutral.*

LOCATION.—Among the breaks of Sugar Creek, 12 miles southwest of Crawfordsville and five miles northwest of Waveland, a station on the T. H. & L. and C. & S. E. railways, 38 miles northeast of Terre Haute. Marshall, a station on the C., I. & W. Railway, 56 miles west of Indianapolis, is four miles distant from Garland Dells. Carriages can be secured at either of these places for the springs. An electric railway from Crawfordsville to the springs is under contract and will probably be built in 1903.

ORIGIN AND CHARACTER OF THE WATER.—Three springs, about 100 feet apart, flow from crevices near the base of the Mansfield sandstone, on the south side of a deep ravine. The point of issue is about 125 feet below the crest of the hill on which the hotel is located, and 115 feet above the level of Sugar Creek in the valley below. The overflow of water from the springs finds its way into a stream called "Little Ranty," which, during the ages past, has eroded its way through the sandstone to its present level, thus forming the ravine.

The water of No. 1, the upper spring, is very clear, odorless and tasteless. A basin three and a half feet deep has been blasted out in the stone and then walled up. A gasoline engine is used to pump the water to a 30-barrel tank at the hotel.

Spring No. 2, the middle one, has not been improved. A portion of the water flows through an iron pipe, making it easier to obtain for drinking purposes.

The lower spring, No. 3, is likewise confined only in part. Its waters are said to be much more laxative than either of the others. A brownish red precipitate of iron oxide about the orifice, indicates a stronger chalybeate water than in the other springs.

Partial analyses of the waters made some years ago by Dr. J. N. Hurty, showed the presence of the following mineral salts per U. S. gallon:

ANALYSES OF WATERS FROM GARLAND DELLS, MONTGOMERY COUNTY, INDIANA.

	No. 1. *Grains.*	No. 2. *Grains.*	No. 3. *Grains.*
Calcium carbonate ($CaCO_3$)......	12 to 16	12 to 16	12 to 16
Magnesium carbonate ($MgCO_3$)...	10 to 15	8 to 12	10 to 12
Iron oxide (FeO)...............	trace	trace	trace
Sodium chloride (NaCl)..........	trace	1 to 2	1 to 2
Sodium sulphate (Na_2SO_4)........	trace	trace	trace
Sodium carbonate (Na_2CO_3)......	trace	trace	trace
Silica (SiO_2)....................	.....	.....	trace

Carbonic acid gas—small amount in each spring.

"The total amount of solid matter runs from 30 to 36 grains per gallon in each spring. The waters answer every test for purity and are unexceptionable as potable waters." The three springs flow about 60 gallons per minute, the amount showing but little depreciation in the dryest season.

IMPROVEMENTS.—Garland Dells, or "Shades of Death," has been open to the public as a resort for almost 20 years, and has been a camping ground for pioneers from the earliest settlement. In 1815 Government surveyors noted these springs as land marks on their records. At that time Indians in great numbers were using the high bluffs above the springs for their camping grounds.

About 1895, a company known as the Garland Dells Mineral Springs Association was organized, and secured control of 300 acres of land, including the springs. A 40-room frame hotel, eight cottages and numerous tents with board floors were erected. These furnish accommodations for almost 200 persons during the season, which lasts from May 1st to November 1st.

The scenery about the "Shades of Death" ranks among the most picturesque in the State. Professor Collett, in the report of this Department for 1875, thus describes some of the features of the place: "'Little Ranty,' flowing from the south, approaches in a flume-like passway, cut 50 feet deep in heavy sandstone, and thence rushes in a filmy sheet 45 feet down an almost perpendicular bank of dark shale, like an endless ribbon with warp of silver and woof of sparkling crystals. Silver Cascade is nestled away in an amphitheatre, 200 feet in diameter, crowded with shrubs, ferns and tenderest wild plants, here untrodden and unseen. Traveling ferns creep over and cling to the ragged masses of tufa, which guard the narrow entrance from the eye of the careless observer. More than a hundred feet above, tall oaks and pines, encircling the rim, swing their branches together across the cove and chasm." Here also grow the pine, yew, hemlock and cedar in abundance, while many rare forms of ferns, orchids and other herbaceous plants bring delight to the visiting botanist. Sugar Creek, flowing over its rocky bed, is a famous place for boating and bass fishing. Wherever the visitor may wander, among the hills and ravines along this portion of its course, new scenes of interest and of beauty will be presented. The scent of evergreens and all the spicy odors of the forest primeval will greet him, while a coolness peculiar to these shaded glens will, even in the hottest day of midsummer, invigorate and please. That these gifts of nature, together with the purity of the waters, are a panacea to the ailing, many will testify who in the past have visited this charming resort of Garland Dells.

MORGAN COUNTY.

MARTINSVILLE MINERAL WELLS.

WATER = *Alkaline-saline-sulphuretted.*

LOCATION.—In different parts of Martinsville, the county seat, a city of 4,200 population, situated on the west fork of White River, 30 miles southwest of Indianapolis. The I. & V. Branch of the Pennsylvania Railway and the Indianapolis and Martinsville Electric Railway furnish easy access from Indianapolis. From Cincinnati and points east the city may be reached by the Fairland, Franklin and Martinsville Branch of the Big Four Railway.

Martinsville possesses all modern improvements of a city of its size. It lies at the foot of a range of varied and beautiful hills on the east and north, with White River winding toward the west and south through the valley below, thus providing most pleasing and romantic scenery. The streets are broad and clean, are lined on either side with spreading shade and forest trees, and lead out into smooth gravel-road drives which wind away among the scenic hills and valleys into the beautiful country beyond.

ORIGIN AND CHARACTER OF THE WATER.—Nine wells, sunk to depths ranging from 668 to 704 feet, produce a copious supply of alkaline-saline-sulphuretted water. Seven of these wells are connected with sanitariums which will be mentioned below; one is in Forest Grove Park, just west of the city, and the other is on the farm of C. S. Cunningham, one and a half miles south.

The first well was sunk in search for gas in 1887, to a depth of 1,470 feet. It was in the west part of the city, near the I. & V. Railway, on the grounds of the present site of the Barnard Sanitarium. In it, as in the other wells, the first vein of mineral water was struck at about 620 feet and a second vein at 640 to 650 feet. From 700 feet down the bore was wholly dry. The top of Trenton was reached at 1,700 feet.

After penetrating the drift, which is 90 to 117 feet in thickness, the wells at Martinsville pass through a formation of Knobstone shale 120 to 140 feet in thickness. Below this is about the same thickness of limestone which overlies 150 or more feet of black Genesee shale. The Corniferous and Niagara limestones are then entered, and the latter, at about 600 feet from the surface, becomes water bearing. The amount of water increases within the next 75 or 100 feet to its maximum flow. The rate of flow per minute, as determined in 1896 at several of the sanitariums, was as follows:

Home Lawn Sanitarium, 40 gallons; Highland Sanitarium, 25 gallons; Barnard's Sanitarium, 28 gallons; Martinsville Sanitarium, 35 gallons. Since then most of the wells have been closed in and connected with pumps, so that now only the one at Barnard's flows naturally.

The water at all the wells is clear and sparkling with carbonic acid and other gases. The odor of hydrogen sulphide is present, but not strong. The taste is agreeable, being but slightly bitter; a pinch of salt to the glassful renders it more palatable to many. The temperature, as it flows from the Barnard well, is 54° F.; at other points, after passing through pipes for some distance, it ranges from 56° to 60.°

Four analyses of the Martinsville water have been made, two by Dr. W. E. Stone, of Lafayette; one by Dr. J. N. Hurty, of Indianapolis, and one by Dr. T. C. Van Nuys, of Bloomington. These, reduced to the common standard of grains per U. S. gallon, are herewith printed side by side for comparison:

ANALYSES OF WATERS FROM MARTINSVILLE MINERAL WELLS.

	STONE. *Martinsville Sanitarium Well.*	STONE. *Home Lawn Well.*	HURTY. *Forest Grove Park Well.*	VAN NUYS. *Barnard Well.*
Sodium chloride ($NaCl$)	58.580	55.861	44.429	18.630
Potassium chloride (KCl)	1.775	14.779	1.559	20.485
Magnesium chloride ($MgCl_2$)	.....	.....	8.490	7.502
Calcium chloride ($CaCl_2$)	.....	.....	31.707	10.121
Sodium sulphate (Na_2SO_4)	1.879	1.697	.....	.....
Potassium sulphate (K_2SO_4)	.....	.....	.....	.897
Sodium sulphide (Na_2S)	.....	.....	.533	1.091
Calcium sulphide (CaS)	.....	.....	.500	.....
Potassium sulphide (K_2S)	.....	.....	.713	.....
Calcium carbonate ($CaCO_3$)	16.902	6.555	4.245	7.327
Magnesium carbonate ($MgCO_3$)	15.359	5.359	1.819	.....
Sodium carbonate (Na_2CO_3)	2.482	3.272	2.292	.....
Alumina (Al_2O_3)	.661	.997	.....	.....
Silica (SiO_2)	.556	8.456	.....	.....
Total solids	98.194	96.976	96.288	66.053
Gases.	*Cu. In.*	*Cu. In.*	*Cu. In.*	*Cu. In.*
Carbon dioxide (CO_2)	21.24	45.50	47.980	23.07
Hydrogen sulphide (H_2S)	.86	6.92	20.725	1.02

In connection with the analysis furnished of the Forest Grove water, Dr. Hurty made the following statement: "This water will be found alterative, resolvent and antacid, and generally will be found gently aperient. Its richness in carbonic acid gas will make it gratifying and agreeable to the stomach, while the sulphuretted hydrogen will act as anti-ferment and eliminant. The proportion of sulphides of calcium, sodium and potassium in ~~each pint seems~~ particularly happy, as the quantities here shown are those in which they are most frequently given."

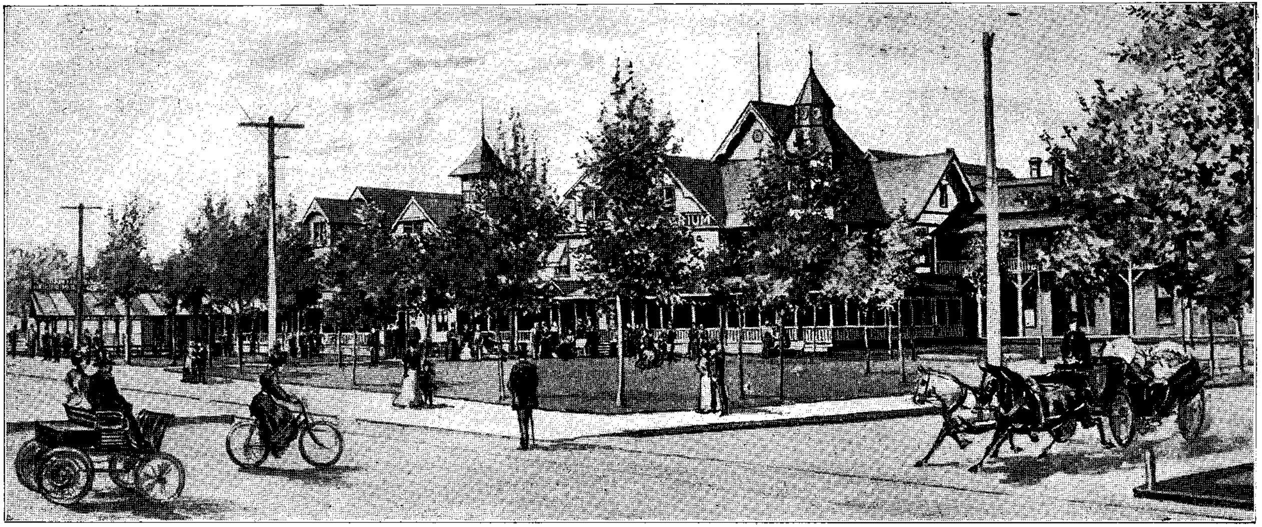
It will be seen that Drs. Stone and Hurty agree very closely as to the number of grains of solid matter contained in the water, but differ widely as to the forms of salts in which this solid matter occurs. This difference is, however, only the individual opinion of each chemist. The water of all the wells comes from the same level and the same vein, and the mineral constituents can, therefore, vary but little, if at all.

IMPROVEMENTS.—Soon after the water was first found at Martinsville, a bath house for utilizing it was opened up on a small scale by Mr. Barnard. This was just across the street from the well, and was burned after a year or two. A second and enlarged house was then erected on the present site. As the curative properties of the water became recognized and its fame spread, the guests increased largely in number and enterprising citizens began the erection of new and commodious sanitariums for their accommodation. The benefits to Martinsville from the finding of the water have been many. The city almost doubled in population between 1890 and 1900. Many new dwellings and business houses were erected and the place is now well known, not only in Indiana, but throughout the Union.

At present five sanitariums furnish treatment and home-like accommodations for thousands of patients throughout the year. These are as follows:

Martinsville Sanitarium and Mineral Springs Hotel.—This is a large two-story frame structure, located opposite the I. & V. Depot. The grounds and buildings occupy an entire block. The lawn between the sanitarium and the railway station is spacious and well shaded. There are 86 rooms for guests; 17 well-equipped bath rooms with facilities for mineral, vapor and electrical baths; billiard and pool rooms, offices, etc. The building is steam heated, electric lighted and in every way fitted up in modern style. The front, facing the shady lawn, is a delightful promenade and a most enjoyable resort, its entire length being brilliantly lighted by electric light, and in the winter season a space of 275 feet of it is enclosed in glass, thus permitting the guests who congregate there to experience the sensations of the warmth of summer in the midst of winter's inclement weather.

Plate IX.



Martinsville Sanitarium and Mineral Springs Hotel, Martinsville, Indiana.

Two mineral wells furnish an inexhaustible supply of water which is piped to various drinking fountains and to all parts of the building. A resident physician of long experience devotes his entire time to looking after the needs of the patients.

Home Lawn Mineral Springs.—This sanitarium and hotel is located four blocks east of the public square and seven blocks southeast from the I. & V. Station, where free wagonettes meet all trains. The site is ten feet higher than the level of the I. & V. Railway and the wide lawn contains many large and beautiful trees. The sanitarium consists of three buildings, two brick and one frame, connected by wide enclosed, steam heated and electric lighted corridors. The south building contains the offices and bath rooms, the latter being ten in number, equipped with solid porcelain tubs and also with facilities for vapor, Russian and electric baths. A deep well furnishes a copious supply of the celebrated mineral water. The middle building of brick has been recently erected for hotel purposes. It and the north one contain 46 finely furnished apartments for guests, a number of them with private bath rooms attached. Billiard and music rooms furnish means of indoor amusement. The veranda in front, 130x20 feet in size, is enclosed completely with immense panels of plate glass and steam heated, thus forming a "winter sun parlor" which is much enjoyed by the patients during cold and damp weather. In the evening it is often used as a dancing pavilion or for private theatricals. The proprietors are experienced physicians who give the sanitarium their undivided attention.

Highland Hotel and Sanitarium.—Located five blocks northeast of the I. & V. Depot, on the brow of a hill 25 feet above the railway level. From its broad verandas a fine view is afforded of the surrounding valleys and undulating country beyond White River. The building is three stories in height and of modern construction and equipment. It contains 70 rooms for guests and ten bath rooms, all finely furnished. There are also facilities for electric, vapor and shower baths. Two large music and amusement rooms furnish a place for indoor recreation. One of these is supplied with billiard tables and gymnasium apparatus. From a deep well an unlimited supply of mineral water is piped to all parts of the building. The resident physician in charge has had long experience with the water and understands fully its curative powers for different diseases.

National Hotel and Sanitarium.—Located three squares southeast of the I. & V. Depot and one block west of the public square. This is a large two-story frame building, with wide veranda on the second floor, which furnishes a delightful promenade, 180 feet in length.

The hotel contains 25 rooms for guests, and ten well equipped bath rooms, each with separate cooling room at side. The ladies' bathing department is on the second floor, thus securing greater privacy. The building is heated throughout by steam, and possesses other modern impovements. An attendant physician is constantly at hand, and an adequate supply of mineral water is piped from a deep well on the grounds to all parts of the building.

Barnard Sanitarium.—This, the oldest bath house and sanitarium in the city, is located one block south of the I. & V. Depot. It is a two-story frame building used chiefly for bathing purposes. There are two deep wells on the grounds, one flowing a plentiful supply of mineral water. There are 28 bath rooms, well equipped for mineral, vapor and mud baths. An experienced physician is in regular attendance. The building is heated by steam, and there are sleeping accommodations for a limited number of guests, but most of the patients room and board elsewhere.

ORANGE COUNTY.

ORLEANS MINERAL WELLS.

WATER = *Saline* (?).

LOCATION.—Near the center of Orleans, a town of 1,300 population, situated on the C., I. & L. (Monon) Railway, 62 miles north of Louisville. The French Lick Springs Branch of the same railway joins the main line at the town.

ORIGIN AND CHARACTER OF THE WATER. — Two wells, formerly flowing, now pumped, one being located in a handsome grove one block north of the center of the town; the other two blocks southwest, at the northwest corner of the school house square. These wells were started for gas in 1889, but at a depth of 176 feet struck a strong vein of mineral water, which for several years flowed out of a three-inch casing, three feet above the surface. The casing was in time destroyed by the sulphuric acid in the water, and the flow ceased. Pumps were then inserted and are now used, the supply of water being seemingly inexhaustible. The water is clear and odorless, but has quite a bitter taste, probably due to the presence of Epsom and Glauber's salts. No analysis has been made. The temperature of the water as pumped is 55° F. It is used quite extensively by the citizens of Orleans as a laxative, and as a remedy in kidney troubles, and is deserving of more extended development than it has received in the past.

MOORE MINERAL WELL.

WATER = *Saline* (Purgative).

In the summer of 1902 a third well was sunk in the outskirts of Orleans, on property belonging to W. T. Moore. No data regarding the depth of the well is available, but a strong flow of mineral water resulted. An analysis of a sample of this by T. W. Smith, of Indianapolis, resulted as follows:

ANALYSIS OF WATER FROM MOORE MINERAL WELL, ORLEANS, INDIANA.

Bases and Acid Radicals.	*Grains per U. S. Gallon.*
Silica (SiO_2)	3.04
Ferrous oxide (FeO), Aluminum oxide (Al_2O_3)	1.05
Calcium (Ca)	19.18
Magnesium (Mg)	8.70
Sodium (Na)	18.59
Potassium (K)	3.72
Sulphate (SO_4)	113.76
Chlorine (Cl)	9.20
Total	177.24

The above constituents are probably combined as follows:

	Grains per U. S. Gallon.
Silica (SiO_2)	3.04
Iron and aluminum oxides (Fe_2O_3+Al_2O_3)	1.05
Calcium sulphate ($CaSO_4$)	67.13
Magnesium sulphate ($MgSO_4$)	43.50
Sodium sulphate (Na_2SO_4)	45.85
Sodium chloride (NaCl)	9.50
Potassium chloride (KCl)	7.10
Total solids	177.17

This water is similar to but not so strong as those described above from the springs issuing from the New Providence shales of Clark County, and it may be that it comes from the same formation. Taken in quantity, it will act as an active cathartic. In smaller doses it will be found remedial in stomach and liver troubles.

PAOLI ARTESIAN WELLS.

LOCATION.—Three wells, each producing an artesian flow of mineral water, are located within the environs of Paoli, the county seat, a town of 1,200 population, situated on the French Lick Branch of the Monon Railway, 10 miles distant from French Lick, and eight miles from the main line of the Monon at Orleans. Five trains run daily each way between French Lick and Paoli.

(a) Paoli Lithia Spring.

Water = *Saline-sulphuretted.*

Origin and Character of the Water.—The water of this so-called spring comes from a well 1,000 feet in depth, which was sunk on the north side of Lick Creek about one-quarter of a mile west of the court house for gas or oil, in 1892. A vein of mineral water strongly charged with hydrogen sulphide, was struck at 250 feet, while a second vein, containing lithia, was found in a blue shale at 1,000 feet. The two veins were allowed to mix and at present flow from an iron pipe into a stone basin at the rate of about two gallons per minute. An analysis of the water, made by Dr. W. A. Noyes, of Terre Haute, showed the presence of the following mineral ingredients:

ANALYSIS OF WATER FROM PAOLI "LITHIA SPRING."

	Grains per U. S. Gallon.
Calcium sulphate ($CaSO_4$)	101.124
Magnesium chloride ($MgCl_2$)	4.395
Magnesium sulphate ($MgSO_4$)	52.138
Magnesium carbonate ($MgCO_3$)	20.430
Lithium bi-carbonate ($LiHCO_3$)	1.630
Sodium chloride ($NaCl$)	120.433
Potassium chloride (KCl)	2.364
Silica (SiO_2)	0.747
Alumina (Al_2O_3)	0.093
Ferrous carbonate ($FeCO_3$)	0.251
Total solids	303.605
Gases.	*Cu. In.*
Hydrogen sulphide (H_2S)	1.591
Free carbon dioxide (CO_2)	5.914

Besides the above, a trace of calcium phosphate and small amounts of strontium sulphate, sodium bromide and sodium borate were present.

This is one of the few deep wells of the State in which the water is not excessively charged with common salt. It has but a slight odor of hydrogen sulphide, though bluish-black flakes of iron sulphide are abundant in the stone receptacle. The taste is a sweetish saline and quite agreeable. In the circulars sent out by the proprietors, this water is advertised as being "unexcelled as an eliminator of diseased conditions of the system and as a blood purifier and remedy" for 38 named diseases. It is piped to the "Mineral Springs Hotel" near the center of the town, and is also shipped, bringing $2.50 per case of 24 quart bottles.

(b) Paoli Gas Well.

Water = *Saline-sulphuretted.*

Origin and Character of the Water.—A well sunk for gas in 1897, developed a strong vein of mineral water in a hard limestone at a depth of 1,130 feet. Quite a quantity of gas issues with the water. The well is located in low ground, 122 yards east of the lithia well above described. The water rises just to the surface and the output is about five gallons per minute. It is quite salty in taste but not bitter, has a temperature of 58° F. and but a slight odor of sulphuretted hydrogen. An analysis make by Chas. B. Stout, a student at Earlham College, showed the mineral constituents of the water to be as follows:

ANALYSIS OF WATER FROM THE PAOLI GAS WELL.

	Grains per U. S. Gallon.
Magnesium sulphate ($MgSO_4$)	127.692
Magnesium chloride ($MgCl_2$)	149.434
Magnesium nitrate ($Mg(NO_3)_2$)	1.506
Calcium sulphate ($CaSO_4$)	10.369
Calcium chloride ($CaCl_2$)	185.337
Iron chloride ($FeCl_2$)	.231
Iron carbonate ($FeCO_3$)	2.669
Sodium silicate (Na_4SiO_4)	70.268
Sodium phosphate (Na_3PO_4)	4.300
Sodium chloride ($NaCl$)	614.537
Ammonium chloride (NH_4Cl)	4.757
Total solids	1171.100

(c) Paoli Sulphur Well.

Water = *Saline-sulphuretted.*

Origin and Character of the Water.—This well was sunk to a depth of 250 feet, in 1895, in search of mineral water, as two wells, one put down by Studebaker Brothers, one-half mile west, and another on the John Maris farm, one mile east, had both developed veins of water strongly charged with hydrogen sulphide. The attempt was successful, a good vein of flowing water being found at the depth mentioned. The well is located on the south bank of Lick Creek, one-quarter of a mile east of the lithia well, and 400 feet south of the public square. A kiosk, or open building, has been erected above the well. The water is quite bitter with the taste of Epsom salt and hydrogen sulphide, and has a temperature of 56° F. It is used at the Mineral Springs Hotel, and quite extensively by the citizens of the town. The waters of both the lithia well and gas well could be readily piped to the sulphur well and would there flow, thus furnishing three waters, each possessing distinct medicinal virtues.

IMPROVEMENTS.—The Paoli Mineral Spring Hotel, a three-story building of brick and stone, with accommodations for 100 guests, and a number of well-equipped bath rooms, was erected for the express purpose of a resort and sanitarium, where the mineral waters of Paoli could be used. Billiard halls, bowling alleys and ball rooms afford means of indoor recreation. The scenery about Paoli is varied and pleasing, and good roads diverging from the town furnish excellent opportunities for driving, cycling or walking.

LAMBDEN SULPHUR SPRING.

WATER = *Saline-sulphuretted.*

LOCATION.—On the land of Nathan Lambden, three-fourths of a mile northeast of West Baden, on the south bank of Lost River. The French Lick Branch of the Monon Railway runs just above the spring. Postoffice, West Baden.

ORIGIN AND CHARACTER OF THE WATER.—A strong flowing spring emerges from the base of the limestone bluff of Lost River, here 20 feet in height, and flows about 30 feet into the waters of that stream. The output is about eight gallons per minute, of water which is dark with particles of iron sulphide. The odor of sulphuretted hydrogen is strong; the temperature 55° F., and the taste of the water very similar to that of the Pluto Spring at French Lick. A frame building stands on the top of the bluff above the spring. It was built a number of years ago and fitted up for bottling the water for shipment, but the enterprise was short-lived. Both in quantity and quality the water is excellent, but the surroundings are not especially favorable for a sanitarium.

RYAN AND MICKLER SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—These springs are about 100 feet apart, Ryan being in the southeast quarter of the northeast quarter, and Mickler in the northeast quarter of the northeast quarter of Section 10 (1 N., 2 W.), about one-half mile up French Lick Creek from the village of French Lick.

ORIGIN AND CHARACTER OF THE WATER.—Ryan Spring wells up in the bed of French Lick Creek, while Mickler is about 20 feet back from the bank of that creek. The latter is owned by Dr. J. L. Howard, of West Baden, who proposes developing it in the near future. The flow from both springs is rather small, but the water is of the same character as found at French Lick and West Baden.

RHODES' MINERAL SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—On the land of E. B. Rhodes, one-quarter of a mile southeast of the postoffice at West Baden.

ORIGIN AND CHARACTER OF THE WATER.—A spring wells up through a crevice in the Chester limestone. A wooden casing or box, five feet square and 12 feet deep, has been sunk above the outlet and is full of water. This is one of the oldest known springs in the valley of French Lick Creek, its waters being used by the early settlers years before the springs at West Baden, one-third of a mile northwest, were improved. The water is of the same character as that of the leading springs at French Lick and West Baden.

A bore was sunk by Mr. Rhodes about 30 rods northwest of this spring to a depth of 91 feet. The bore passed through 27 feet of surface material (soil and clay) and then through limestone to the bottom, where, in a soft, shaly limestone, a vein of sulphur water was developed, which flows above the surface. The overflow is carried through a ditch into a large cistern, and from this through a public ditch into Lost River. The water resembles closely that produced by the natural springs throughout the valley. It is Mr. Rhodes' intention to further improve both the well and spring and to erect a large hotel in the near future.

FRENCH LICK SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—In the west half of Section 3 (1 N., 2 W.), French Lick Township, Orange County, at the terminal of a branch of the C., I. & L. (Monon) Railway, 279 miles south of Chicago, 80 miles northwest of Louisville, 18 miles southwest of Orleans, where the branch railway connects with the main line of the Monon. Five trains run daily each way between Orleans and French Lick. Four trains also run daily between French Lick and Mitchell, where connection is made with the B. & O. S.-W. Railway for passengers from Cincinnati, St. Louis and intermediate points.

ORIGIN AND CHARACTER OF THE WATER.—Three strong flowing mineral springs emerge from crevices in the Chester limestone at the point of junction of that formation with the overlying Mansfield sandstone. *Pluto Spring*—The largest and most noted of these is Pluto Spring, the water of which wells up from a perpendicular cleft in the limestone at the rate of about 18 gallons per minute. It has a constant temperature of 56½° F., a strong odor of sulphuretted hydrogen, and a bitter taste, due to the presence of large quantities of Epsom and Glauber's salts and other sulphates. Four analyses of the water of this spring have been made, one by Dr. J. G. Rogers, in 1869; a second by Prof. E. T. Cox, in 1870; a third by Mariner & Hoskins, of Chicago, in 1899, and the fourth at the Columbus Medical Laboratory, of Chicago, in 1901. The analyses made by Professor Cox and at the Columbus Medical Laboratory gave the percentage composition of the bases and acid radicals present as follows:

ANALYSES OF WATER FROM PLUTO SPRING, FRENCH LICK, INDIANA.

Bases and Acid Radicals.	COX. Parts per 1,000,000.	COLUMBUS MEDICAL LABORATORY. Parts per 1,000,000.	COX. Grains per U. S. Gallon.*	COLUMBUS MEDICAL LABORATORY. Grains per U. S. Gallon.*
Lime	675.92	703.60	39.413	41.027
Soda	1140.20	1226.90	66.485	71.541
Potash	41.72	.....	2.433	.....
Magnesia	723.26	387.32	42.173	22.584
Alumina	48.10	trace	2.805	.....
Chlorine	1185.96	1065.00	69.153	62.100
Carbonic acid	690.55	266.02	40.266	15.511
Sulphuric acid	845.55	1631.00	49.304	95.104
Silicic acid	9.42	24.40	.549	1.423
Oxide of iron	1.90	trace	.111	.....
Total	5362.58	5304.24	312.692	309.290

*Reduced from grains per imperial gallon by multiplying by .833.

PLATE X.

PLUTO SPRING, AT FRENCH LICK, INDIANA.

The compounds of mineral salts present, according to the views of the different chemists, are as follows:

	ROGERS.	COX.	MARINER & HOSKINS.	COLUMBUS MEDICAL LABORATORY.
		Grains per U. S. Gallon.		
Calcium sulphate ($CaSO_4$)......	60.59	13.005	72.88	99.628
Potassium sulphate (K_2SO_4)....	.....	1.009	.....	.....
Sodium sulphate (Na_2SO_4)......	22.37	3.391	96.36	39.651
Magnesium sulphate ($MgSO_4$)...	18.12	55.652	.....	20.070
Aluminum sulphate ($Al_2(SO_4)_3$)..	trace	4.983	.....	.....
Calcium carbonate ($CaCO_3$).....	6.92	33.470	13.14	.....
Sodium carbonate (Na_2CO_3).....	.....	3.995	.....	.....
Potassium carbonate (K_2CO_3)...	.....	2.769	.....	.....
Magnesium carbonate ($MgCO_3$).	1.59	43.907	trace	32.573
Calcium chloride ($CaCl_2$).......	5.35	27.408	.....	.....
Sodium chloride (NaCl).........	140.54	118.197	33.28	116.328
Magnesium chloride ($MgCl_2$)....	.....	4.246	56.88	.....
Silicic acid (SiO_2)..............	.....	.549	.....	1.423
Iron oxide (FeO).............	trace	.111	.....	.....
Iodides and bromides..........	.....	trace	.....	.....
Undetermined matter..........	.54	.....	.....	.....
Total solids...............	256.02	312.692	272.54	309.673
Gases.	*Cu. In.*	*Cu. In.*	*Cu. In.*	*Cu. In.*
Hydrogen sulphide (H_2S).......	25.05	5.595	5.40	5.233
Carbon dioxide (free) (CO_2).....	15.00	6.111	.....	.....

In an article in the Western Journal of Medicine for December, 1869, Dr. Joseph G. Rogers calls attention to these springs, after visiting them and making a careful quantitative analysis of the waters. The original analysis is given in the paper referred to, the amount of sulphuretted hydrogen being given as 25.05 cubic inches of gas in a wine gallon; that of carbonic acid gas as 15.00 cubic inches. The doctor first suggested the name "Pluto's Well," which was favorably received, and by which it has since been generally known.

It seems that in the various transcriptions which have been made of the analytical table of Dr. Rogers, the figures of his analysis above given have suffered a decided change, often some of them not appearing at all. The comparatively low figures for the amount of hydrogen sulphide gas in the tables given by the other chemists are due to the fact that their samples of water were not examined until some time after their arrival in the laboratory, after much of the gas had disappeared. Dr. Rogers' examinations were made at the well, and his figures regarding the gases are, therefore, to be accepted as correct.

The water of Pluto Spring has the widest reputation of any mineral water occurring in Indiana. It has been bottled and shipped for many years, and thousands of people have visited its source and have been benefited by the outing and the use of the water. It has been found beneficial in many cutaneous diseases and is valuable as a diuretic, alterative, laxative or saline aperient. It is especially adapted to persons who lead a sedentary life.

Bowles Spring.—This spring issues from the base of a sloping, wooded hillside, 320 yards northwest of Pluto. It wells out at the base of a mass of Mansfield sandstone, of which the hill is mainly composed. The output of the spring, in September, 1901, was about six gallons per minute, having a temperature of 56½° F. A white sulphur deposit coats objects close to the outlet; and the overflow is through a ditch containing much black iron sulphide. The water is quite bitter, and smells and tastes strongly of sulphuretted hydrogen. It is bottled and shipped, but not to a large extent.

An analysis of the water from Bowles Spring, made in the Columbus Medical Laboratory, Chicago, Ill., in 1901, resulted as follows:

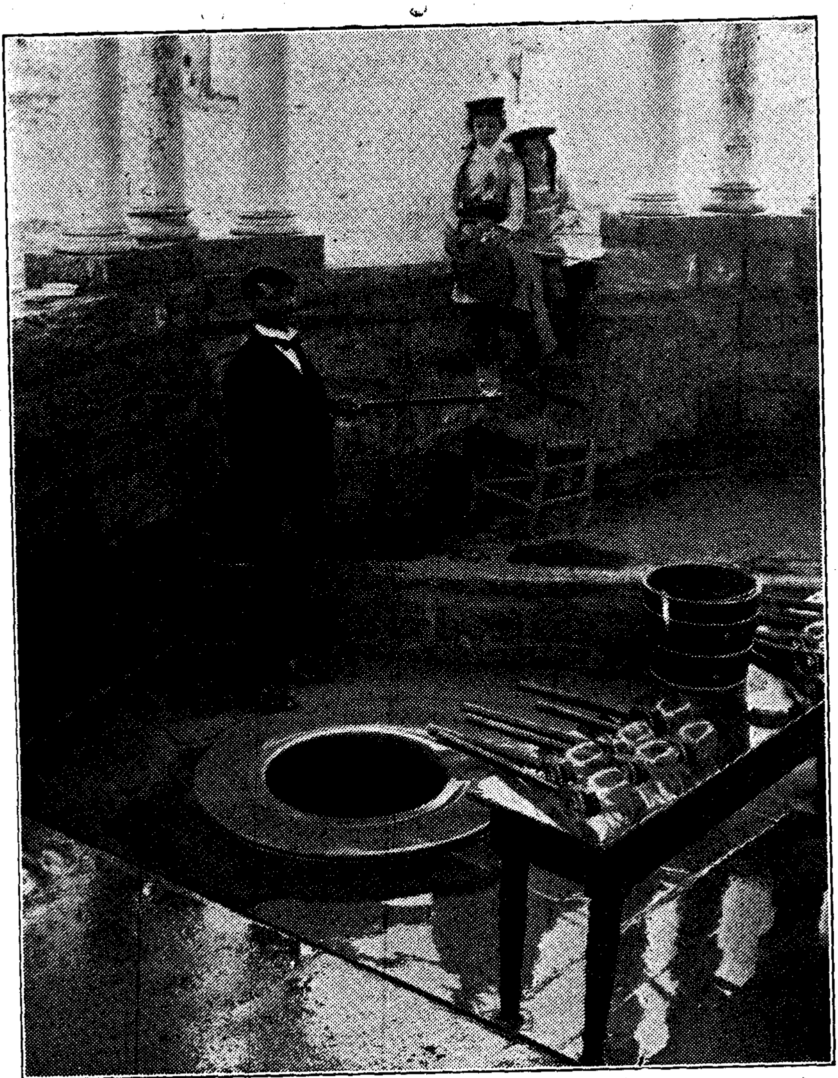
ANALYSIS OF WATER FROM BOWLES SPRING, FRENCH LICK, INDIANA.

Bases and Acid Radicals.	*Parts per 1,000,000.*	*Grains per U. S. Gallon.*
Nitrogen	2.630	.....
Hydrogen sulphide	23.720	.....
Silica	12.000	.700
Iron and alumina	1.000	.058
Calcium oxide	593.000	34.578
Magnesium oxide	321.440	18.743
Sodium oxide	989.000	57.669
Chlorine	810.580	47.265
Sulphuric anhydride	1421.000	82.859
Carbonic acid	237.500	13.849
Total	4411.870	255.721

The above constituents are probably combined as follows:

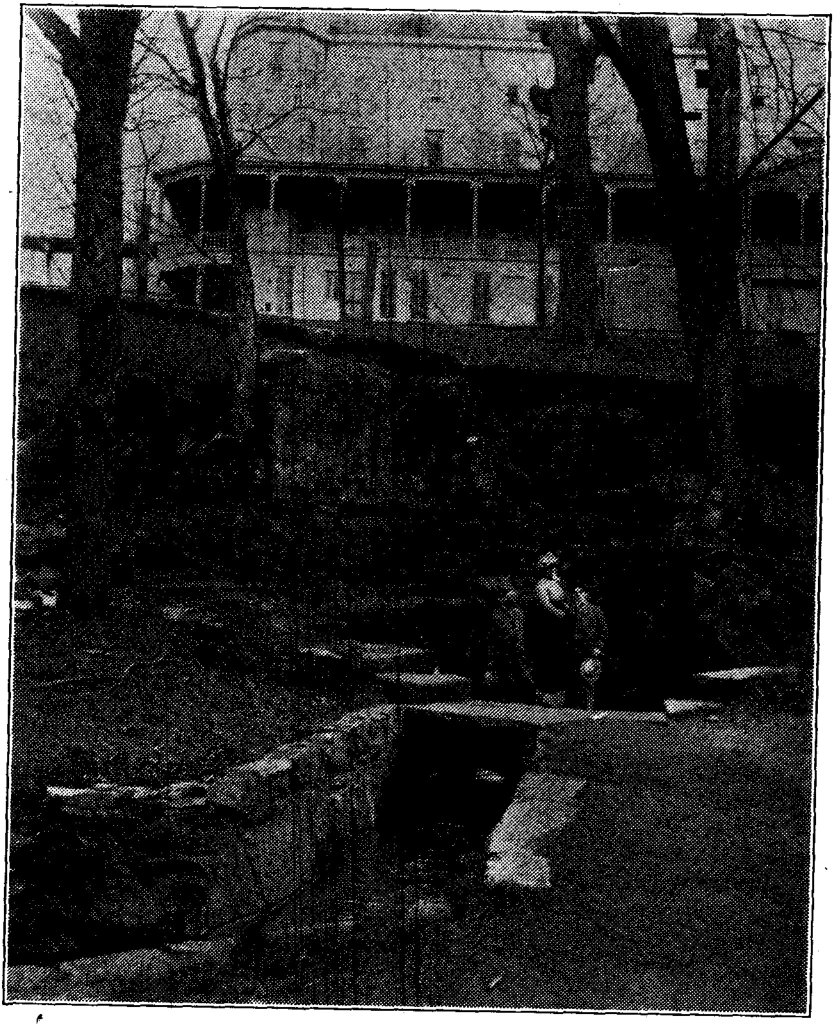
	Parts per 1,000,000.	*Grains per U. S. Gallon.*
Calcium sulphate ($CaSO_4$)	1440.14	83.974
Magnesium sulphate ($MgSO_4$)	316.59	18.460
Sodium sulphate (Na_2SO_4)	644.50	37.581
Magnesium carbonate ($MgCO_3$)	453.40	26.438
Sodium chloride (NaCl)	1518.41	88.539
Silica (SiO_2)	12.00	.700
Iron and alumina	1.00	.058
Total solids	4386.04	255.750
		Cu. In.
Hydrogen sulphide gas (H_2S)		3.667

PLATE XI.



INTERIOR OF PAGODA AT PLUTO SPRING, FRENCH LICK, INDIANA.

PLATE XII.



AT FRESH WATER SPRING, FRENCH LICK, INDIANA.

Proserpine Spring.—Located 100 yards east of Pluto, in front of the newer portion of the hotel. The water rises just to the level of the floor of the large circular depression about the spring, which has been excavated and then cemented. The output is small, about five gallons per minute, of a more saline water than is afforded by the other two springs. The temperature is also higher, being 58½° F., while the odor and taste of sulphuretted hydrogen is milder. Two analyses of the water of this spring have been made, one in 1869, by Dr. J. G. Rogers, and a second in 1901, at the Columbus Medical Laboratory, Chicago. Only the latter gave a percentage composition of the bases and acid radicals, as follows:

ANALYSES OF WATER FROM PROSERPINE SPRING, FRENCH LICK, INDIANA.

Bases and Acid Radicals.	*Parts per 1,000,000.*	*Grains per U. S. Gallon.*
Nitrogen	3.56	.....
Hydrogen sulphide	26.98	.....
Silica	13.60	.793
Iron and alumina	trace	.....
Calcium oxide	679.60	39.627
Magnesium oxide	369.28	21.532
Sodium oxide	1105.95	64.488
Chlorine	958.50	55.890
Sulphuric anhydride	1573.00	91.722
Carbonic acid	292.60	17.062
Total	5023.07	291.114

According to the views of the two chemists, the mineral compounds present in the water of Proserpine Spring are as follows:

	ROGERS.	COLUMBUS MEDICAL LABORATORY.
	Grains Per	*U. S. Gallon.*
Sodium carbonate (Na_2CO_3)	10.52	.....
Magnesium carbonate ($MgCO_3$)	4.50	29.598
Calcium carbonate ($CaCO_3$)	20.29	.....
Sodium sulphate (Na_2SO_4)	36.72	35.916
Magnesium sulphate ($MgSO_4$)	29.33	22.321
Calcium sulphate ($CaSO_4$)	141.00	96.235
Sodium chloride (NaCl)	90.92	104.696
Potassium chloride (KCl)	5.01	.....
Magnesium chloride (MgCl)	8.05	.....
Silica (SiO_2)	1.69	.793
Iron and aluminum carbonates	2.49	trace
Total solids	350.52	289.559
Gases.	*Cu. In.*	*Cu. In.*
Carbonic acid (CO_2)	10.116	.....
Sulphuretted hydrogen (H_2S)	17.000	4.103

With the analyses submitted by the Columbus Medical Laboratory of the waters from the three springs at French Lick was the following statement: "These waters were examined to determine the number of bacteria, the presence of disease-producing bacteria, bacterial evidence of sewage contamination, etc. There were no disease-producing bacteria, and no evidence of sewage contamination. The water was excellent from a sanitary standpoint.

"The waters are a carbonated, sulphuretted solution of sulphates, carbonates and chlorides of magnesium, sodium and calcium. In addition, there are traces of iron and aluminum, but these are in too small quantities to add value to the waters.

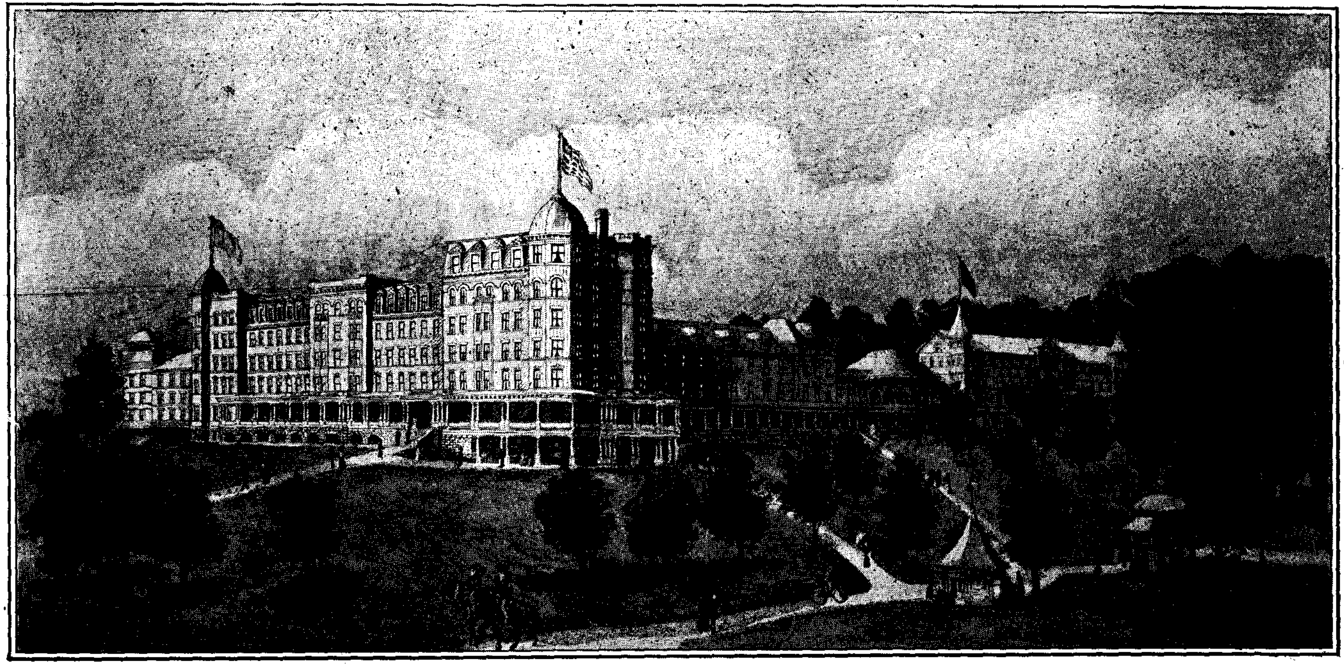
"After all, a great and perhaps the greatest advantage of a sojourn at the springs is drinking large quantities of good water, without reference to the salts and gases. Here one drinks very freely of a sanitary water, free from disease-producing bacteria, and, lastly, a great adjunct is the good air and the opportunity for exercise. A course of ten days to two weeks of these waters, together with outdoor exercise and moderate eating, is highly beneficial to every one, whether they are sick or not."

HISTORY* AND IMPROVEMENTS.—French Lick Springs are the oldest known springs of natural mineral water in Indiana. Their history long antedates the coming of the white man. The aboriginal inhabitants of the region were the Miamis and the Piankeshaws, but Indians from other tribes came here to drink the healing waters; the tract surrounding the springs being held as neutral ground on this account. The French of Vincennes were the first white settlers, being in quest of salt, and a salt depot was attempted by them, but was broken up by the hostility of the Indians in the latter part of the eighteenth century. The saline character of the water tempted the deer, buffalo and other animals of the forest, and from this fact it was known as a "lick;" hence the name "French Lick."

General George Rogers Clark, in the latter part of the eighteenth century, mentions this region in his memoirs of his famed expedition to Kaskaskia and Vincennes as a great resort for deer and buffalo. In 1832 the government sold a large tract of land, including both West Baden and French Lick Springs, to Dr. Wm. A. Bowles. About 1836 Dr. Bowles formed a partnership with one John Hungate. They opened a little store in French Lick village, and also put up a small frame hotel, for at this time people were beginning to flock here to partake of the health-giving water. In 1840 John A. Lane,

*For most of the facts relating to the History of French Lick and West Baden Springs, I am indebted to Dr. John L. Howard, of West Baden.

Plate XIII.



French Lick Springs Hotel, French Lick, Indiana.

a traveling doctor, passed through the country and drank of the water. He saw at once the possibilities of the place, and secured a lease from Dr. Bowles for five years at $500 a year. The hotel was a plain frame building, standing at the foot of the hill on which had been erected the old French fort many years before. For a long period it could only be reached by stage from Orleans, Mitchell or Shoals, they being the nearest railroad stations.

In 1846 Dr. Bowles resumed the management, which he retained until 1864, when he rented the hotel and springs to Dr. Samuel Ryan for 15 years. Under Dr. Ryan's management a new impulse was given to the business, and much improvement was made. In 1880 the property was sold by the heirs of Dr. Bowles to a stock company, of which Dr. Ryan was the head. This company owned it until 1895, when it was purchased by some Louisville parties, who in turn sold it to the present proprietors in 1901, for $410,000. Of this amount $385,000 was paid for 400 acres of land surrounding the springs and the improvements thereon, and $25,000 for 80 acres adjoining, upon which several deep wells had been sunk, which threatened to diminish the flow of Pluto Spring. Four of these wells have been drilled within one-quarter of a mile of French Lick and three-quarters of a mile of West Baden, viz.: the Wells and Andrews well, in 1890; the Cerberus well, in 1897; the Baden-Lick and the H. E. Wells bores in 1901. These wells are all within a few hundred feet of each other, and veins of sulphur water were struck at 40, 200 and 480 feet from the surface. Only the deepest vein, however, resembled the output of the natural springs.

The fall of 1897 was marked by an extreme drouth, and after the Cerberus well had been drilled the French Lick Springs dropped three and one-half feet in their natural level, and lost a large percentage of their gaseous constituents. The Pluto Spring was especially affected, but as soon as the wells were plugged it regained, for the most part, its constant effervescence and boldness of flow.

The improvements at French Lick Springs are those of a first-class sanitarium and resort. They consist of a large hotel and two annexes, furnishing accommodations for 700 guests, and equipped with steam heat, electric lights, etc. A modern bath house is connected with the main hotel by a heated vestibule, and is fitted up with every facility for giving mineral, Turkish, Russian, electric, mud and other baths. The Casino contains the latest regulation bowling alleys, with all the modern improvements, new billiard and pool tables and gymnasium. A dancing pavilion, enclosed in glass and surrounded by galleries, is one of the largest in the country. For out-of-door exercise there are golf, tennis, croquet and baseball grounds. The park in front of the hotel contains many magnificent forest trees, as do also the wooded slopes of the hills which border this park on the west. Game is plentiful in the region about the springs. A large addition to the hotel has been recently completed, making these famous springs a resort the equal of any in the Union as a place for recreation and health recuperation.

WEST BADEN SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—One mile northeast of French Lick Springs, above described, in the north half of Section 34 (2 N., 2 W.), a short distance from the station of West Baden, on the French Lick Branch of the C., I. & L. (Monon) Railway. Postoffice, West Baden.

ORIGIN AND CHARACTER OF THE WATER.—A number of springs break forth from the Chester limestone, at the junction of that formation and the overlying Mansfield sandstone. Of these, four have been improved by excavating large circular basins, six to ten feet in depth, about their outlets and then cementing the floor and walls of these basins. By this means a natural flow above the level of the floor of the basin is obtained, as the flow of no one of the springs would reach the natural level of the surface of the low land of French Lick Creek, in which they are located. The springs are known respectively as Nos. 1, 3, 5 and 7.

No. 7 Spring.—Of these No. 7 is the principal one. Its basin is located near one side of the bottling works, to which its waters are in part pumped. When first improved, its basin was excavated 17 feet to a hard, flinty limestone or bed rock. A large curb was sunk about the outlet, and the regulation cement-lined basin then completed. The output of the spring in September, 1901, was about 12 gallons per minute, of clear, sparkling water, having a temperature of 56½° F., and possessing a strong odor of hydrogen sulphide and the characteristic bitter taste of the saline waters of this valley. An analysis of the water of this spring was made for this paper by Dr. W. A. Noyes, of Terre Haute, who reported on it as follows:

ANALYSIS OF WATER FROM NO. 7 SPRING, WEST BADEN, INDIANA.

Bases and Acid Radicals.	*Parts to 1,000,000.*	*Grains per U. S. Gallon.*
Silica	7.6	0.443
Calcium	577.2	33.671
Magnesium	228.2	13.312
Sodium	514.1	29.990

ANALYSIS OF NO. 7 SPRING—CONTINUED.

Bases and Acid Radicals.	*Parts to 1,000,000.*	*Grains per U. S. Gallon.*
Potassium	33.9	1.977
Chlorine	798.0	46.551
Sulphate (ion)	2046.0	119.353
Carbonate (ion)	179.9	10.494
Hydrogen sulphide	32.5	1.896
Total	4417.4	257.687

Besides the above, traces of each of the following elements were found: Alumina, iron, barium, strontium, lithium, bromine, iodine, phosphate (ion), borate (ion).

These bases and acid radicals may be considered as combined in the following manner:

	Parts to 1,000,000.	*Grains per U. S. Gallon.*
Silica (SiO_2)	7.6	0.443
Calcium sulphate ($CaSO_4$)	1962.5	114.482
Magnesium sulphate ($MgSO_4$)	781.3	45.577
Magnesium carbonate ($MgCO_3$)	251.9	14.694
Potassium chloride (KCl)	64.5	3.775
Sodium sulphate (Na_2SO_4)	52.6	3.075
Sodium chloride (NaCl)	1264.5	73.745
Total solids	4384.9	255.791
	Cu. In.	*Cu. In.*
Hydrogen sulphide gas (H_2S)	32.5	4.922

This analysis shows the water to belong to the saline-sulphuretted group, and to be very similar to that of the leading springs at French Lick. The water of No. 7 Spring has been the principal one served hot to the guests at West Baden for a number of years. It has also been extensively bottled and shipped. A new company, called the West Baden Springs Water Company, has been recently formed for the purpose of distributing the waters of this and the other springs more extensively. That from No. 7 will henceforth be sold under the name of "Baden Sprudel."

No. 5 Spring.—This spring is located northeast of the bicycle track and about 20 rods east of No. 7. The floor of the circular basin surrounding it is about six feet below the level of the surface. A handsome pavilion of modern design has been erected above this spring, as well as above No. 3. In 1901 the output of the spring was about six gallons per minute, of water which bore a close resemblance in temperature, odor and taste to that issuing from No. 7. An analysis of the water from this spring was made in 1870 by Prof. E. T. Cox, with the following result:

ANALYSIS OF WATER FROM NO. 5 SPRING, WEST BADEN, INDIANA.

Bases and Acid Radicals.	*Parts per 1,000,000.*	*Grains per U. S. Gallon.*
Lime	539.11	31.436
Soda	765.26	44.622
Potash	19.37	1.129
Magnesia	610.76	35.613
Alumina	43.50	2.536
Chlorine	779.26	45.439
Carbonic acid	675.21	39.371
Sulphuric acid	601.30	35.062
Silicic acid	7.50	.437
Oxide of iron	1.50	.087
Totals	4042.77	235.734

The above constituents are probably combined as follows:

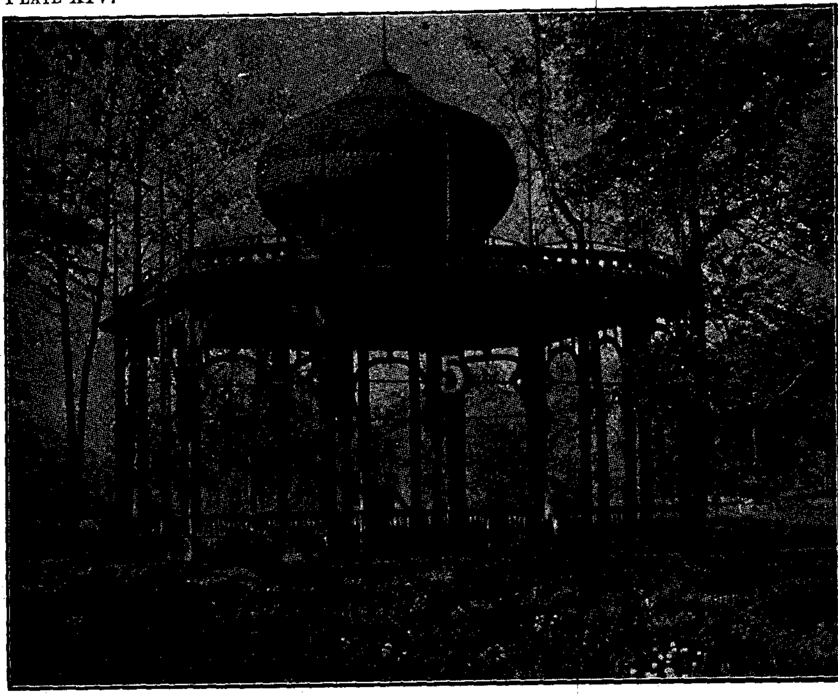
	Parts per 1,000,000.	*Grains per U. S. Gallon.*
Calcium sulphate ($CaSO_4$)	191.70	11.178
Sodium sulphate (Na_2SO_4)	53.28	3.107
Potassium sulphate (K_2SO_4)	23.48	1.369
Magnesium sulphate ($MgSO_4$)	619.83	36.142
Aluminum sulphate ($Al_2(SO_4)_3$)	77.28	4.506
Calcium carbonate ($CaCO_3$)	709.43	41.367
Sodium carbonate (Na_2CO_3)	19.08	1.113
Potassium carbonate (K_2CO_3)	10.71	.625
Magnesium carbonate ($MgCO_3$)	671.48	39.154
Calcium chloride ($CaCl_2$)	124.78	7.276
Sodium chloride ($NaCl$)	1337.18	77.971
Magnesium chloride ($MgCl_2$)	195.54	11.402
Silicic acid (H_4SiO_4)	7.50	.437
Oxide of iron (FeO)	1.50	.087
Totals	4042.77	235.734

Gases.	*Cu. In.*
Carbonic acid (CO_2)	5.163
Hydrogen sulphide (H_2S)	4.941

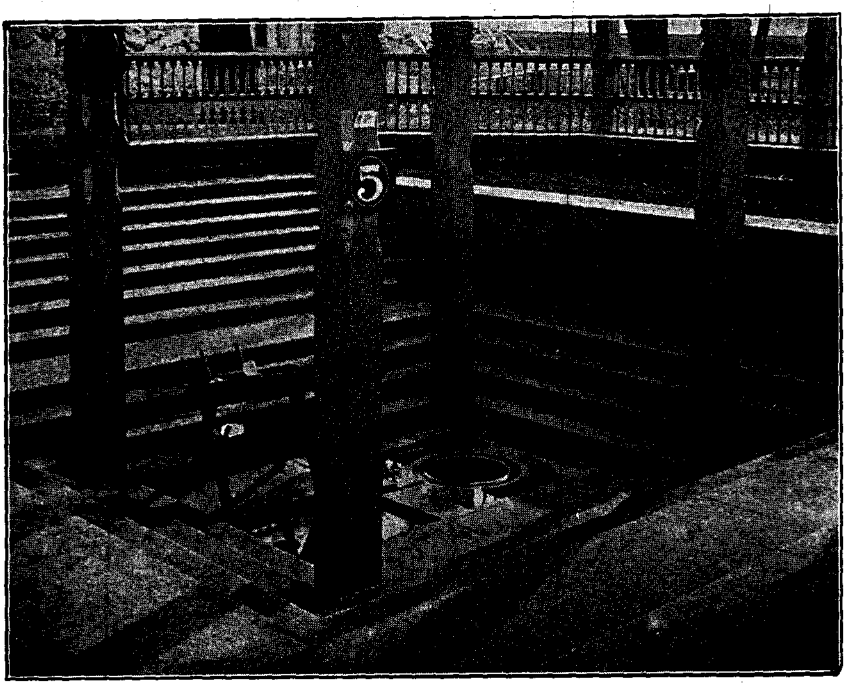
"This water, judging from the analysis, possesses the same medicinal properties as that of the French Lick Springs, but it contains less free gases and a less quantity of solid constituents in a gallon, being a difference in degree rather than in quality."—*Cox.*

No. 3 Spring.—This spring wells up about 12 rods north of No. 7. Its flow is about the same as that of No. 5, and the water possesses the same properties. The floor of the basin is seven feet below the surrounding level.

PLATE XIV.



a



b

(a) Pagoda or Spring-house, No. 5 Spring, West Baden Springs.
(b) Interior of Pagoda, Spring No. 5, West Baden Springs.

An analysis of its water, made in 1899 by Mariner & Hoskins, of Chicago, showed the presence of the following mineral compounds:

ANALYSIS OF WATER FROM NO. 3 SPRING, WEST BADEN, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	11.68
Magnesium carbonate ($MgCO_3$)	trace
Calcium sulphate ($CaSO_4$)	96.88
Magnesium chloride ($MgCl_2$)	52.96
Sodium chloride (NaCl)	20.20
Sodium sulphate (Na_2SO_4)	61.16
Total solids	242.88
	Cu. In.
Hydrogen sulphide gas (H_2S)	4.491

It will be seen that the chemists agree closely as to the amount of mineral salts present in the waters of the three leading springs at West Baden, their results being as follows:

	Total Solids. *Grains.*
No. 7 Spring—Analyzed by Noyes	255.791
No. 5 Spring—Analyzed by Cox	235.734
No. 3 Spring—Analyzed by Mariner & Hoskins	242.88

However, their individual opinions, as to the kinds of salts present and percentage of each, vary widely, as will be noted by reference to the different analyses. There is little doubt but that the waters of the three springs have a common source and approximately the same chemical ingredients, and their medicinal actions are essentially alike.

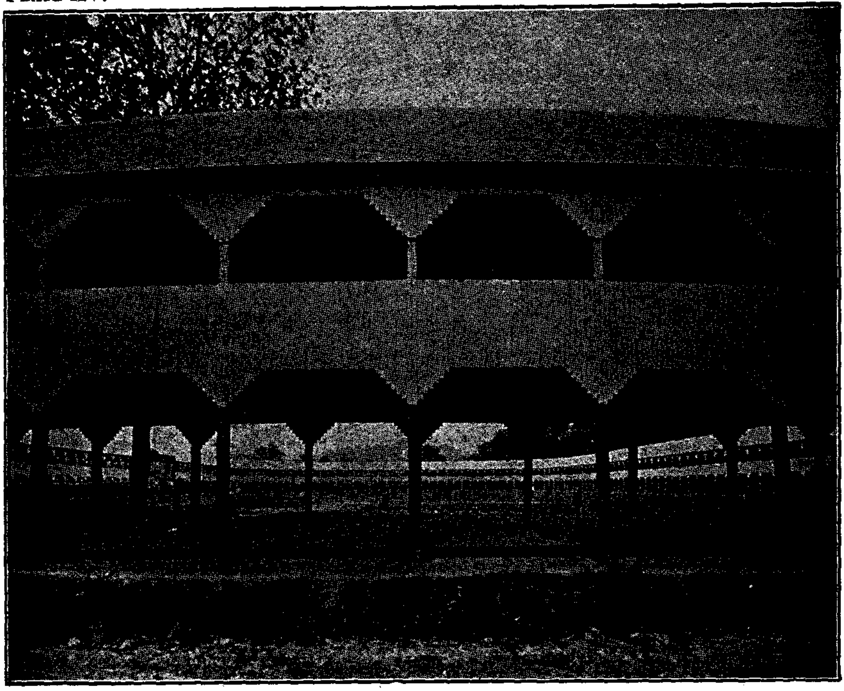
Spring No. 1.—This spring is located about half way between No. 7 and the hotel, beneath the opera house and club rooms, these buildings having been constructed above its artificial basin. The outflow is smaller than that of any of the other three, about three gallons per minute in 1901. No analysis of the water has been made. It differs but little, if any, from that of the others, though it is claimed to be a stronger diuretic.

History and Improvements.—The tract of land now including West Baden Springs was a part of that bought from the United States by Dr. Wm. A. Bowles in 1832. He sold 770 acres, including West Baden Springs, to Dr. John A. Lane in 1846. Dr. Lane erected a small hotel and gradually improved the surroundings. Hugh Wilkins controlled the place from 1864 to 1872, during which time the hotel was greatly enlarged and other substantial improvements made. In 1873 Dr. Lane again took charge and held it for 10 years, when he sold 667 acres, including the springs, for $23,000 to a company of Paoli and Salem citizens, two of whom, Messrs. E. B. Rhodes and L. W. Sinclair, in time became sole owners. By persistent advertising and improving they finally made the resort famous throughout the United States, and shortly before the fire which completely destroyed the hotel, were offered $1,000,000 for the property. This fire occurred in May, 1901. Mr. Rhodes soon after sold his share to Mr. Sinclair, who organized a stock company and contracted for a new brick and stone hotel, to cost $514,000. This was completed in the fall of 1902. The main portion of this hotel is six stories high and contains 600 rooms. A dome of steel and glass, 200 feet in diameter, covers a large rotunda in the center of the building. Each room is supplied with hot and cold water and other modern equipments.

Aside from the hotel, the improvements consist of a fine bath house, with facilities for giving all kinds of baths, and with a large natatorium attached. A gymnasium, equipped with all the paraphernalia of a modern athletic club, an opera house, billiard rooms and bowling alleys, furnish plenty of means for indoor exercise and amusement. A double-decked, covered bicycle and pony track, one-third of a mile in length, is an unique feature, furnishing, as it does, a place for cycle racing at all seasons, as well as a popular walk during inclement weather. Enclosed within the bicycle track is a baseball diamond, while tennis courts and croquet grounds are found in various places.

The West Baden Springs occupy a natural amphitheater in the valley of French Lick Creek. The hills that rise above this valley to a height of 60 to 80 feet, form a half circle back of the springs and grounds about the hotel. The slopes of these hills, as well as a large portion of the grounds, are wooded with magnificent specimens of many kinds of native forest trees. For years these grounds have been under the care of a landscape gardener. Rough pathways cut along the hillsides have given place to smooth, graveled walks, winding in and out among the stately trees. Unsightly embankments have been transformed into walled-up terraces, intersected here and there with stone stairways, on either side of which are carved pieces of statuary and urns, from which spring variegated flowers. Broad driveways leading to various points of interest throughout the country surrounding, tell of months of patient labor in hauling sand, stone and gravel with which to form the roadbeds. The new hotel but adds lustre to the beauty of these surroundings, and West Baden Springs well merit the name which they have often

PLATE XV.



a

b

(a) The double-deck track and baseball grounds, West Baden Springs.

half-mile bicycle track and promenade at West Baden Springs.

received—"The Carlsbad of America," although in chemical composition their waters differ widely from those of their European namesake.

LOST RIVER MINERAL SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—Along Lost River, between Orangeville, a village situated in the northwestern part of Orange County, and West Baden.

ORIGIN AND CHARACTER OF THE WATER.—Several mineral springs well up from the bed, or issue from the bases of the bluffs of Lost River. One of these, one mile south of Orangeville, on land owned by the Travelers' Insurance Company, south half of Section 7 (2 N., 1 W.), is in the bed of the stream, and is covered during high water. A barrel has been sunk around the orifice of the spring, and a constant stream of water, highly charged with hydrogen sulphide, overflows. No analysis of the water has been made, but its taste, odor, etc., show it to be of the same character as that of the French Lick Springs.

Wilson's Spring is located about two miles southwest of the one above described, on the west half of the southwest quarter of Section 14 (2 N., 2 W.). It is one and a half miles north of West Baden, and is owned by John H. Wilson, County Surveyor of Orange County. The spring emerges from the base of a bluff on the bank of Lost River, and has an output of about four gallons per minute. The water is very similar to that at West Baden. Another spring of the same nature is on the farm of John A. Stackhouse, adjoining that of Mr. Wilson; while a third issues a little farther down the stream on the land of Chambers Campbell.

FLAT LICK SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—On the land of Thomas Lane, west half of Section 26 (1 N., 2 W.), two miles west of Helix, a postoffice six miles southwest of Paoli and five miles southeast of French Lick, the nearest railway station.

ORIGIN AND CHARACTER OF THE WATER.—Two springs emerge from crevices in a hard white limestone near the banks of Flat Lick Creek, a tributary of French Lick Creek. The large one flows four and a half gallons per minute, and the smaller about one-half as much, of a very clear, saline water, containing much sulphuretted hydrogen. No analyses of the waters have been made. They have been used locally for stomach and kidney troubles and are of the same nature as those at French Lick.

OWEN COUNTY.

SPENCER ARTESIAN WELLS.

WATER = *Saline-sulphuretted.*

LOCATION.—Two wells yielding an artesian flow of mineral water have been put down in Spencer, and a third about one-half mile northeast of the city. Spencer, the county seat, is a city of 2,100 population, situated on White River, 53 miles southwest of Indianapolis. The I. & V. Railway passes through the city while the C., I. & L. (Monon) connects with the I. & V. at Gosport, six miles east.

The streets are broad, beautiful, shaded avenues, forming cool, delightful walks and drives, frequently terminating in shady country roads, winding among the hills, through some of the wildest and most romantic scenery of the State.

ORIGIN AND CHARACTER OF THE WATER.—The first of the wells is located three squares north of the court house, near the high school building. It was sunk in 1889 to a depth of 1,150 feet. The mineral water was found in the Niagara limestone. The head of the water was sufficient to cause it to rise 65 feet above the well mouth, or 625 feet above tide. In 1890, after the well had been drilled 100 feet deeper, the estimated flow was 200 gallons per minute.

An analysis of the water, made by Dr. J. N. Hurty, of Indianapolis, revealed the presence of the following mineral salts:

ANALYSIS OF WATER FROM SPENCER ARTESIAN WELL.

	Grains per U. S. Gallon.
Calcium sulphide (CaS)	.393
Potassium sulphide (K_2S)	1.906
Sodium sulphide (Na_2S)	.940
Calcium carbonate ($CaCO_3$)	12.222
Magnesium carbonate ($MgCO_3$)	2.386
Sodium carbonate (Na_2CO_3)	4.162
Calcium chloride ($CaCl_2$)	8.110
Potassium chloride (KCl)	18.113
Sodium chloride ($NaCl$)	66.813
Magnesium chloride ($MgCl_2$)	5.031
Silica (SiO_2)	.360
Ferric oxide (Fe_2O_3)	.553
Alumina (Al_2O_3)	.713
Total solids	121.702
Gases.	*Cu. In.*
Hydrogen sulphide (H_2S)	1.796
Carbon dioxide (CO_2)	11.294

In September, 1901, the water, after flowing a square underground and emerging at a fountain at the corner of the high school yard, had a temperature of 64° F. The taste was an agreeable saline-sulphur. The odor of hydrogen sulphide was not strong.

A second well, sunk in the court house yard, at a level of 20 feet below that of No. 1, found the same water at 1,150 feet. The pressure of the outflowing stream is 62 pounds per square inch, and the output 350 barrels per hour, having a temperature of 66° F. The water from this well is used for drinking purposes, at three fountains in the court house yard, for street sprinkling purposes, etc. It is also supplied to the Central Sanitarium and Hotel.

The third well, put down on the farm of Calvin Fletcher, developed a smaller flow of the same water at a depth of 1,300 feet. It is not now utilized.

IMPROVEMENTS.—A large sanitarium and bath house was erected near the first well, at a cost of $20,000, and was in operation from 1890 to 1897. It was well patronized, having at times 100 or more patients. A change of ownership, and resulting change of parties in charge, caused dissatisfaction, litigation, etc., until the place was abandoned. It is now uninhabited and in a bad condition. If repaired and taken in charge by a good physician, it could, without much doubt, be made a paying institution, as the water is well worthy a more extended medicinal use than it is now receiving.

The "Central Mineral Springs Sanitarium and Hotel" is located on the east side of the public square, within one block of the railway station. It contains 24 rooms for guests and a well-fitted bath house, with facilities for mineral, vapor, Russian, shower and needle baths. The mineral water is piped from the well in the court house yard. Both hotel and bath rooms are steam-heated and are open to guests the year around.

GOSPORT ARTESIAN WELL.

WATER=*Saline-sulphuretted* (?).

LOCATION.—Within one block of the railway station at Gosport, a town of 750 population, located on White River, at the crossing of the I. & V. and C., I. & L. (Monon) railways, 44 miles southwest of Indianapolis, 204 miles southeast of Chicago, and 119 miles northwest of Louisville.

ORIGIN AND CHARACTER OF THE WATER.—A well 936 feet in depth was, in the autumn of 1895, bored by a citizens' stock company in the valley of a small tributary of White River, near the eastern side of the town. The well is cased about 500 feet to shut out salt water. A strong flow of "white sulphur" water was struck near the bottom of the bore, presumably in Niagara limestone. This water will flow freely at the top of a pipe 30 feet above the mouth of the well, or 610 feet above tide. In October, 1901, the flow was about 20 gallons per minute. As it issues from the discharge pipe it is quite clear, but becomes milky almost instantly, on account of the escaping bubbles of gaseous hydrogen sulphide and the resulting deposition of free sulphur. The water has the odor and taste of similar sulphur waters, but does not contain as much sodium chloride (common salt) as many of them. Its temperature is 63½° F. No analysis of the water has been made. It is quite similar, however, to the mineral waters at Martinsville and Spencer, and its medicinal effects are practically the same.

The stock company which sunk the well gave it to a smaller company of citizens on condition that a sanitarium and bath house be erected. This was done at a cost of $6,800, and was in successful operation until November, 1901, when it was destroyed by fire. The owners have not yet decided whether it will be rebuilt or not.

PARKE COUNTY.

MONTEZUMA ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—On the east bank of the Wabash River, in the southern part of Montezuma, a town of 1,200 population, situated on the C., I. & W. Railway, 67 miles west of Indianapolis; and within two miles of Hillsdale, a station on the C. & E. I. Railway, 155 miles south of Chicago and 23 miles north of Terre Haute. Also within one and a half miles of the C., I. & W. Crossing, a station on the Brazil Division of the C. & E. I. Railway.

ORIGIN AND CHARACTER OF THE WATER.—The bore producing the water was sunk in 1889, in search of gas, to a depth of 1,686 feet. It is located on a tract of nine and one-half acres of land abutting the channel of the Wabash River and about 30 feet above low water mark. At a depth of 298 feet in the bore a small vein of salt water was struck, and another at 450 feet, both of which had sufficient head to rise to the surface. At 1,200 feet, in a limestone immediately below the Devonian shales, the present flow of mineral water was developed. In a test it was shown that the water would rise in and overflow from a one and one-half-inch pipe 80 feet above the well opening, or 573 feet above tide.

An analysis of the water by Dr. W. A. Noyes, of Terre Haute, showed the mineral constituents to be as follows:

ANALYSIS OF WATER FROM THE MONTEZUMA ARTESIAN WELL.

	Grains per U. S. Gallon.
Calcium chloride	11.655
Calcium sulphide	3.553
Calcium sulphate	7.117
Calcium bi-carbonate	11.183
Magnesium chloride	9.975
Magnesium bi-carbonate	17.885
Potassium chloride	2.683
Sodium chloride	357.710
Silica	0.828
Alumina	0.070
Total solids	422.659
	Cu. In.
Hydrogen sulphide gas (H_2S)	9.678

In addition to the above, traces of strontium sulphate, calcium phosphate, lithium chloride, sodium bromide, sodium iodide and borax were present.

The flow of water has diminished little, if any, since the well was completed. In August, 1901, it was estimated at 17,000 barrels per day, or about 472 gallons per minute. The odor of hydrogen sulphide in the vicinity of the well is strong, but the taste, modified by the sodium chloride and other salts, is rather agreeable, and becomes more so by use. The temperature of the issuing water is 72° F. It is useful for catarrh, rheumatism, skin diseases and all other ailments for which mineral waters of a similar kind are used.

IMPROVEMENTS.—In 1890 a large frame hotel and sanitarium was erected on the grounds. A swimming pool 132x72 feet in size, nine feet deep at one end and gradually sloping to two and a half feet at the other, was excavated and lined with cement. Bath houses were built along one side of the pool. A steam-heated bath house, with 35 tubs, was also erected for use by invalids and when the water of the pool was too cool. The sanitarium was run successfully for several years, but dissensions finally arose between the proprietor and the citizens of Montezuma, and these, with a failure to properly advertise, caused the closing of the sanitarium. It is now used as a tenement house, and is in poor repair. The entire property was sold in 1900 to the present owner, Mr. G. W. Hughes, of Hume, Illinois, for $3,000.

The pool is still much frequented during the summer months. A charge of 25 cents is made for each bath therein, which includes the rental of bathing suit. During the month of July, 1901, the revenue from this source was $156.00.

The water is shipped to all who request it, but the demand is not as great as during the time the sanitarium was open. It brings $1.00 per barrel, or 10 cents per gallon on board the cars. This does not include the cost of receptacle. To the citizens of Montezuma it is free, and a large local use is made of it.

PIKE COUNTY.

COATES' SPRINGS.

WATER = *Alkaline-saline-chalybeate.*

LOCATION.—On the land of S. S. Shannon, southeast quarter Section 10 (1 S., 9 W.), eight miles southwest of Petersburg, the county seat, on the E. & I. Railway; eight miles northwest of Oakland City, on the St. Louis Division of the Southern Railway; 15 miles northeast of Princeton. Carriages or other conveyance may be obtained at these towns at reasonable rates. Postoffice, Coates' Springs. Daily mail.

ORIGIN AND CHARACTER OF THE WATER.—Three springs are found on the grounds. The one whose waters are most noted is located a few rods from the hotel, on the side of a gentle slope. The water is in a well-like basin, which has been excavated in sandstone rock. A section from the surface to the bottom of the spring is as follows:

	Ft.	*In.*
(1) Soil and yellow clay	4	..
(2) Sandstone	2	6
(3) Black sheety bituminous shale	0	4
(4) Sandstone	?	

A cavity two and a half feet in depth has been cut in the lower sandstone, which holds the water. The latter is drawn to the surface, as needed, in a bucket. It probably derives most of its mineral constituents by leaching through the black shale, which is rich in pyrites of iron and alumina.

These springs were formerly known as the West Saratoga Springs. The only analysis of the water available was under that name in Peale's "Mineral Waters of the United States."* It is accredited to E. T. Cox, and gives only the percentage of bases and acid radicals present, as follows:

*Bulletin 32, U. S. Geological Survey, 1886, p. 140.

ANALYSIS OF WATER FROM COATES' SPRING.

Bases.	*Grains per U. S. Gallon.*
Calcium oxide	2.024
Sodium and potassium	.142
Ferric oxide	1.874
Alumina	.183
Acid Radicals.	
Chlorine	1.049
Sulphuric acid	7.289
Phosphoric acid	.533
Insoluble matter	.466
Total solids	13.560

This combination of bases and acid radicals denotes that the principal salts present are iron sulphate, aluminum sulphate and calcium carbonate. The presence of the first two is clearly indicated by the taste, which is quite bitter and astringent. The water is clear and has a temperature of 64° F. It is said "to be very beneficial in malarial troubles; also in inflammatory rheumatism. When taken in quantity it usually acts as a purgative. Being especially strong in sulphates and iron, it should be taken only on the advice of a physician." It is shipped, when desired, at a rate of 10 cents per gallon. The same price is charged when taken away from the premises.

A second spring issues from a hillside about 100 yards southeast of the one above described. Its water has been piped some distance and issues in a stone basin arranged as a receptacle. No analysis was available. Judging from the taste, it contains only iron and calcium carbonates, and is, therefore, an ordinary chalybeate water. Its temperature is 63° F., and the flow about three gallons per minute.

A third spring, a short distance north of the hotel, possesses also a chalybeate water of less strength. The waters of both these minor springs are valuable chiefly as a diuretic, and in cases of anæmia, or poverty of the blood.

History and Improvements.—Coates' Springs were first opened to the public in 1867 by the Hon. James A. Coates, then owner. They were under control of the present proprietor, S. S. Shannon, from 1871 to 1885, and gained quite a renown, being much frequented by citizens of Evansville, Vincennes and other places in southwestern Indiana. The farm was then leased to other parties, who gave little attention to the mineral waters. In 1900 they were again opened as a resort. The hotel has accommodations for 40 guests. There are good bowling alleys, croquet grounds, dancing pavilions, etc., while the spacious lawns and good country roads furnish excellent facilities for riding and driving. Many campers and picnic parties visit the place and partake of the waters. The hotel is open from May to November, though guests will be taken at any season.

SWEET SULPHUR SPRINGS.

WATER = *Alkaline-saline-sulphuretted.*

LOCATION.—Two miles north of Velpen, a station on the St. Louis Division of the Southern Railway, 84 miles west of Louisville; 189 miles east of St. Louis, and 57 miles northeast of Evansville. The railway makes a rate of one and one-third fare round trip for visitors to the springs during the season. Conveyances from the springs meet all day trains. They also meet night trains when notified in advance.

ORIGIN AND CHARACTER OF THE WATER.—Three springs issue about 100 feet apart from the base of a gentle slope, which rises to the west, 30 feet above their level. In Spring No. 1 the water rises in a stone basin one foot above the surface, and the flow is about four gallons per minute. In Spring No. 2 it does not flow, but is pumped. In No. 3 it flows, but only about one and one-half gallons per minute.

Analyses of the water from each of the springs have been made by L. D. Kastenbine, Professor of Chemistry, Louisville Medical College, who reported the presence of the following mineral salts:

ANALYSES OF WATERS FROM THE SWEET SULPHUR SPRINGS, PIKE COUNTY, INDIANA.

	Grains per U. S. Gallon.		
	No. 1.	*No. 2.*	*No. 3.*
Calcium sulphate ($CaSO_4$)	47.159	18.136	38.952
Magnesium sulphate ($MgSO_4$)	32.165	42.054	27.558
Calcium carbonate ($CaCO_3$)	25.617	28.347	32.521
Magnesium carbonate ($MgCO_3$)	2.821	2.154	.....
Ferrous carbonate ($FeCO_3$)	.....	1.924	2.110
Sodium chloride (NaCl)	2.498	1.693	3.847
Potassium chloride (KCl)	0.107	0.303	0.971
Silica (SiO_2)	0.091	0.876	0.752
Alumina (Al_2O_3)	.015	0.126	.011
Total solids	110.473	95.613	106.722
Gases.	*No. 1.*	*No. 2.*	*No. 3.*
Carbonic acid (cu. in.)	4.843	5.987	4.197
Hydrogen sulphide (cu. in.)	1.386	.....	1.911

The temperature of the waters in September, 1901, was 63° F., 63½° F. and 68° F., respectively. The taste of all is quite similar, being a bitter sulphur. The odor of hydrogen sulphide is present in all, though probably a little stronger in No. 3. The water will be found a good remedy in excessive acidity of the stomach on account of the small amount of sodium chloride and fair amounts of sulphates and carbonates. It is served hot, when desired, in a small building located near the springs.

Improvements.—A frame hotel, with accommodations for 80 guests, stands on the high ground west of the springs. The water is pumped by a gasoline engine into tanks, thence into the bath house, where it is heated. There are six well equipped bath rooms. A bowling alley, pool and billiard room, croquet grounds, dancing hall, etc., furnish facilities for amusement and exercise. A very pretty grove of native forest trees occupies a portion of the lowland to the east. The property belongs to the heirs of Charles Fisher, the former proprietor, who died a few years ago. It is now run under the management of Edward Fisher, 712 Twenty-third Street, Louisville, Kentucky. The hotel is open to guests from June 1st to October 1st. The majority of the visitors are from Louisville, St. Louis, Evansville and other points on the "Air Line" Railway.

* * *

Besides the springs above described, the following are mentioned by Dr. John Collett, in his paper on the "Geology of Pike County."* The time at our disposal would not allow of their visitation.

"'Miller's Ague Spring,' Section 5 (1 S., 6 W.), is locally known as a 'cure' for that disease. The waters are a saline chalybeate, flowing out of ferruginous beds of sandstone. Their qualities are highly esteemed by those who have tried them.

"'Milburn's Spring,' T. C. Milburn, proprietor, situated on the southeast quarter Section 35 (1 S., 7 W.), has a high reputation in that vicinity as a remedy for diseases of the stomach, bowels, kidneys and of the skin. It is generally known as the 'ague cure,' but is reputed as still more efficacious in derangements of the liver and digestive organs. Many certificates from reputable persons indicate especial virtue in cases of gravel and rheumatism. At the time of my visit, not less than 20 persons were drinking the water, and it was being hauled away so extensively as to almost exhaust the receiving cask. It contains salts of soda, magnesia and iron, with traces of bromine and arsenic. The spring flows out at about the level of coal K, the shales and roof stones of which are near by."

*Geological Survey of Indiana, 1872, pp. 265, 286.

PORTER COUNTY.

PORTER ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—On the grounds of the Chicago Hydraulic Press Brick Company at Porter, a town at the junction of the Lake Shore and Michigan Southern, Michigan Central and E., J. & I. railways, 40 miles east of Chicago and 12 miles southeast of Michigan City.

ORIGIN AND CHARACTER OF THE WATER.—This well was bored in search of gas to a depth of 860 feet. At present it flows about 60 gallons per minute of water that is highly charged with hydrogen sulphide, as well as with the following mineral salts:

ANALYSIS OF WATER FROM THE PORTER ARTESIAN WELL.

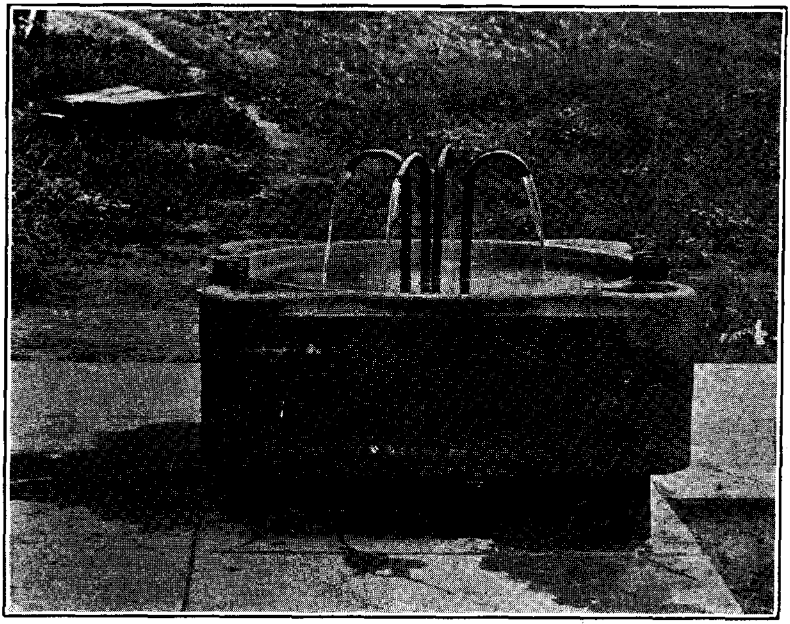
	Grains per U. S. Gallon.
Sodium chloride ($NaCl$)	208.76
Calcium chloride ($CaCl_2$)	51.93
Magnesium chloride ($MgCl_2$)	38.71
Ammonium chloride (NH_4Cl)	0.44
Potassium chloride (KCl)	13.18
Potassium sulphate (K_2SO_4)	17.08
Calcium carbonate ($CaCO_3$)	11.14
Silica (SiO_2)	1.10
Total solids	342.34

This analysis was made by Dr. J. H. Salisbury, Professor of Chemistry in the Women's Medical College, Northwestern University, who speaks of the water as follows: "The water from Porter is very free from injurious organic matters. It is very useful for drinking at the well in cases which need alterative or laxative treatment, and is also useful for baths and for sanitarium purposes. Its sulphuretted hydrogen will not be long retained if exposed to the air."

* * *

The Blair artesian well is also located in the northwestern corner of Porter County. It is, however, so near to Michigan City that its waters have been described on a previous page under the head of Laporte County.

PLATE XVI.



WINAMAC ARTESIAN MINERAL WELL, WINAMAC, PULASKI COUNTY, INDIANA.

PULASKI COUNTY.

WINAMAC ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—On the west bank of the Tippecanoe River, two squares northeast of the court house at Winamac, a town of 1,700 population, situated on the P., C., C. & St. L. Railway, 92 miles southeast of Chicago and 103 miles northwest of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—The well producing the artesian flow was sunk by a citizens' stock company in 1889, to a depth of 1,260 feet. The vein of mineral water was developed in a limestone, 205 feet below the surface. When the bore was found to be devoid of gas it was plugged just below the vein of water, and the latter then rose about four feet above the surface of the terrace or second bottom of the Tippecanoe, on which the well is situated. This terrace is about 12 feet lower than the level of the city to the westward.

In October, 1901, the water was flowing at the rate of 20 gallons per minute. It was very clear and had a slight odor of hydrogen sulphide, which issues in sufficient quantity to keep the stone basin into which the water falls from the discharge pipes coated white with free sulphur.

A partial analysis of the water, made in the laboratory of the School of Mines of the University of Missouri, resulted as follows:

Bases.	*Grains per U. S. Gallon.*
Iron oxide	.082
Alumina	1.056
Magnesium	2.622
Calcium	.395
Sodium	2.339
Potassium	3.215

Acid Radicals.

Sulphates—large amount.
Chlorides—small amount.
Carbonates—medium amount.
Nitrates—trace.

The total solids are said to approximate 500 parts in 1,000,000. The water issues with a temperature of 53½° F. It has the slightly bitter taste of magnesium sulphate and kindred salts. Small quantities are shipped from time to time to parties in Indianapolis, Chicago and Crown Point, who are much pleased with its beneficial action in kidney and liver troubles. It is also said to be especially useful in dissolving uric acid crystals by diluting the urine.

The well is situated directly opposite a wooded tract on the east bank of the Tippecanoe, which is utilized as a private park, but which could be secured for sanitarium purposes. The river offers exceptional advantages for boating and fishing.

MUDGE ARTESIAN WELL.

WATER=*Alkaline-sulphuretted.*

LOCATION.—On the land of E. T. Mudge, southeast quarter Section 30 (31 N., 4 W.), Pulaski County, Indiana; two miles northwest of Medaryville, a station on the Michigan City Division of the C., I. & L. (Monon) Railway, 65 miles southeast of Chicago. The railway passes one mile east of the well.

ORIGIN AND CHARACTER OF THE WATER.—A well sunk for oil in the spring of 1902, passed through 70 feet of drift material, composed of sand, gravel and clay, then through 25 feet of black Genesee shale, and developed in the underlying Corniferous limestone, at a depth of 109 feet, a strong vein of mineral water. This water rose with such force above the surface that it put a stop to farther drilling, and the flow has continued unabated at the rate of about 40 gallons per minute.

An analysis of the water made by Dr. W. A. Noyes, of Terre Haute, resulted as follows:

ANALYSIS OF WATER FROM THE MUDGE ARTESIAN WELL, PULASKI CO., INDIANA.

Bases and Acid Radicals.	*Grains per U. S. Gallon.*
Silica (SiO_2)	0.560
Alumina (Al_2O_3)	0.099
Ferrous oxide (FeO_2)	0.011
Calcium (Ca)	2.648
Magnesium (Mg)	1.202
Potassium (K)	2.683
Sodium (Na)	3.943
Chlorine (Cl)	3.290
Sulphate (SO_4)	0.280
Carbonate (CO_3)	7.688
Hydrogen sulphide (H_2S)	1.277
Total	23.681

The above constituents may be considered as combined as follows:

	Grains per U. S. Gallon.
Silica (SiO_2)	0.560
Alumina (Al_2O_3)	0.099
Ferrous carbonate ($FeCO_3$)	0.023
Calcium carbonate ($CaCO_3$)	4.731
Magnesium carbonate ($MgCO_3$)	2.526
Potassium carbonate (K_2CO_3)	4.363
Potassium sulphate (K_2SO_4)	0.507
Sodium chloride (NaCl)	5.419
Sodium carbonate (Na_2CO_3)	4.176
Total	22.404

Hydrogen sulphide gas (H_2S), 3.31 cu. in. per U. S. gallon.

Besides the above there were present in the water traces of titanium oxide, strontium sulphate, lithium carbonate, sodium phosphate, and sodium borate. The water is alkaline and contains a high amount of potassium in proportion to the sodium.

As it issues from the well it is clear and sparkling, with a slight but distinct odor of hydrogen sulphide. The well is much frequented by residents of the vicinity, who speak highly of the exhilarating or stimulating effects of its water. It will be found useful for bathing purposes, skin diseases and as an aperient. The well is situated on the north edge of a natural grove, which will furnish a delightful site for a sanitarium.

PUTNAM COUNTY.

McLEAN'S SPRINGS.

WATER = *Alkaline-chalybeate.*

LOCATION.—One and a fourth miles southwest of the court house at Greencastle, the county seat, a city of 3,700 population, situated 39 miles west of Indianapolis, 178 miles south of Chicago, and 145 miles north of Louisville, on the T. H. & I. (Vandalia), St. Louis Division of the Big Four and C., I. & L. (Monon) railways.

ORIGIN AND CHARACTER OF THE WATER.—Four springs, flowing about two gallons a minute each, issue a few rods apart from crevices at the junction of the Mansfield sandstone and the underlying subcarboniferous limestone, on the east half Section 29 (14 N., 4 W.). The springs are in a fine grove of native timber, which is much frequented by picnic parties. This grove is along the south side of the Vandalia Railway, one-half mile west of the city station on that line, and about the same distance northeast of Limedale, the junction of the Monon and Vandalia railways. The springs have been named the

"Daggy," "McLean," "Diamond" and "Dewdrop." The waters from the Daggy and Dewdrop springs were analyzed by Prof. E. T. Cox, and the results published in the report of this department for 1870, pp. 121-124:

ANALYSES OF WATERS FROM "DAGGY" AND "DEWDROP" SPRINGS, NEAR GREENCASTLE, INDIANA.

	Daggy.	*Dewdrop.*
Ferrous carbonate ($FeCO_3$)	.398	2.381
Calcium carbonate ($CaCO_3$)	14.148	11.883
Sodium carbonate (Na_2CO_3)	.099	.071
Potassium carbonate (K_2CO_3)	.087	.074
Magnesium carbonate ($MgCO_3$)	4.700	5.335
Sodium sulphate (Na_2SO_4)	.133	.099
Magnesium sulphate ($MgSO_4$)	1.050	1.036
Sodium chloride (NaCl)	.793	.695
Silica (SiO_2)	.087	.004
Alumina (Al_2O_3)	.157	.074
Loss and undetermined	.093	.228
Total solids	22.157	21.884
	Cu. In.	*Cu. In.*
Carbonic acid gas (free)	3.005	2.98

"When fresh from the springs the water sparkles with the surcharge of carbonic acid gas and is cool and pleasant to the taste The temperature of the Daggy Spring is 56° F.; that of the Dewdrop, 52° F. The water of the Diamond Spring partakes of the character of the other two. It has a temperature of 51° F. at the fountain head; is alkaline to test-paper after standing a short time, and contains 21.0 grains of solid constituents in a U. S. gallon."

For a number of years the water of these springs was bottled and shipped to various points. Through a lack of advertising the demand gradually diminished and the shipment was finally abandoned. The purity and the character of the water and the pleasing natural surroundings merit a more extended use, and would justify the erection of a large hotel and sanitarium, which would doubtless soon become a popular resort for invalids and those who seek a healthful and cool retreat from the cares of business during the summer months.

MAHAN'S SPRING.

WATER = *Chalybeate.*

LOCATION.—On the northwest quarter Section 28 (14 N., 4 W.), about one-half mile east of McLean's Springs, described above, and one-quarter of a mile south of the Vandalia Railway station at Greencastle.

ORIGIN AND CHARACTER OF THE WATER.—This spring formerly issued as a seep, but a basin was dug out and otherwise improved a few years ago, and the water was then bottled and delivered to residents of Greencastle at a fixed price. The water is not sold at present but the spring is much frequented by residents and students. A large deposit of iron oxide from the water has been formed in and below the spring and the taste of this oxide is plainly perceptible in the water. The flow approximates 100 gallons per hour.

REELSVILLE ARTESIAN WELL.

WATER = *Saline-sulphuretted.*

LOCATION.—On the east side of the village of Reelsville, a station on the T. H. & I. (Vandalia) Railway, 47 miles west of Indianapolis, and 26 miles east of Terre Haute.

ORIGIN AND CHARACTER OF THE WATER.—This well, which for a number of years produced a fine artesian flow of mineral water, is situated on the west bank of the Walnut fork of Eel River, 18 feet above low water mark. It was sunk for oil about 1865. At a depth of 1,240 feet, in a hard cherty limestone, there resulted a strong flow of white sulphur water highly charged with sulphuretted hydrogen gas, and containing chlorides of sodium, calcium and magnesium; also sulphites of the same bases with traces of bromine and iodine. It had a pleasant saline, sulphurous taste and pungent odor, and was found to have great medicinal efficacy in cases of dyspepsia, rheumatism and ague.

During the historic "flood" of August, 1875, the overflow from the river washed sand and gravel into the bore and stopped to a large extent the flow. The water continued to ooze out until 1898, when some schoolboys placed rocks in the pipe and stopped the flow entirely. It could be readily opened if so desired.

SNOWDEN SPRINGS.

WATERS = *Alkaline-sulphuretted, and Chalybeate.*

LOCATION.—On the land of James Van Hook, northwest quarter of northeast quarter of Section 6 (15 N., 3 W.), about two miles northeast of Bainbridge, a town of 450 population, situated on the C., I. & L. (Monon) Railway, 170 miles southeast of Chicago. Roachdale, a station at the crossing of the Monon and C., I. & W. railways, 35 miles west of Indianapolis, is six miles north of the springs.

ORIGIN AND CHARACTER OF THE WATER.—Four springs issue from clefts in the Riverside sandstone, on the sides of a ravine. This ravine is 30 to 40 feet in depth and at the point where the springs issue only the same in width. It has been cut through the sandstone by a stream which has its source in these springs and others farther up, and which now flows in a sinuous course over the rocky bottom of the ravine, for a quarter of a mile or more, when it empties into Big Walnut Creek, one of the best bass fishing streams in the State.

At the point where the springs issue the sides of the bluff are precipitous and bend in a curve toward the northwest. A "white sulphur" spring, flowing two gallons per minute of clear sparkling water, issues on the west side, just below the bend and ten feet above the bottom of the ravine. The odor and taste of hydrogen sulphide is noticeable but slight. Enough is present, however, to coat with free sulphur some of the objects near the point of issue. On December 30, 1901, the temperature of the water was 47° F.; that of the air being 41° F.

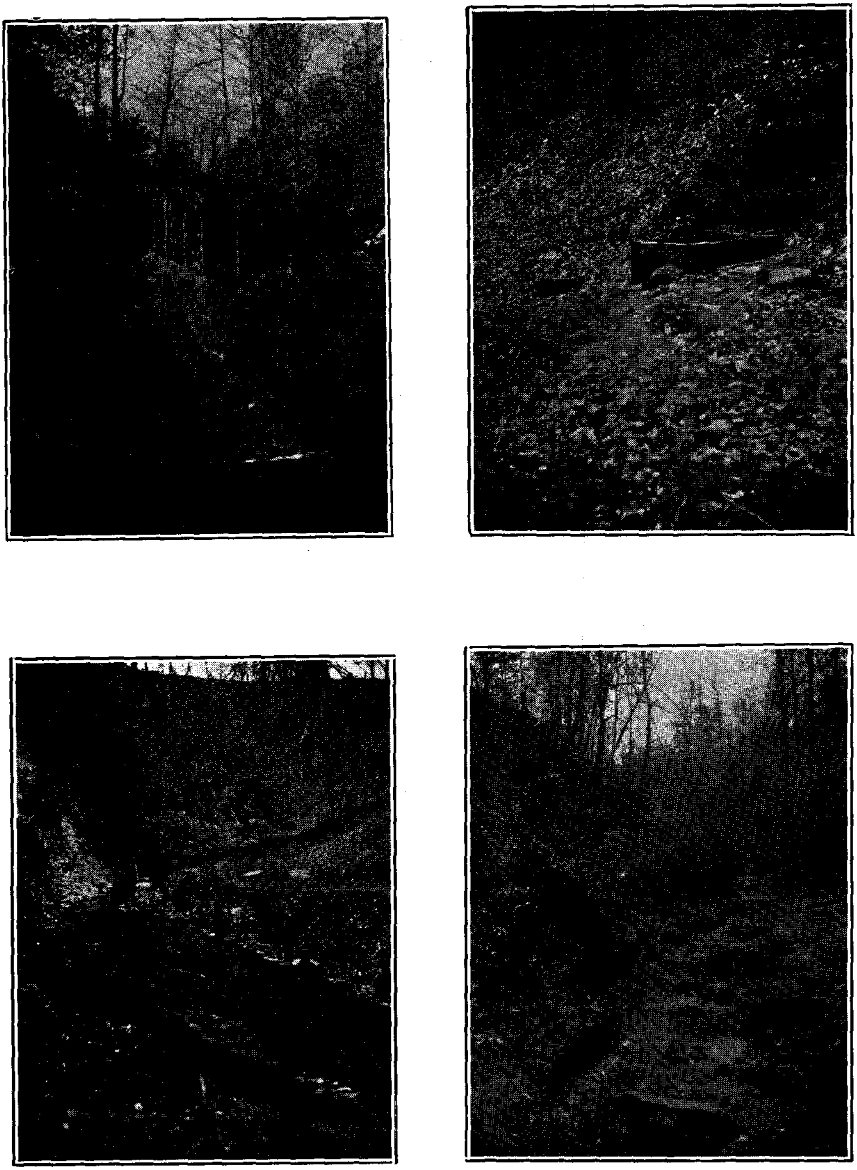
Directly across from this spring, on the east side of the ravine, 35 feet distant and a foot or two higher, a second spring of crystal chalybeate water issues from another cleft. A basin has been cut out in the stone ledge at the point of emergence and the water overflowing from this falls down the side of the ravine, coating everything with a heavy deposit of brownish-yellow oxide of iron. The output of this spring, on the date mentioned, was about two gallons per minute, having a temperature of 48° F.

On the north side of the ravine, at the point of the bend, and about 40 feet distant from the springs above mentioned, the third and fourth springs issue from a long crevice, and flow over a ledge of sandstone into the stream below. These springs are but three feet apart, yet their waters are different in character and of a different temperature, that of the west spring being a "black sulphur" water, with a temperature of 45° F., while the eastern spring produces a

PLATE XVII.

a

b



c

d

VIEWS IN THE VICINITY OF SNOWDEN'S SPRINGS.

(a) Starr's Falls, one-third mile south of the springs.
(b) The White Sulphur spring.
(c) and (d) Two views in the ravine in which the springs are located.

strong chalybeate water, with a temperature of 48° F. It is probable that the temperature of all of these springs varies three or four degrees during the year. That of the "black sulphur" water, in Spring No. 3, was the coldest water tested in the State.

The region within a mile or two of these springs contains some of the wildest and most picturesque scenery of central Indiana. Less than half a mile to the northeast is the "devil's backbone," a long ledge of rock, in places less than three feet in width, and with precipitous sides, dropping down 60 or more feet to the depths below. Here is one of the few spots in Indiana where the hemlock, *Tsuga canadensis* (L.), grows in its natural state, while the American yew, *Taxus minor* (Michx.), trails over the rocky sides of the gulch and flourishes in the deep, cool shade of its more majestic relative.

Other scenes of interest abound in the vicinity; while the nearness of Big Walnut Creek furnishes excellent fishing and boating facilities. Taking into consideration the quantity, quality and variety of the waters at Snowden's Springs, and the beauty of their natural surroundings, no better site for the erection of a large sanitarium and summer resort exists in Indiana.

ROACHDALE MINERAL SPRING.

WATER=*Chalybeate.*

LOCATION.—On the land of Albert Couck, one-third of a mile southwest of the center of Roachdale, a town of 1,000 population, situated at the crossing of the C., I. & L. (Monon) and the C., I. & W. railways, 35 miles west of Indianapolis, and 162 miles southeast of Chicago.

ORIGIN AND CHARACTER OF THE WATER.—A spring wells up in a low spot in a blue grass pasture, with a flow of about two gallons per minute. An excavation three feet in depth and walled with brick contains the water, which is clear and odorless, but has the characteristic taste of iron carbonate, and a heavy yellowish brown deposit of the same about the side of the rill bearing away the overflow. No analysis of the water has been made. Its temperature is 50° F., and it is much used by a number of the citizens of the town, who claim for it superior medicinal virtues.

* * *

A number of other chalybeate springs occur throughout the county, the waters of which are used locally. Among the most important of these are several springs just south of Brick Chapel, in Section 29 (15 N., 4 W.). Their water is similar in taste and appearance to that of McLean's Springs at Greencastle.

At Brick Chapel there is a well 25 feet deep, near the store; one 120 feet deep at the school house, and a third 140 feet deep at the cemetery, all of which furnish strong chalybeate water similar to that in the springs just south of the village. The water is used locally for household purposes. The two deep wells are reported to have penetrated 25 feet through glacial drift into and through a limestone and "flinty rock" into a soft blue rock which is probably the Knobstone.

RIPLEY COUNTY.

JOHNSON MINERAL SPRING.

WATER = *Chalybeate.*

LOCATION.—Three miles southeast of Versailles, on the land of Chas. Johnson, northwest quarter of the southeast quarter of Section 20 (7 N., 12 E.). Milan, the nearest railway station, is distant seven miles northeast from the spring. It is on the B. & O. S.-W. Railway, 42 miles northwest of Cincinnati.

ORIGIN AND CHARACTER OF THE WATER.—This spring, the only one of its character in the southeastern part of the State, emerges from the base of a mass of glacial drift which rises 30 feet above the level of the surrounding region. The flow at the surface is weak, but this is caused, in part at least, by the soaking away of the water in the loose soil. The flow could be largely increased by piping the outlet and conveying all the water into one receptacle. That the water is heavily charged with iron is shown by the large reddish-brown deposit of iron carbonate along the stream flowing from the spring. Its waters are now used locally, but for a long time were believed to be poisonous to both man and beast.

RUSH COUNTY.

CLARK ARTESIAN WELL.

WATER = *Saline.*

LOCATION.—One mile southeast of Carthage, a town of 1,100 population, situated on the Michigan Division of the Big Four Railway, 37 miles east of Indianapolis.

ORIGIN AND CHARACTER OF THE WATER.—This well was bored for gas in 1888 to a depth of 860 feet. It produced quite a quantity of gas, and at the same time a large flow of mineral water, until 1898, when the gas supply became exhausted. The water still flows and is much used locally for affections of the kidneys. An analysis by Prof. J. W. Shepherd, of Terre Haute, Indiana, showed its mineral constituents to be as follows:

ANALYSIS OF WATER FROM CLARK ARTESIAN WELL, NEAR CARTHAGE, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride ($NaCl$)	4101.2
Calcium chloride ($CaCl_2$)	2188.94
Alumina (Al_2O_3)	413.0
Magnesium chloride ($MgCl_2$)	203.2
Ferrous carbonate ($FeCO_3$)	30.85
Potassium chloride (KCl)	19.42
Calcium sulphate ($CaSO_4$)	15.88
Calcium carbonate ($CaCO_3$)	1.89
Total solids	6974.38

This water is remarkable chiefly on account of the large amount of chlorines and chlorides it contains.

* * *

A number of flowing wells have been sunk in the western part of the city of Rushville, the county seat, which yield a chalybeate water of good quality. The source of this water is a fine white sand. This is overlain with an impervious bed of blue clay called "hard pan," 14 to 15 feet in thickness. Above the blue clay are six to eight feet of soil, yellow clay and gravel. In the words of Dr. M. N. Elrod, "These artesian chalybeate wells of West Rushville are curious examples of subterranean streams or sheets of mineral water, held down by the impervious blue clay. The wells are dug in the usual manner, or dug a few feet and then bored through the clay. The water is found in the fine gravel or white sand overlying the bed rock. Pump logs were placed in some of the wells and tamped with clay until the water was forced to flow through the log. The quantity of water discharged was never great, and additional wells seemed to weaken the flow of those previously dug, indicating that the water probably comes from a compact saturated bed of sand that slowly gives up its superabundant moisture."

SHELBY COUNTY.

SHELBYVILLE MINERAL WELL.

WATER = *Alkaline-saline-sulphuretted.*

LOCATION.—Near the junction of the Big Four and Cambridge City branch of the P., C., C. & St. L. railways in the southeastern part of Shelbyville, a city of 7,500 population, situated 27 miles southeast of Indianapolis, and 84 miles northwest of Cincinnati.

ORIGIN AND CHARACTER OF THE WATER.—This well, which produces the "Shelbyville Lithia Water," was sunk in June, 1901, to a depth of 1,450 feet. The top of Trenton limestone was reached at 825 feet, and the bore is said to have penetrated the full thickness of that formation, the bottom being found at 1,415 feet. Below the Trenton, according to Mr. Jno. D. Pugh, who furnished me the data, a blue and more porous rock was found. This was undoubtedly the St. Peter's sandstone, a very porous formation well adapted for transmitting water, and the common source of much of the water in many of the deep artesian borings of northern Illinois and Indiana.

Ten feet in this sandstone a "white sulphur" water was encountered and 15 feet below this the vein of lithia water. The two veins mingled and arose in the bore to within 140 feet of the surface. An analysis of the water was made by Dr. J. N. Hurty, of Indianapolis, who reported the presence of the following mineral ingredients:

ANALYSIS OF WATER FROM SHELBYVILLE MINERAL WELL.

	Grains per U. S. Gallon.
Sodium chloride (NaCl)	696.570
Potassium chloride (KCl)	6.021
Lithium chloride (LiCl)	12.060
Sodium sulphate (Na_2SO_4)	48.190
Magnesium carbonate ($MgCO_3$)	45.762
Calcium carbonate ($CaCO_3$)	65.100
Alumina (Al_2O_3)	0.860
Iron oxide (Fe_2O_3)	0.297
Total solids	874.860
	Cu. In. per Gallon
Free hydrogen sulphide	1.78

"This is an antacid, anti-fermentative water, slightly laxative, and contains lithium and a small amount of iron. It will be found curative in stomach and bowel troubles and indigestion; and will also be found slightly laxative, and on account of the lithium it contains and also its great organic purity, it will cure rheumatism and various bladder disorders. The iron, which most probably exists as ferrous carbonate, is an important ingredient. It will also be found excellent for salt water baths."—*Hurty.*

In November, 1901, the water as it was pumped from the well to the bath rooms equipped by the owner, had a temperature of 51° F. As it emerges from the well it is quite dark with flakes of iron sulphide. After standing in the receiving tank these settle and the water is then clear, with a sweetish and quite strong saline taste. The odor of hydrogen sulphide is not sufficient to render it disagreeable. The water is shipped to order at 25 cents per single gallon, or $5.00 per barrel.

IMPROVEMENTS.—At the well only a pumping station has been erected to lift and force the water to the bath rooms described below and to the sanitarium of Dr. T. C. Kennedy, where it is used. This sanitarium is a private institution, complete with all modern conveniences. The rooms are large and cheerful, steam heated and well ventilated. Each patient is under the personal supervision of trained nurses at all hours.

The "Shelbyville Lithia Water Bath Rooms" were fitted up during the summer of 1901 by the owner of the well, Mrs. E. F. Hamilton, and her manager, Mr. John D. Pugh. The bath rooms are located in a three-story brick building on East Washington Street, near the public square. On the lower floor are the reception room, office, five bath rooms for gentlemen, cooling room, toilet rooms, rooms for vapor, shower and Turkish baths, etc. On the second floor are the bath rooms for ladies, with accompanying parlor, cooling room, etc. The equipment throughout is very fine, the tubs being of solid porcelain, the floors of tile or hard wood, with the other furnishings to match. In the basement are boiler and engine for steam heating, dynamos for electric lighting, water tanks, etc. About $12,000 have been expended in fitting up the interior of the building in good style, and the enterprise certainly merits a good patronage. Hotel accommodations at the bath house are as yet unprovided for, but excellent accommodations at reasonable rates can be secured at the different hotels and at many of the private residences of the city.

* * *

THERMAL WELLS.

Two thermal wells, or wells producing water above 75° F., have, in the past, been discovered in Shelby County. The following information regarding them was written by Dr. John Collett and published in the report of this department for 1881, page 68:

"It is a well known fact that at the level of perpetual spring water a constant temperature of 52° F. is maintained in this latitude; thence downward, the temperature becomes higher with regular increments, and in this State the rate of increase has been found to be 1° F. for each space of 79 feet of depth. By this law we may, without estimating the cooling effects of the stony walls of the fissure and the inflow of surface water, safely conclude that a change of 28° F. indicates the source of supply at a depth of 2,212 feet.

"The Shelbyville thermal well was put down in December, 1870, in the eastern part of the city, near Little Blue River Bridge. At a depth of 18 feet the water was found to be warm, and at the bottom, 24 feet from the surface, a constant temperature, winter and summer, of 76° was maintained.

"The Barlow thermal well is near Barlow's Mills, Section 3 (13 N., 6 E.), nearly four miles west of Shelbyville. An old well, twenty-three feet deep, at the residence of Henry Barlow, had been used for household purposes and was favorably known for furnishing cold water, 52° F. Suddenly the water became warm, and was no longer desirable; the thermometer indicating 65° F. A pipe was driven in November, 1870, from the bottom, through fine sand and pebbles, resting in a bed of gravel, to a depth of 16 feet, or 39 feet from the surface. The water was found to have a temperature of 80° F., and during the next winter attained a maximum heat of 86°. These wells were excavated for potable water only, and being unfit for this use, were neglected and allowed to be filled up. If found permanent, these springs will invite the attention of those needing hot baths, and suggest that it would be cheaper (and surely more efficacious) to use the thermal waters of Shelby County, than the distant hot springs of southern regions."

TIPPECANOE COUNTY.

LAFAYETTE ARTESIAN WELL.

WATER = *Saline-sulphuretted-carbonated.*

LOCATION.—At the northeast corner of the court house square in Lafayette, a city of 18,500 population, located 63 miles northwest of Indianapolis on the Chicago Division of the Big Four Railway. The C., I. & L. (Monon), L. E. & W., and Wabash railways also pass through the city.

ORIGIN AND CHARACTER OF THE WATER.—The "white sulphur water" of the Lafayette artesian well had, for years, a reputation as great as that of any other mineral water in the State. The well was sunk in 1857-'58 to a depth of 230 feet. Its surface is 55 feet above low water mark in the Wabash River, or 560 feet above tide. The material passed through by the bore was as follows:

SECTION OF BORE OF LAFAYETTE ARTESIAN WELL.

		Ft.	*In.*
(1)	Drift composed of soil, clay, gravel and sand	170	0
(2)	Shales, blue and gray	28	6
(3)	Limestone—Corniferous (?)	11	6
(4)	Limestone—Niagara	20	0
	Total	230	0

The mineral water was struck in the Niagara limestone, 13½ feet above the bottom of the well. The flow of the water for some time was variable, ranging from nothing up to 275 gallons per hour. It finally settled down to a steady flow of about 200 gallons per hour. In 1895 this flow began to fail and finally stopped altogether. The county commissioners had the hole drilled a little deeper and then shot with a small quantity of nitroglycerin. This shattered the limestone to such an extent that the supply of water was wholly stopped. A new bore was sunk 40 feet northwest of the old, in 1900, to a depth of 231 feet. In this the water rose only to within 25 feet of the surface. It was pumped and a plentiful supply obtained as long as the pump was in good order, but the sulphuric acid in the water destroyed the iron tubing very rapidly. In August, 1901, the water was not being used, on account of a lack of pumping facilities, but a new pump with clay or wood tubing was soon to be put in.

An analysis of the water was made soon after it was first discovered, by Dr. Chas. M. Wetherill, who also prepared an extended report upon the well itself and the physical properties of the water. From this report I quote as follows: "The Lafayette artesian water is of an extreme limpidity when freshly taken from the well. The deposit upon the pebbles over which it flows is white, entitling it to the name of "white sulphur water." Standing in imperfectly closed vessels, a similar bluish-white deposit takes place. Under certain conditions, the deposit contains black flakes of sulphuret of iron. The smell of the water is strongly of sulphuretted hydrogen, so as to be perceived at a distance (with the wind) of two squares from the well. The taste is similar to that of the celebrated Kentucky Blue Lick water, though less strong. It is pleasantly brackish, resembling in taste the liquor from oysters freshly opened. The temperature of the water when first taken from the well is 56° F. Its density is 1.00523."

ANALYSIS OF WATER FROM ORIGINAL LAFAYETTE ARTESIAN WELL.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	12.024
Magnesium carbonate ($MgCO_3$)	.400
Calcium sulphate ($CaSO_4$)	56.016
Calcium chloride ($CaCl_2$)	3.720
Magnesium chloride ($MgCl_2$)	29.656
Sodium chloride (NaCl)	324.768
Peroxide of iron with alumina, phosphate of lime, fluoride of calcium and faint trace of manganese	.496
Silica	.464
Total	427.544

Gases.	*Cu. In.*
Hydrogen sulphide	2.2960
Carbonic acid	12.2024
Nitrogen	4.9280

By comparison Dr. Wetherill found that the water of the Lafayette artesian well contained "as much calcium carbonate as the water of the White Sulphur Springs, of Virginia; as much calcium sulphate as the same springs, and as the Sharon Sulphur and the Avon Lower Springs, of New York; as much magnesium chloride as the Blue Lick Spring, of Kentucky, and more iron and less silica than the same spring. One and a half gallons of the Lafayette artesian water contains as much common salt as one gallon of the Blue Lick water."

PAPER MILL ARTESIAN WELL.

WATER=*Saline-sulphuretted* (?).

LOCATION.—One and one-half miles south of the court house at Lafayette, near the junction of the C., I. & L. and L. E. & W. railways.

ORIGIN AND CHARACTER OF THE WATER.—A well was put down for gas in 1888 to a depth of 1,300 feet, a few rods south of the old paper mill and on the grounds belonging to the owners of that mill. A strong vein of "white sulphur" water was developed at a depth of 330 feet. In August, 1901, it was flowing at the rate of 15 gallons per minute. The water has an agreeable sweetish-saline taste combined with the odor and taste of hydrogen sulphide. No analysis has been made. Within five feet of the top of the bore, a spring of fresh water was issuing from the base of a gravel bluff, with an output of eight gallons per minute.

The sulphur water has for some time been jugged and delivered to many of the citizens of Lafayette. Large quantities of the water are also carried away by the nearby residents. It is regarded as a specific for some skin diseases; also for certain forms of indigestion.

The flow is sufficient and the quality of the water seemingly high enough to warrant the erection of a bath house and sanitarium for its more extended use.

BUCK CREEK ARTESIAN WELL.

WATER = *Saline-sulphuretted* (?).

LOCATION.—On the farm of S. T. Blood, one and one-half miles northwest of Buck Creek, a station eight miles northeast of Lafayette, on the Wabash Railway.

ORIGIN AND CHARACTER OF THE WATER.—The well producing this water was sunk for gas to a depth of 960 feet. At 600 feet a vein of mineral water was developed, which has since been flowing. In August, 1901, the output was about two gallons per minute of water which gives off a strong odor of hydrogen sulphide. A heavy deposit of the black flakes of sulphuret of iron is left in the stream bearing away the overflow from the well. The water is used locally as a laxative, for skin diseases, etc.

BATTLE GROUND SPRING.

WATER = *Chalybeate.*

LOCATION.—On the bank of Burnett's Creek, near the Tippecanoe Battle Ground, seven miles north of Lafayette, on the C., I. & L. (Monon) Railway.

ORIGIN AND CHARACTER OF THE WATER.—This spring has long been a favorite resort for the many visitors to the famous Tippecanoe Battle Ground. It emerges from the bank of Burnett's Creek and the ground over which the water flows is coated with an ocherous deposit of oxide of iron. The flow is a plentiful one and the temperature 53° F. The water is of a mild chalybeate character and very agreeable to the palate. At a short distance up the creek there is a second spring of a similar character.

It would be difficult to find a place better adapted for a sanitarium than the region near this spring. The Battle Ground itself is a place of much interest, which is yearly visited by many. It has beautiful surrounding scenery, especially along the old Tippecanoe trail, on the west bank of the Wabash River between the Battle Ground and Lafayette. Here there are many picturesque hills covered with fine groves of native timber, with pleasant roadways for riding and driving, winding among them. Excellent opportunities for bathing would be afforded, not only with the mineral water, but also in the waters of Burnett's Creek and the Wabash River. The sulphur water from the paper mill well in South Lafayette could be easily piped to such a sanitarium, thus affording a combination of waters of exceeding merit.

VANDERBURGH COUNTY.

FRITZLAR MINERAL WELL.

WATER=*Alkaline-saline-chalybeate.*

LOCATION.—On the west bank of Pigeon Creek, in the western part of Evansville, a city of 60,000 population, situated on the Ohio River, 122 miles by rail below Louisville. Seven railways enter the city, furnishing easy transportation facilities in all directions. Electric cars run within two blocks of the well.

ORIGIN AND CHARACTER OF THE WATER.—Like the great majority of flowing wells in the State, this one was bored for gas in 1887. The total depth of the bore was 1,830 feet. The vein of mineral water was struck at 1,030 feet, presumably in the Niagara limestone. The surface of the bore is 30 feet above low water mark in Pigeon Creek, and the water bubbles up with great force through a five-inch casing. An analysis, by Wm. Fritsch, a chemist of Evansville, showed the mineral ingredients of the water to be as follows:

ANALYSIS OF WATER FROM THE FRITZLAR MINERAL WELL, EVANSVILLE, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride (NaCl)	2227.120
Calcium sulphate ($CaSO_4$)	32.704
Calcium carbonate ($CaCO_3$)	220.188
Magnesium carbonate ($MgCO_3$)	64.816
Iron oxide (Fe_2O_3)	20.35
Aluminum oxide (Al_2O_3)	6.172
Silica (SiO_2)	3.088
Total solids	2574.438

The water as it issues is very salty, too much so for internal use without dilution. The temperature is 72° F. It has purgative qualities when taken inwardly. Externally it is much used for skin diseases, catarrh, etc. It is claimed that one gallon of the water yields a little over one-half pound of salt by evaporation. The owner, Dr. Wm. Cluthe, of Tell City, Indiana, was, in September, 1901, making arrangements for putting in an evaporating plant for securing the salt.

IMPROVEMENTS.—A bath house with facilities for summer bathing only has been erected a few rods from the well. Two cement lined pools are in use. The principal one is 90x45 feet in size; the water being eight feet in depth at one end and three feet at the other. The water passes by separate pipes into each pool, and a constant current passes from the pools into Pigeon Creek. Numerous bath houses for dressing surround the pools. In the bath house proper there are facilities for shower baths and mineral baths, there being 21 well equipped bath rooms. There are no means of heating the water, so that the place is kept open only during the summer months. It is well patronized by the citizens of Evansville; the income being $1,800 to $2,000 from bathing privileges and rent of suits during the season.

SEVENTH AVENUE MINERAL WELL.

WATER = *Alkaline-chalybeate-sulphuretted.*

LOCATION.—On Seventh Avenue, Evansville, in front of the Indiana Stove Works, and belonging to that corporation.

ORIGIN AND CHARACTER OF THE WATER.—This well, the water of which is much used locally, is but 185 feet in depth and the water is raised by a pump. An analysis of the water by Mr. Wm. Fritsch resulted as follows:

ANALYSIS OF WATER FROM THE SEVENTH AVENUE WELL, EVANSVILLE, INDIANA.

	Grains per U. S. Gallon.
Carbonate of iron ($FeCO_3$) and alumina (Al_2O_3)	8.001
Calcium carbonate ($CaCO_3$)	12.96
Calcium sulphate ($CaSO_4$)	.123
Magnesium carbonate ($MgCO_3$)	2.76
Sodium chloride (NaCl)	3.08
Silica (SiO_2)	1.235
Total solids	28.159

Gases.	*Cu. In.*
Sulphuretted hydrogen (H_2S)	1.224
Ammonia (NH_3)	0.108

In September the water as pumped had a temperature of 63° F. and a distinct, though not strong, odor and taste of hydrogen sulphide.

WILLARD MARKET WELL.

WATER = *Saline-chalybeate.*

LOCATION. — On the Willard or Lower Market Square, in the western portion of Evansville.

ORIGIN AND CHARACTER OF THE WATER.—The water of this well is also much used locally. The well is 187 feet deep and the water is raised by a pump. An analysis by Mr. Fritsch resulted as follows:

ANALYSIS OF WATER FROM WILLARD MARKET WELL, EVANSVILLE, INDIANA.

	Grains per U. S. Gallon.
Carbonate of iron ($FeCO_3$) and alumina (Al_2O_3)	2.76
Calcium sulphate ($CaSO_4$)	46.28
Magnesium carbonate ($MgCO_3$)	7.252
Sodium chloride ($NaCl$)	7.88
Silica (SiO_2)	.500
Total solids	64.672

VIGO COUNTY.

EXCHANGE MINERAL WELL.

WATER = *Thermal.. Alkaline-saline-sulphuretted.*

LOCATION.—Three blocks southeast of the Union Railway Station at Terre Haute, a city of 40,000 population, situated on the Wabash River, 73 miles west of Indianapolis, 167 miles east of St. Louis and 178 miles south of Chicago. Nine railways make the city easy of access from all directions. Electric lines penetrate all portions of the city, and pass within two squares of the well.

ORIGIN AND CHARACTER OF THE WATER.—This well has a depth of 1,865 feet. The mineral water comes from a limestone struck at about 1,800 feet. Gas enough issues with the water to heat the latter for bathing purposes, and partially heat a large bath house. The output of mineral water is estimated at 100 gallons per minute. A portion of the surplus water not needed in the bath house, is used on a water wheel to pump fresh water from a driven well.

An analysis of the mineral water, made by Dr. W. A. Noyes, of the Rose Polytechnic, gave the following result:

ANALYSIS OF THE WATER FROM THE EXCHANGE ARTESIAN WELL, TERRE HAUTE, INDIANA.

	Grains per U. S. Gallon.
Calcium chloride ($CaCl_2$)	12.941
Calcium sulphide (CaS)	1.197
Calcium sulphate ($CaSO_4$)	0.257
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	19.927
Magnesium chloride ($MgCl_2$)	11.055
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	15.344
Potassium chloride (KCl)	3.625
Sodium chloride (NaCl)	301.258
Silica (SiO_2)	0.706
Alumina (Al_2O_3)	0.053
Iron bi-carbonate	0.035
Total solids	366.398
	Cu. In.
Hydrogen sulphide gas (free)	12.017

Besides the above, traces of strontium chloride, lithium chloride, borax, calcium phosphate, sodium iodide and sodium bromide occur in the water.

The water, as it issues from the well, has a constant temperature of 80° F. It is therefore to be classed as a thermal water, and is one of the few examples of such waters occurring in the State. The amount of hydrogen sulphide present is not sufficient to lessen the very agreeable sweetish-saline taste which the water possesses, though the high temperature renders it somewhat less palatable than it would otherwise be. Testimonials from many persons attest the value of the water for the cure of rheumatic affections, skin diseases, indigestion, catarrh, etc.

IMPROVEMENTS.—"The Exchange Artesian Mineral Springs Bath House and Swimming Pool" is the name of a commodious, finely equipped bath house, built of brick and stone, which has been connected with the Exchange well for a number of years. It contains 34 bath rooms, with all necessary appliances; facilities for vapor and Turkish baths; a swimming pool 66x75 feet in size, the water being 10 feet deep at one side, and three feet at the other. A large laundry and drying room, engines, boilers, etc., occupy the basement. Hotel accommodations are lacking in the building but can be readily secured elsewhere in the city. The present proprietor, Mr. David Bronson, is quite old and wishes to dispose of the property. He has, it is claimed, $40,000 invested. A tract of land adjoining, well suited for the location of a hotel and park, can be secured for a reasonable sum. The bath house is open the year round, and is well patronized by the citizens of Terre Haute.

MAGNETIC MINERAL WELL.

WATER = *Thermal...Alkaline-saline-sulphuretted.*

LOCATION.—At the foot of Walnut Street, Terre Haute, within a short distance of the Wabash River. An electric street car line runs within two blocks of the well.

ORIGIN AND CHARACTER OF THE WATER. — This well was sunk about 1868, in search of oil, to a depth of 1,912 feet. A strong flow of mineral water was developed at about 1,800 feet, in probably the same stratum as that from which the water of the Exchange Well is obtained, and two other veins at 1,840 and 1,912 feet, respectively. All three were allowed to mix, and the flow from them approximates 180 gallons per minute of a thermal water, having a constant temperature of $80\frac{1}{2}°$ F. An analysis of the water by Dr. W. A. Noyes, showed the mineral salts present to be as follows:

ANALYSIS OF WATER FROM THE MAGNETIC MINERAL WELL, TERRE HAUTE, INDIANA.

	Grains per U. S. Gallon.
Calcium chloride ($CaCl_2$)	16.297
Calcium sulphide (CaS)	2.078
Calcium sulphate ($CaSO_4$)	0.274
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	21.942
Magnesium chloride ($MgCl_2$)	13.945
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	16.445
Potassium chloride (KCl)	3.957
Sodium chloride ($NaCl$)	347.734
Silica (SiO_2)	0.718
Alumina (Al_2O_3)	0.175
Total solids	423.565
	Cu. In.
Hydrogen sulphide	15.259

In addition to the salts given above, traces of strontium chloride, calcium phosphate, lithium chloride, borax, sodium iodide, sodium bromide and methane or marsh gas occur in the water. The water from this well is mildly aperient, alterative and tonic. It closely resembles the water from the Exchange Well in taste and odor, and has proven very beneficial for the same diseases. It is used extensively in the sanitarium connected with the well, and is also sold quite extensively, bringing 20 cents a gallon in kegs, or $4.00 a barrel when shipped.

IMPROVEMENTS.—A sanitarium and bath house was erected in 1875, and remodeled and refurnished in 1889. It is open all the year. It contains 35 private bath rooms and good facilities for Turkish, vapor and mud baths. Connected with it is a natatorium or swimming pool, 40x60 feet in size, in which the water ranges from four to seven and a half feet in depth. This is not under roof, yet the water never freezes, as a constant stream flows through it from the well. It is open four months in the year. Both the sanitarium and natatorium are under the charge of A. P. Conant, a gentleman who has had long experience in the business. Both deserve and are receiving a good patronage not only from the citizens of Terre Haute, but from those of many other parts of the Wabash Valley.

TERRE HAUTE GAS COMPANY'S ARTESIAN WELL.

WATER=*Thermal... Saline-sulphuretted* (?).

LOCATION.—Within a few rods of the Wabash River, near the foot of Swan Street, one and one-half squares below the Magnetic Mineral Well above described.

ORIGIN AND CHARACTER OF THE WATER.—This well was drilled in 1889 for gas or oil. It is the only well in and about Terre Haute which has been sunk to the Trenton limestone. According to Martin N. Diall, who superintended the boring, the total depth of the bore is 2,930 feet. The top of Trenton was reached at 2,680 feet and that formation was pierced 250 feet. Between 1,800 and 1,900 feet, a strong vein of sulphur water was encountered, and 50 feet in the Trenton limestone, a second vein of water, rich in hydrogen sulphide gas and very black with particles of iron sulphide, was also developed. When the casing of the well was pulled, these veins mixed and are now flowing from the well with a very strong pressure and an output of 250 gallons or more per minute. A test was made soon after the well was finished which showed that the water would rise 85 feet above the surface and overflow in a four and a half inch pipe. The flow has decreased little, if any, since. A large amount of hydrogen sulphide gas (estimated by Mr. Diall at about 50,000 cubic feet per 24 hours) also issues with the water. This coats everything near by with a white coating of free sulphur. The water has a temperature of 81½° F. The taste is sweetish-saline-sulphuretted, not disagreeable after a little experience. No use is made of the water, and the site is an excellent one for a large medical sanitarium, operated under the management of an experienced physician.

ROSE ARTESIAN WELL.

WATER = *Alkaline-saline-sulphuretted.*

LOCATION.—Near the northwest corner of Eighth Street and Wabash Avenue, back of the present "Terre Haute House."

ORIGIN AND CHARACTER OF THE WATER.—A bore was made by Chauncey Rose on the ground mentioned in 1865. It reached a depth of 1,793 feet, passing through three horizons of salt water in the carboniferous rocks, and one or more in the sub-carboniferous. In the lower 100 feet of the well a strong flow of sulphur water was obtained. It is thought that the well terminated near the base of the sub-carboniferous limestone. The water rose to a considerable elevation above the surface, with an irregular pulsating flow, and was mixed with gas emitting a strong odor of sulphuretted hydrogen, and leaving on the reservoir a deposit of sulphur. An analysis of the water made by Dr. J. G. Pohle showed its mineral constituents to be as follows:

ANALYSIS OF WATER FROM ROSE ARTESIAN WELL, TERRE HAUTE, INDIANA.

	Grains per U. S. Gallon.
Sodium chloride ($NaCl$)	316.000
Magnesium chloride ($MgCl_2$)	6.428
Calcium chloride ($CaCl_2$)	4.816
Potassium chloride (KCl)	1.232
Sodium bi-carbonate ($Na_2H_2(CO_3)_2$)	.520
Calcium sulphate ($CaSO_4$)	2.325
Magnesium bi-carbonate ($MgH_2(CO_3)_2$)	6.420
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	25.026
Silicic acid (SiO_2) and alumina (Al_2O_3)	1.200
Nitrogenous organic matter	1.100
Total	365.067

Besides the salts mentioned, traces of magnesium bromide, calcium sulphate and calcium phosphate were present.

By comparison it will be seen that the analyses of the waters from the Rose, the Exchange and the Magnetic Mineral wells are very similar, and there is little doubt but that the water from all three had a common source in a stratum of limestone lying at approximately 1,800 feet below the surface.

But little use was ever made of the water from the Rose Well. It was finally plugged, and remains thus at the present time.

WABASH COUNTY.

WHITE'S INSTITUTE ARTESIAN WELL.

WATER = *Chalybeate.*

LOCATION.—By the side of the public road in the valley of Treaty Creek, three-quarters of a mile southeast of White's Institute; on the southeast quarter Section 31 (27 N., 7 E.). Six miles southeast of Wabash, the county seat, a city of 8,700 population, situated on the Wabash River, at the junction of the Michigan Division of the Big Four and Wabash railways, 88 miles northeast of Indianapolis, and 30 miles southwest of Fort Wayne.

ORIGIN AND CHARACTER OF THE WATER.—A well, sunk for gas in 1887 to a depth of 1,000 feet, developed in the Niagara limestone at a depth of 240 feet a strong vein of mineral water. In November, 1902, the water was flowing from an iron pipe, four feet above the ground, at the rate of 40 gallons a minute. It was clear and sparkling, and had a temperature of 56° F. No odor of hydrogen sulphide gas was detected. Objects about the well were, however, coated with the brownish red precipitate of carbonate of iron, and the characteristic taste of that salt was present. No analysis of the water has been made. It is often brought into Wabash by the barrel and is used for stomach troubles.

The well is located near the edge of a fine piece of woodland, which is much frequented by picnic parties, the drive from Wabash being in many places very picturesque.

WARREN COUNTY.

INDIANA MINERAL SPRINGS.

WATER = *Neutral.*

LOCATION.—On the northwest quarter of the southeast quarter of Section 23 (22 N., 8 W.), four and one-half miles northwest of Attica, a city of 3,100 population, situated on the Wabash River, and at the junction of the Wabash Railway and the Brazil Division of the C. & E. I. Railway; 21 miles west of Lafayette, 118 miles south of Chicago and 87 miles northwest of Indianapolis. Conveyances from the springs meet all trains. Reduced rate round trip tickets on the railways include transportation fees from Attica to the springs and return. Postoffice, Kramer. Telegraph and telephone office in the hotel.

Origin and Character of the Water.—Three springs emerge from the base of a prettily wooded ridge whose crest is 50 feet above the level of their point of issue. The main spring is 200 yards from the hotel, the others 75 yards further. Well-like pits have been sunk about their openings. In the pit of the main spring an iron cylinder, 12 feet in length and eight feet in diameter, has been sunk. In the other two, stone cylinders of smaller size retain the water. There is no overflow from any of the springs. On August 6, 1901, the water in each was about three feet in depth. Iron pipes connect the springs with tanks in the hotel, and the supply is largely pumped to these tanks and from them finds its way to the bath house, and to the drinking fountain in the hotel office. The total output from the three springs is estimated at 20 gallons per minute.

The water when dipped up from the springs, is clear, sparkling with bubbles of carbonic acid gas, and tasteless. The temperature is 53° F. The only quantitative analysis of the water of these springs available was made for Wm. Cameron, the former owner, by Dr. Stockder, and published by Dr. A. C. Peale.* It shows the composition of the water to be as follows:

ANALYSIS OF WATER FROM INDIANA MINERAL SPRINGS.

	Grains per U. S. Gallon.
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	17.696
Calcium sulphate ($CaSO_4$)	1.850
Sodium chloride ($NaCl$)	.331
Magnesium oxide (MgO)	6.005
Silica (SiO_2)	.964
Total solids	26.846
	Cu. In.
Carbonic acid gas	3.836

This analysis shows a very pure ordinary spring water which may be classed as slightly alkaline or neutral.

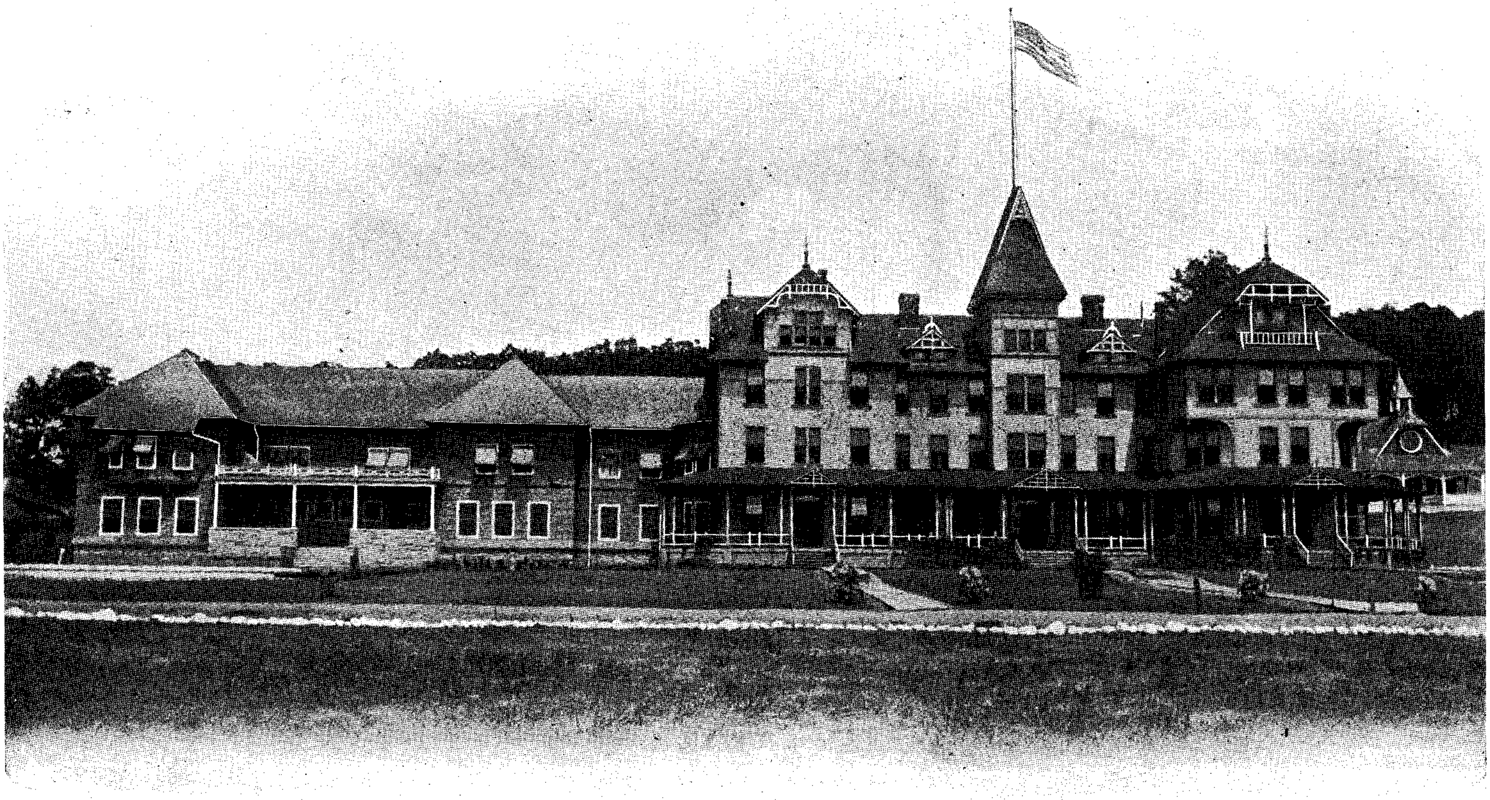
A qualitative analysis made by J. B. Russell, of Detroit, Michigan, in 1893, showed the presence of the following:

Bases.	*Acid Radicals.*
Magnesium.	Carbonic.
Sodium.	Hydrochloric.
Calcium.	Sulphuric.
Lithium.	
Potassium (traces).	

	Grains.
Total solid residue from one U. S. gallon	20.21

*Bulletin 32, U. S. Geological Survey, 1886, p. 141. The figures given by Peale are "parts in 100,000." These have been reduced to grains per U. S. gallon by multiplying by .583.

PLATE XVIII.



HOTEL AND BATH HOUSE AT INDIANA MINERAL SPRINGS, WARREN COUNTY, INDIANA.

(Bath House on the Left.)

The water is sold under the name of "Magno-Lithia" water. It is shipped to consumers in five-gallon glass bottles, the price per bottle being $1.50 at the springs. It is served at meals in the hotel and is an excellent table water.

At the foot of the slope, just below the springs, is a large deposit of muck or black mud, formed of decayed vegetation. Into this deposit the seepage from the springs, before they were improved, had found its way for an indefinite time. This mud is excavated and used in the bath room connected with the hotel in giving mud baths; after using, it is carted back and allowed to remain in or near its original resting place for a period, after which it is reused. I secured samples of this muck from a place where the supply of the day before had been gotten out for the bath room, and had them analyzed by Dr. W. A. Noyes, of Terre Haute. The results of this analysis are herewith given:

ANALYSIS OF MUD FROM INDIANA MINERAL SPRINGS.

	Per Cent.
Silica (sand) (SiO_2)	12.76
Carbon dioxide (CO_2)	0.22
Ferrous oxide (FeO)	0.85
Alumina (Al_2O_3)	2.95
Lime (CaO)	1.60
Magnesia (MgO)	0.44
Potash (K_2O)	0.83
Soda ($NaCl$)	0.27
Hygroscopic moisture	9.10
Combustible matter (decomposed vegetation) and water of constitution	70.98
Total	100.00

"In addition to the above, minute traces of phosphoric acid (P_2O_5), manganese oxide (MnO), and lithia (Li_2O) were present. The amount of lithia was so small that it could only be found by a careful spectroscopic examination."—*Noyes.*

The analysis shows that the deposit is largely muck, and in every way similar to thousands of others which occur in the marshes and about the lakes of northern Indiana.

IMPROVEMENTS.—A large three-story hotel, with accommodations for 150 guests, stands just west of the springs. Connected with it is one of the finest bath houses in the State, erected and especially equipped for giving the famous "mud baths" for which the resort has become noted in recent years. If necessary 200 such baths can be given daily. In giving the bath, the mud is heated by steam until it has reached a high temperature. Cold mud is then mixed with the hot until the latter is about 98° F. This is then applied by an attendant to the affected parts—the whole body if required—in the form of a poultice. From 30 to 50 minutes is required for the mud bath, when the patient passes under a shower bath and remains until all traces of the mud are removed. He is then placed in a porcelain tub filled with water from the springs, for a soaking, after which comes a refreshing rubbing by the attendant, who often uses salt as a skin tonic. After this the patient goes to the cooling room where another rubbing with alcohol is given if required. Wonderful cures of rheumatism and skin diseases are claimed to be made by these hot mud baths, and the claims are borne out by many testimonials published in the advertising sheets of the company.

The grounds about the hotel are ample, and contain many trees and shrubs. Billiard rooms, bowling alleys, tennis courts, music rooms, dancing halls, etc., furnish plentiful means of recreation and amusement.

HUNTER MINERAL SPRINGS.

WATER = *Neutral.*

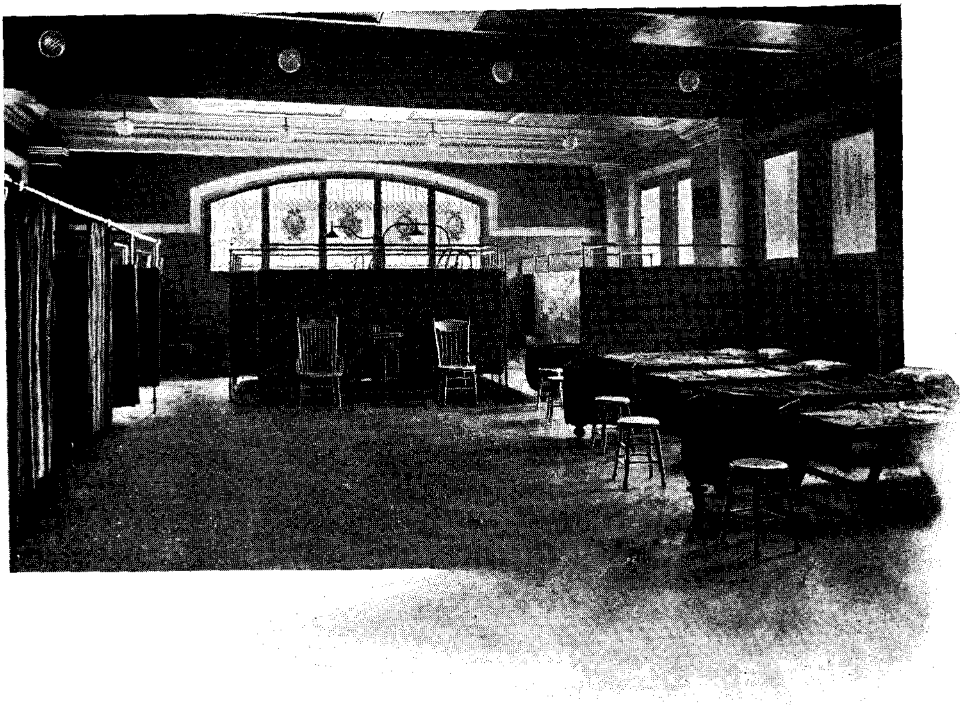
LOCATION.—Five miles northwest of Attica, on the southeast quarter of the northwest quarter of Section 23 (22 N., 8 W.), one-fourth mile northwest of the Indiana Mineral Springs above described. Conveyances meet all trains at Attica. Telegraph and telephone service in the office of the hotel. Postoffice, Kramer.

ORIGIN AND CHARACTER OF THE WATER.—A spring flowing about 15 gallons per minute issues from the foot of a high, wooded bluff. The water is clear, odorless and tasteless. According to Dr. W. H. Dinsmore, the physician in charge, it contains 10.86 grains of mineral matter per U. S. gallon. Of this amount calcium bi-carbonate comprises 4.5 grains, calcium sulphate 1.5 grains, and potassium sulphate .86 of a grain. The remaining four grains are composed of magnesium carbonate, sodium chloride and silica. It is a simple alkaline water of great purity. Its temperature is 51° F. It is pumped through pipes to the fountain in the office of the hotel, and to tanks for use in the bath rooms. It also flows through a pipe to a point some 50 feet from the spring, where it issues in a drinking fountain.

The water is sold for shipment at $1.00 per five-gallon bottle. This does not include the price of receptacle, which, if desired, can be returned free by express.

IMPROVEMENTS.—A hotel with accommodations for 65 people occupies a commanding site on the crest of the hill, 110 feet above Pine

PLATE XIX.



ROOM IN BATH HOUSE AT INDIANA MINERAL SPRINGS, WARREN COUNTY, INDIANA.

Creek Valley. The view from the grounds over this valley is a magnificent one for Indiana.

Connected with the hotel are well equipped bath rooms, where mud baths are a specialty. The mud or muck is hauled from a point a mile or two distant. These baths are given under the guidance of an experienced physician, each case being diagnosed, and the temperature of the bath, length of time to be taken, etc., governed by the physical condition of the patient.

There are fine roads for driving, riding and cycling about Hunter's Springs; also beautiful grounds for field sports and good fishing in adjacent streams. The place is to be commended to those who are suffering from diseases which a plentiful supply of pure water or an application of hot mud will benefit and who are seeking a quiet retreat in a picturesque region.

KICKAPOO MAGNETIC SPRING.

WATER = *Alkaline.*

LOCATION.—On the land of J. B. Lebo, near Kickapoo, a station on the Brazil Division of the C. & E. I. Railway, three miles northeast of Attica, and 115 miles south of Chicago. Postoffice, Kickapoo.

ORIGIN AND CHARACTER OF THE WATER.—A spring of clear water wells up in a valley, on either side of which hills rise to a height of 60 or more feet. Between these hills run picturesque ravines, whose precipitous walls, composed, in some places, of soapstone, in others of gray or brown sandstone, show, by their transverse markings, the course of the ancient river as it flowed in torrents down the hillsides from the stranded and rapidly melting icebergs, during the glacial period of our world's history. Within short distances of the spring are to be seen several beautiful cataracts, from 30 to 100 feet in height, as the purling streams of this region are hurled from the precipitous bluffs over which they flow on their way to the Wabash River, a mile or two distant.

It is said that the principal spring was discovered by Kickapoo Indians as early as June, 1750. The water was analyzed in 1885 by H. A. Huston, of Purdue University, Assistant State Chemist, with the following results:

ANALYSIS OF WATER FROM KICKAPOO MAGNETIC SPRINGS, WARREN COUNTY, INDIANA.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	12.35
Magnesium carbonate ($MgCO_3$)	5.38
Ferrous carbonate ($FeCO_3$)	0.05
Silica (SiO_2)	0.68
Sodium sulphate (Na_2SO_4)	0.99
Sodium carbonate (Na_2CO_3)	0.36
Organic and volatile matter	4.61
Total solids	24.42

The flow of water from this spring is about 1,500 gallons per hour, having a temperature of 50° F.

The water is a very good antacid and diuretic. It is remarkable on account of its containing no chlorides, a fact which may render its use of importance in certain disturbed conditions of the stomach. It is sold in bottles holding five gallons at $2.25. A limited number of persons can secure accommodations at the farm house near the spring. There is also a bath house which is open during the summer months.

WARRICK COUNTY.

DE GONIA SPRINGS.

WATER = *Alkaline-saline-chalybeate.*

LOCATION.—On the northwest quarter of Section 27 (6 S., 7 W.), one-fourth mile south of De Gonia, a station on the Evansville Branch of the St. Louis Division of the Southern Railway, 22 miles east of Evansville. A rate of one and one-third fare, good for 30 days, is made over the Southern to parties visiting the springs. Hacks meet all trains during the season. Postoffice, De Gonia Springs.

ORIGIN AND CHARACTER OF THE WATER.—The water at De Gonia Springs is very similar to that at McCullough's Spring, near Oakland City, and Coats' Springs, Pike County, both of which are described on previous pages. It occurs in a well 12 feet in depth. In this the water stands between seven and eight feet deep, the supply being constant at all seasons. It was reported by J. G. Ford, the proprietor, in 1901, that with two hand pumps and a man in the well to dip with a bucket, he finally succeeded in reducing the water so that the bottom could be seen and the well thoroughly cleaned. According to his report, the bottom of the well is in white clay, no rock or shale being found. A second spring, 200 feet west, has water of the same character, but is little used. A well sunk 20 feet through loess and clay at the back of the hotel, produces a very "hard water," which is free from the bitter taste of that at the "Spring."

The only analysis of the mineral water available was that published by A. C. Peale, in 1886.* The name of the chemist is not given, but it was probably made by Dr. T. C. Van Nuys, formerly chemist at Indiana University.

ANALYSIS OF WATER FROM SPRING NO. 1, DE GONIA SPRINGS.

	Grains per U. S. Gallon.
Calcium carbonate ($CaCO_3$)	16.00
Ferrous carbonate ($FeCO_3$)	4.00
Sodium sulphate (Na_2SO_4)	25.00
Potassium sulphate (K_2SO_4)	7.00
Magnesium sulphate ($MgSO_4$)	56.00
Calcium sulphate ($CaSO_4$)	4.00
Calcium phosphate ($Ca_3(Po_4)_2$)	2.00
Calcium chloride ($CaCl_2$)	4.00
Silica (SiO_2)	3.00
Total solids	121.00
	Cu. In.
Carbonic acid gas	8.02

The water, when pumped, has a temperature of 62° F. It is free from the odor of hydrogen sulphide or other gas. The taste is quite bitter and astringent. When boiled, a brownish-white sediment sinks to the bottom, which removes the skin from the tongue.

The water is said to be very beneficial in diseases of the bowels and kidneys, dyspepsia, ague and skin diseases.

IMPROVEMENTS.—A frame hotel, containing 44 furnished rooms, is located a short distance from the well, and is open from June 1st to October. The grounds are spacious and well shaded. There are no facilities for baths and but few for amusement, other than walking or driving. The springs are well patronized during the season, the water having an excellent reputation among the citizens of Evansville and surrounding towns.

ASH IRON SPRINGS.

WATER = *Alkaline-saline-chalybeate.*

LOCATION.—Five miles east of Boonville, on the southwest quarter Section 34 (6 S., 7 W.). One mile south of De Gonia Springs, a station on the "Air Line" Railway, 22 miles east of Evansville, and 98 miles west of Louisville.

*Bulletin 32, U. S. Geological Survey, 1886, p. 138.

ORIGIN AND CHARACTER OF THE WATER.—These springs are three in number, situated a few rods apart on the western slope of a prettily wooded knoll which rises 20 or more feet above the surrounding plain. Formerly the waters seeped from the side of the knoll. In the present site of the main spring a hole was dug, into which part of a hollow black gum tree was sunk. At present the "springs" are wells, eight to twelve feet in depth, from which the water is raised by pumps. There is a plentiful supply of the water, the temperature of which, when pumped, is 63° F. It is of the same general class as the water at De Gonia Springs, saline-acidulous, chalybeate, bitter and astringent. No analysis was available. Circulars, issued by the company formerly operating the springs, state that the principal constituents are iron, lime, magnesia, silica, carbonic acid, sulphuric acid and chloridic acid, and claim the water to be a "valuable specific for the cure of rheumatism, diarrhea, effects of alcoholism and chronic diseases." It is claimed by persons living in the vicinity that the waters of both Ash Iron and De Gonia springs are a certain cure for hog cholera.

HISTORY AND IMPROVEMENTS.—The Ash Iron Springs are said to have been well known to the Indians, who visited them when suffering from any one of many ailments. "About fifty years ago the late James Ash became the owner of the farm upon which the springs are located. At that early day the waters had a local reputation, and were used by the neighboring farmers in the treatment of chronic cases. Mr. Ash was in time compelled to erect an addition to his farm house in order to accommodate the increasing demand of those who desired to board at the springs and drink the water. The "hotel" was enlarged from time to time to meet the requirements of his patrons, and Mr. Ash refused many large offers from parties who desired to purchase his property. The buildings were poor and constructed of rough boards, to which an annual coat of whitewash was applied. The fare was of the substantial kind that "sticks to the ribs." Amusements were limited, baths unknown.

On the death of Mr. Ash the springs property was sold at commissioners' sale. In the spring of 1897 a company was organized to take charge of the property and erect buildings suitable to the reputation of the waters. A large three-story hotel and bath house was erected and handsomely equipped on the knoll above the springs. Separate buildings for use as bowling alleys, electric light plant, dancing halls, etc., were constructed. The place was opened, and for three seasons was well patronized, when the hotel was destroyed by fire. The other buildings are still standing and the water is at present unused. The site is an excellent one for a large sanitarium, with many necessary improvements already on hand.

FAIRVIEW SPRINGS.

WATER = *Saline-chalybeate.*

LOCATION.—One mile northeast of Boonville, the county seat, a town of 3,000 inhabitants, situated on the Evansville branch of the Southern Railway, 17 miles east of Evansville. Conveyances meet all trains during the season, which lasts from June 1st to October.

ORIGIN AND CHARACTER OF THE WATER.—One natural spring and two wells furnish the water at this resort. The spring issues from the side of a knoll 150 yards southeast of the hotel. The flow is small, the water very clear, with the bitter, astringent taste which characterizes the acidulous chalybeate waters of this region. At times a white deposit of ferrous sulphate (copperas) is found on the earth around the opening of the spring. The temperature of the water is 66° F.

The shallower of the two wells produces a water less strongly charged with iron sulphate and containing more magnesia. It is nine feet in depth, with five feet of water within, and is located a few rods south of the hotel. The temperature of the water is 64° F., and the taste that of Epsom salt (magnesium sulphate).

The second well is 40 feet in depth and six feet in diameter. It was dug through fossiliferous limestone and black shale for about 32 feet, then through seven feet of blue clay to another limestone. The water is highly charged with carbonate of iron, but contains little or no sulphur or magnesium.

IMPROVEMENTS.—A good hotel and bath house, with accommodations for 40 guests, is run in connection with the springs. The grounds belonging to the property are ample, and contain many fine forest trees and much shrubbery. A small artificial lake furnishes facilities for rowing and fishing, while croquet and tennis grounds supply other modes of amusement.

WASHINGTON COUNTY.

UNDERWOOD MINERAL WELL.

WATER=*Saline.*

LOCATION.—On the land of J. W. Underwood, Section 26 (4N., 3 E.), 13 miles north of Salem, the county seat, a town of 2,000 population, situated on the C., I. & L. (Monon) Railway, 282 miles southeast of Chicago, 41 miles northwest of Louisville. The nearest railway station is Medora, seven miles north, on the B. & O. S.-W. Railway. Postoffice, Vallonia, R. F. D.

ORIGIN AND CHARACTER OF THE WATER.—A well 19 feet in depth was sunk about 1870, through clay, gravel and blue mud into a shale from which the water is derived. The well is located in rather low ground, wooded ridges rising 10 to 30 feet on each side. The water stands 10 feet deep in the well, and when raised by a wooden pump has a temperature of 58° F. While free from the odor of hydrogen sulphide it has a distinct but slight sulphur-saline taste. A rather heavy whitish efflorescence on the ground below the well, and on rocks removed and thrown to one side when the well was dug, was pronounced by T. W. Smith, a chemist, of Indianapolis, to be aluminum silicate. This efflorescence was noticed before the well was sunk, and was the principal cause of its being dug. A partial analysis of the water made in May, 1875, by a Cincinnati chemist, resulted as follows:

QUALITATIVE ANALYSIS OF WATER FROM UNDERWOOD MINERAL WELL, WASHINGTON COUNTY, INDIANA.

Bases	*Acid Radicals.*
Sodium.	Sulphuric.
Potassium.	Hydrochloric.
Calcium.	Carbonic.
Magnesium.	Phosphoric.
Iron.	

"Of these, the sodium, calcium and magnesium among the metals and the sulphuric and hydrochloric of the acids are the most abundant. The carbonic acid is less abundant. The iron and potassium are present only in very small proportion. The phosphoric acid was found only in traces. Among the more soluble salts, the chlorides and phosphates of sodium and magnesium exist in by far the largest quantities. Of the less soluble salts the sulphate of calcium is the most abundant; next come the carbonates of sodium and magnesium.

"The specific gravity of the water is 1.0033. It affords, upon standing, but a very slight sediment, containing a small quantity of organic matter, part of which was probably formed in the water after removal from the well as the salt contained but the merest trace.

"This water is to be classed with that of the saline springs and wells such as those of Seidlitz, Pyrmont, the Ballston Spa of Saratoga, N. Y., the St. Louis Artesian Well, etc."

The water has quite a local reputation for kidney, bladder, stomach and rheumatic troubles. It is not a cathartic or purgative. On the day of my visit to the well, October 23, 1902, a young man had driven 10 miles for a half barrel of it, to be used by his father, who was suffering from inflammation of the bladder, the water having been prescribed by a Louisville physician. It has been shipped to a number of towns and cities of southern Indiana, bringing $5.00 per barrel on board the cars.

BECK'S SULPHUR SPRINGS.

WATER = *Saline-sulphuretted.*

LOCATION.—On the northeast quarter of Section 10 (1 N., 3 E.), six miles southwest of Salem, the county seat, and one-half mile northwest of Beck's Mill, the nearest postoffice.

ORIGIN AND CHARACTER OF THE WATER.—Three springs issue from limestone rock; two of them about 30 feet apart on opposite sides of a shallow ravine. The water of the larger spring flows horizontally from the ledge of limestone at the rate of one gallon per minute, and is collected in a cavity hollowed out in the rock. In this cavity and in the rill bearing away the overflow there were white, black and purple precipitates of salts of sulphur. The water had a distinct taste and odor of hydrogen sulphide, combined with a slight saline taste, and a temperature of 60° F. On the whole, it was very palatable.

The water of the second spring, very similar in character, wells up perpendicularly from a crevice in the limestone rock, at the rate of one-half gallon per minute.

The third spring is located one-quarter of a mile farther north, on the west bank of Mill Creek, a tributary of Blue River. The water flows about 15 feet into that stream, at the rate of about one gallon per minute. Two other springs of similar water formerly welled up in low ground 30 rods west of the first two mentioned, but their openings are now covered with mud and decayed vegetation. If deemed expedient they could probably be easily put into a suitable condition for use.

The water of all these springs has quite a local reputation for dyspepsia and stomach trouble. The region in which they are located contains several caves, and the scenery along Mill Creek is in places very romantic and pleasing.

WAYNE COUNTY.

GLEN MILLER SPRINGS.

WATER = *Chalybeate.*

LOCATION.—In Glen Miller Park, a tract of 164 acres of natural woodland lying on the eastern side of Richmond, a city of 18,500 population, situated 68 miles east of Indianapolis and 75 miles northwest of Cincinnati. Four railways enter the city, viz.: The G., R. & I., the Cincinnati and Richmond and the Columbus and Indianapolis Divisions of the Pennsylvania; also the C., R. & M.

ORIGIN AND CHARACTER OF THE WATER.—Glen Miller Park is one of the most beautiful and picturesque municipal parks in Indiana. It is just broken enough to add variety to its topography and is wooded with most of the indigenous trees and shrubs of eastern Indiana. To these natural characters have been added an artificial lake, numerous roadways, bypaths and bridges, ornamental shrubbery and flowering plants, until the whole has become a place of beauty, in which the citizens justly take great pride.

Adding not a little to the value of the park is the presence of chalybeate "springs," or rather wells, three shallow and one deep, with artesian flows, which supply an abundance of pure and wholesome drinking water to its visitors. The deep well, or "big spring," as it is called, is located in a ravine near the eastern side of the park. It was drilled to a depth of 282 feet, and a strong flow of chalybeate water rises a foot above the surface, and would rise six feet if the necessary pipe were inserted. The temperature of the water is 53° F. It tastes slightly of iron and deposits the brownish-red precipitate which characterizes a true chalybeate water.

At three other points in the park bores have been sunk to a depth of 22 feet, which yield an artesian flow of excellent chalybeate water. From one of these the water is piped into Cook's Grotto, and has a temperature of 58° F. as it issues frm the discharge pipe. The temperature of the others is a degree or two lower.

In addition to these springs producing chalybeate water there are three producing fresh water, whose temperature is 54° F. One of these has a large output, sufficient to form quite a rivulet. Bordered with willows and producing from its pellucid depths many matted masses of green watercress, this stream ripples along its sinuous bed into the lake, its presence adding much to the beauty of the park.

The waters of all these springs, both chalybeate and fresh, are much used by the citizens of Richmond, many of whom visit the park with jugs and convey a plentiful supply to their homes.

REID'S SPRING.

WATER = *Alkaline-chalybeate.*

LOCATION.—On the farm of David Reid, near the center of Section 29 (14 N., 1 W.), two and one-fourth miles north of Richmond.

ORIGIN AND CHARACTER OF THE WATER.—This spring wells up on the side of a gentle slope in an oak and beech grove. A section of sewer pipe three feet in diameter has been sunk about the orifice of the spring, and a square bed of cement placed around the upper end of the pipe. In this pipe the water stands three feet in depth and flows over the mouth at the rate of five gallons per minute.

A partial analysis of the water made by Dr. J. N. Hurty showed its constituents to be as follows:

QUALITATIVE ANALYSIS OF WATER FROM REID'S SPRING.

Bases.	*Acid Radicals.*
Iron.	Carbonic.
Magnesium.	Sulphuric.
Potassium.	Silicic.
Sodium.	
Calcium.	

Total solids present, 25.2 grains per U. S. gallon.

The water is clear and sparkling with carbonic acid gas. It has had a local reputation for years, chiefly as a diuretic. Large quantities are sold in Richmond at six cents per gallon, delivered in jugs.

HAWKINS' SPRING.

WATER = *Alkaline-chalybeate.*

LOCATION.—On the farm of John Hawkins, one mile northeast of the city of Richmond.

ORIGIN AND CHARACTER OF THE WATER.—A lack of time forbade a visit to this spring while gathering data for this paper. The following account is taken from the report on Wayne County by Prof. E. T. Cox, in the report of this department for 1878, pp. 213, et. seq.:

"The most important springs, in a medicinal point of view in Wayne County, are on Mr. John Hawkins' farm, just northeast of the city of Richmond. The water breaks out from the junction of the drift and the blue argillaceous shales that form the upper part of the Lower Silurian beds. There are a number of springs on the place, but Mr. Hawkins has only thought proper to enclose three with cement pipes that are about two feet in diameter. They are situated on the south side of the East Fork of White River, and about 20 feet above the bed of the stream and 60 feet below the crest of the hill, at Mr. Hawkins' residence. The springs are only a few feet apart, and arranged in the form of a triangle. The ground around is neatly paved, and the overflow of water is carried off in a paved chute. This chute is well lined with a brownish-red gelatinous precipitate of ferric oxide, which tells at once the chalybeate character of the water. There is considerable gas bubbling up from the bottom of each spring, which appears to be mainly carbonic anhydride and carbonic dioxide. No odor of sulphydric acid could be detected at the spring or in the water shipped to the laboratory for analysis.

ANALYSIS OF WATER FROM HAWKINS' MINERAL SPRING, RICHMOND, INDIANA.

	Grains per U. S. Gallon.
Silicates	.158
Ferrous carbonate ($FeCO_3$)	.192
Calcium sulphate ($CaSO_4$)	11.684
Magnesium sulphate ($MgSO_4$)	1.599
Calcium bi-carbonate ($CaH_2(CO_3)_2$)	9.448
Potassium carbonate (K_2CO_3)	1.170
Sodium chloride (NaCl)	.333
Calcium chloride ($CaCl_2$)	.323
Total solids	24.907

Free carbolic acid, 4.302 cubic inches per U. S. gallon.

"This is a sulphatic and carbonated chalybeate water; its action is that of a mild tonic, aperient and diuretic and decided alterative. A qualitative examination of the two other springs on Hawkins' farm showed no perceptible difference in the quality of the water."

THE MEDICINAL PROPERTIES AND USES OF INDIANA MINERAL WATERS.

By Robert Hessler, A. M., M. D.

INTRODUCTORY.

The use of mineral waters in the treatment of diseases is an important one, particularly in Europe, where special attention has long been given to the subject. Strictly speaking, even the use of ordinary water comes within the domain of medicine—the amount of water and the time for taking it play an important role in many diseases.

Views on the uses and functions of water, either pure or holding other substances in solution, have been modified from time to time, with the advance of civilization, just as they have been changing on other subjects. Before the days of chemistry, about one hundred years ago, ideas about the ingredients of mineral waters were very vague, and explanations of their actions or the effects on the human body were equally so.

The first book published in this country on the uses of water was in 1725, and it was a reprint of an English work. The first distinctively American work on mineral springs was by Dr. John Bell, in 1831; since then several books relating to mineral waters have appeared. The most exhaustive compilation of the mineral waters of this country is a report which appeared as Bulletin No. 32 of the U. S. Geological Survey, though treating the subject from a nonmedical standpoint.

Water, pure and simple, is one of the essentials of life. All our drinks are water with varying admixtures of other substances; most of our fruits and vegetables are mainly water. The human body itself is three-fourths water.

Whether a sick man needs a water with one or more mineral substances in solution will depend on a variety of conditions. A mineral water may perhaps help him, at any rate an invalid who has been in ill-health for a long time will, probably, at one time or another consider the advisability of going to some health resort, to some mineral spring.

In gathering together all available data, the State Geologist, Mr. Blatchley, has certainly done something that will be fully appreciated by the physicians of the State. Such data can be used in arriving at proper conclusions in regard to the use of the waters of many of our springs and wells, and it will enable them to decide intelligently where to send patients afflicted with different ailments. It is true that the mineral water treatment of diseases is a much neglected subject among our physicians, and this is due chiefly to the fact that until recently there has been comparatively little demand for such methods of treating diseases, partly also to the fact that, with very few exceptions, until quite recently, we have had scarcely an institution worthy of the name of health resort making use of mineral waters, internally, or, in the form of baths, externally.

It should be said that the remarks in this paper are not intended for the physician, but for the ordinary layman, the average citizen of the State, informing him briefly about the properties and uses of our various mineral waters. It will be noticed that certain statements are repeated in different places, as, the use of pure water, of certain salts, the relation of diet, etc. This repetition is made purposely to emphasize their importance.

The writer's thanks are due to Dr. Joseph G. Rogers, Superintendent of the Northern Indiana Hospital for Insane; to Dr. Robert E. Lyons, Professor of Chemistry in the Indiana University, and to Dr. Ernest C. Reyer, Professor of Materia Medica in the Medical College of Indiana, for their kindness in going over the manuscript.

Logansport, Indiana, January 14, 1902.

WATER.

Kinds and Uses. Pure and Impure.

Water is composed of oxygen and hydrogen chemically combined. As found in nature, it is accompanied with more or less mineral matter and at times with vegetable and animal impurities.

The rainfall furnishes us all our water; it is the moisture of the air condensed and precipitated to the earth.

Different names are applied to the water we use, according to the place from which we take it after it is precipitated. That which is caught from the roof of a house and stored in a cistern is called "cistern water;" that which flows away from the face of the earth is "river" or "stream water;" that which has penetrated into the soil and is collected in wells is known as "well water;" when it flows naturally from a hillside, from an opening in a hilly country, we call it "spring water." Some water gets down deep into the geological strata of the earth, and when tapped by a deep bore is known as "underground" or "deep-well water;" if the water flows naturally out at the surface or mouth of the well it is known as "artesian water." Any water, whether from a spring or deep well, which is charged with mineral matter in appreciable quantity and possesses a peculiar taste or odor, is commonly called "mineral water."

The crust of the earth is built up of certain materials, and the water percolating or passing through these will hold in solution certain of the substances with which it has come in contact. If the underlying strata are of limestone, the water will be charged with lime; if of magnesia, with that mineral. Waters of this kind are known as "hard waters." Where there is little material to go into solution, as in a freestone or granite country, the more shallow waters are apt to be almost free from mineral matter, and in this case the water is called "soft water."

In the strict scientific sense, absolutely pure water is unknown in nature. The purest rain water contains traces of gases, of mineral matter and small amounts of organized matter. Water caught in the open country in clean receptacles may be regarded as practically pure. The process of contamination begins with the passage of the water through the gas and dust-laden atmosphere and is continued with renewed vigor when the water reaches the earth.

PURE WATER.

A few words in regard to the meaning of the words "pure water" may not be amiss. The term "pure water" is capable of various definitions; it depends altogether on the standpoint from which considered. The chemist, for instance, may say a water is pure for chemical purposes—"chemically pure"—when it contains no appreciable amount of gases or leaves no residue on evaporation to dryness. Water used for chemical purposes might contain innumerable minute organisms, micro-organisms, and he not concern himself about their presence. The bacteriologist will call a water bacteriologically pure if it be free from living micro-organisms and their spores, although it may contain considerable chemical impurity; in this case the water would be "germ free," or "bacteriologically pure." A mechanical engineer would call a water pure, or fit for boiler purposes, if it contained only small quantities of lime or magnesia—these forming the boiler scale—and (excluding gases from decaying vegetable matter which may cause troublesome foaming or frothing) with him the term "pure water" is generally synonymous with "soft water."

To the sanitarian a water is pure if it is free from disease-producing microbes or bacteria, and if the quantities of the commonly occurring chemical impurities fall within certain accepted limits.* Certain chemical impurities may be present, as well as harmless bacteria, but water reasonably pure in these respects may pass as "potable water." The waters from many of our slightly mineralized springs properly come under this head.

In ordinary daily life the use of the terms "pure" and "impure" varies somewhat; a water may be sufficiently pure for one purpose, but not for another. The water that we ordinarily demand for drinking and household purposes must be clear, odorless and without any marked taste. Any turbidity, peculiar flavor or odor leads us to regard a water as impure. However, conformity to these three conditions alone must not be accepted as proof of the purity and wholesomeness of a water.

Some waters possess a peculiar flavor, but by constant use this is noticed less and less—we "get accustomed to it," as we say. People coming from a sandstone country to one of limestone are apt to complain of the water, and, on the other hand, on reversing the conditions, complaint will be made of the flat taste of the sand or freestone water. It may be added that whenever any diarrheal symptoms occur in a person away from home he at once ascribes it to the water, when, as a matter of fact, the water rarely has anything to do with it, and the real cause may be obscure. Slight traces of sulphuretted hydrogen gas or of iron compounds produce peculiar flavors, but these, in the course of time, are no longer noticed. The same may be said of the alkali waters of the Western plains.

The difficulty of obtaining a pure water supply for our towns and cities is increasing from year to year. Our streams are becoming more and more polluted, and water from wells is objectionable on account of its hardness. It is only a matter of time until each city dependent upon a surface water supply will be compelled to erect a filtration plant, after the fashion of European cities. A properly filtered water does away with the danger of many water-borne diseases, such as typhoid fever and cholera.

The water from streams, rich in vegetal or animal life, especially in summer and fall, at times acquires a disagreeable flavor, due to the decay of these organisms. At times, also, the water is full of

*These standards differ with the kind of water, locality, etc.

mud—"mud baths," after a fashion, can readily be had by the use of some city waters following a heavy rain. With such a water we can never be safe from typhoid fever.

Water performs a most important part in nature; wherever there is life, whether in animals or plants, water plays a part. Even in the mineral kingdom the formation of many crystals would be impossible without the presence of water.

Mineral Waters.

SOURCE. ELEMENTS IN THEM AND HOW COMBINED.

In any part of Indiana a variety of waters is to be found. Rain water is ordinarily regarded as pure water, especially if carefully collected. The water from our streams and lakes may or may not be pure, depending on circumstances. Well water which in its descent through the soil filters through a sand soil is usually a pure, soft water, but in a limestone or drift-covered region it will contain considerable lime and magnesia, with more or less well-marked traces of sodium, iron, alumina, etc. Unless a water has filtered slowly through a thick stratum of earth, it is apt to contain more or less organic matter derived from plants and animals with which it came in contact on the surface.

As ordinarily understood, the term "mineral water" is applied to a water which is used in the treatment of diseases, either internally or externally, and which differs from ordinary water in that it holds in solution certain solids or gases. Mineral water may come from springs or from wells, especially deep wells.

A large number of ingredients occur in mineral waters. Primarily, these are chemical elements, as calcium, sodium, iron, sulphur, chlorine, etc., but only a few are to be found in an uncombined state, oxygen, for instance. With few exceptions, chemical elements are found combined with each other, usually as bases and acids, forming salts. The element sodium—a white metal in its pure state—is, for instance, never found in this condition in water, nor in nature, as far as known, but is always combined with some other element or elements. When combined with chlorine, we have sodium chloride, common salt; with sulphur, sodium sulphide. Sodium in combination with sulphur and oxygen forms sodium sulphate. There are a large number of sodium compounds found in different waters. Among them may be mentioned: Sodium arsenite, borate, bromide, carbonate, chloride, iodide, nitrate, phosphate, silicate, sulphide, sulphite and sulphate.

The chief ingredients of the mineral waters of Indiana are, from a medical standpoint: Calcium, magnesium, sodium, potassium, iron, aluminum, silicon, chlorine, sulphur, carbon, phosphorous—these latter generally in combination with oxygen as sulphates, carbonates, bi-carbonates or phosphates.

Among the minor ingredients, because occurring very rarely or only in minute quantities, may be mentioned: Lithium, bromine, iodine, boron, zinc, with perhaps a few others.

Among the gases may be mentioned oxygen, nitrogen and hydrogen; also sulphuretted hydrogen and carbonic acid gas.

It should be kept in mind that the above substances are not to be looked for in their uncombined state; they occur combined with each other, and usually as salts.

Elements are usually grouped on account of some properties they have in common. Some of the metallic elements form a group known as the alkaline metals, the two chief ones, as far as concerns the purpose of this paper, being sodium and potassium. They are found, in combination, throughout nature, and we take variable amounts in almost every mouthful of food we eat.

Sodium and Potassium.

Sodium enters into the chemical composition of every part of the human body; potassium, also, though to a much less extent. These elements are to some extent interchangeable in the body. On a vegetable diet, potassium accumulates. In the case of the herbivora it may gradually accumulate to such an extent that animals like the buffalo will go hundreds of miles to the "salt licks" to satisfy the craving for common salt, the sodium displacing the accumulated potassium. Animals living on flesh, the carnivora, get all the sodium required, in fact, all the needed mineral matter in their food. A cow will gnaw at bone to get the needed calcium or phosphorous of which bone is composed. We, as a rule, use salt, that is, table salt, more as a seasoning than on account of the actual need of it; some stomachs get too much salt.

It may, perhaps, appropriately be here stated that the substances needed in largest quantity by the body of man, as well as of other animals, are so-called carbon compounds, or organic compounds, the element carbon being in combination with oxygen, hydrogen and nitrogen mainly. These compounds are the substances that are mostly concerned in our daily life, in the wear and tear of the body, and they are obtained primarily from the vegetable kingdom, and are produced—manufactured, if the term may be so used—by the plants themselves from the inorganic materials—earth.

Sodium, as such, does not occur in the body, but is always found in combination with other substances, notably with chlorine, and in this combination we take it daily as table salt, or, chemically speaking, sodium chloride, the older name being chloride of sodium. It is found in every part of the body, and some of it is decomposed by special cells in the stomach wall, into hydrochloric acid, also known under the older name of muriatic acid; it is a combination of chlorine with hydrogen and is needed in the process of digesting albuminous foods, such as meats and eggs.

Combined with carbonic acid, a compound of carbon and oxygen, sodium occurs in small amounts in the body, also with phosphoric and sulphuric acids. Besides these, there are a number of other combinations, some of them being with so-called organic acids, as those of bile or urine. Some of the sodium compounds will be again referred to under their medicinal properties and uses.

In a general way, the above remarks on sodium also apply to potassium, but, since the latter plays a less important part, no special mention need be made of it at present.

The element lithium is one of the rarer members of this group. Lithium plays an important role in the advertisements of mineral waters and health resorts—often waters with a mere trace of it are called "lithia waters" and extravagant claims are made for their curative properties. Lithium owes its medicinal reputation to the fact that it brings uric acid or deposits of uric acid in the body into solution, its solvent power in this respect being greater than that of potassium or sodium.

Calcium and Magnesium.

Calcium and magnesium belong to the group of alkaline-earth metals; they are the chief elements entering into the composition of bone—in combination with phosphoric and carbonic acids. They occur more or less abundantly in our food and drink.

Our drift soils, covering the greater portion of the State, are full of lime, and water in contact with such soils becomes saturated with it—becomes "hard." To persons using a freestone water, free from lime, additional quantities of it may be of advantage, but too much lime is by some authorities considered detrimental to the body, as it may help to produce a degeneration of the arteries—so-called calcareous degeneration, known also as pipe-stem arteries. It is sometimes said that a man is no older than his arteries, meaning that he will show his age most in the condition of the arteries; some men old in years are young in this respect.

Strontium and barium are elements that occur in some mineral waters, though very sparingly. They have a great affinity for sulphuric acid, with which they are usually combined. They may be dismissed with this bare mention.

Iron.

Iron as found in our mineral waters is combined with carbonic or sulphuric acids. Chalybeate waters, which will be referred to more in detail later on, are iron waters.

Iron is an important element entering into the composition of the body, or, to be more exact, into the coloring matter of the blood. Ordinarily, we get all the iron we need from our food, from beefsteak, especially. Where there is a deficiency, a condition which can be accurately determined by the use of diagnostic instruments, additional iron may have to be supplied to the body.

Among the rarer and less important members of the group to which iron belongs may be mentioned aluminum and manganese. The latter is a very rare ingredient of mineral waters, and to a certain extent possesses the properties of iron, but as far as its uses by the body are concerned we may neglect it altogether in this paper. Aluminum is a common ingredient of nearly all mineral waters, though usually only in infinitesimal amounts. Alum waters contain it in considerable quantity, and such waters have a peculiar astringency. Aluminum plays no especial part in the nutrition or functions of the human body, nor does the small amount in ordinary mineral waters have any medicinal effects.

Arsenic, belonging to a different group from any of the preceding, occurs in some waters, notably the poison waters of Tyrol. Arsenical water, or arsenic, has a peculiar effect on the body and is sometimes used in medicine, but since our Indiana waters do not contain this substance, no further mention need be made of it.

Chlorine, Phosphorus, Sulphur, Carbon.

The above elements, as found in our waters, are in combination with other elements, occurring usually as acids, and these in turn are combined with bases, the chief ones having been enumerated above. The principal acids are: Hydrochloric, phosphoric, sulphuric and carbonic. As their effects on the body are dependent almost wholly on their combination with bases, these combinations, so-called "salts," may now appropriately be considered.

Taking up the salts in the order in which their bases have been given above, we may now briefly enumerate the chief ones, with mention of their physiological and therapeutical, or medicinal, action, or effect, on the human body, though in a general way only.

Sodium Chloride.—Common Table Salt.—This is the most common combination of sodium; it is found everywhere, and all mineral waters contain it, in quantity from a mere trace up to 10,000 grains per gallon. This salt occurs in every part of the body, and a certain amount is required every day to keep the system in a healthy condition; the longing for salt is hence a very natural one. Sodium chloride regulates absorption, nutrition and secretion, and is of the utmost importance in these vital processes. It was for a long time held that if given in increased amounts it would promote tissue changes—proteid metabolism, as it is called in physiology. Taken into the stomach, it causes, or may produce, an increase of the gastric juice, of bile, pancreatic juice and intestinal fluid, promoting the appetite and assisting digestion. Part of the salt is decomposed by the stomach, and the acid, set free, with the secreted pepsin, brings albuminous foods (meats and eggs, for instance,) into solution ready for absorption. On the bowels it has a slight aperient effect, and also restrains decomposition of the intestinal contents. It has some expectorant action on the respiratory mucous membranes. Large doses are emetic and purgative.

It finds its chief employment in disturbances and diseases of the alimentary tract, in certain affections of the stomach, liver and bowels. It is of service in certain forms of dyspepsia marked by atony or a deficient secretion of acid; in forms marked by an excessive secretion of acid it may aggravate the difficulty. Stomach disturbances should always be thoroughly investigated and diagnosed, and the amount of free acid determined before attempting to prescribe a remedy, and especially before sending a patient to any mineral spring.

Sodium Sulphate, Glauber's Salt, is a common and abundant constituent of most of our mineral waters. It may be so abundant in a water as to exceed in its action all other constituents. This salt is not needed by a healthy body, and it plays no part in the tissue changes of daily life; any that might possibly be required is obtained from our food, which contains it in minute quantities. Taken medicinally, as by drinking a water containing it in solution, it acts chiefly by the process of endosmosis and exosmosis, or the to and fro movements of soluble substances in liquids. Small doses stimulate the intestinal and urinary secretions, larger doses are laxative, and still larger doses are cathartic; in other words, the amount of reaction depends on the amount taken.

This salt is useful in some disordered conditions of the digestive tract—gastric, hepatic and intestinal—and may be used daily in small doses, or in one or two large ones, as may be required. When the action on the bowels is gentle, it is known as aperient; when more active it is called laxative, and when very active, cathartic. An aperient is very frequently indicated, that is, it may be properly used, in deranged conditions of the alimentary tract, and may act very beneficially, while a cathartic is rarely indicated, and, given in improper cases under unfavorable conditions, may act injuriously. In their action, salts, or salines, may take much fluid from the body. In certain dropsical conditions, as that dependent on some forms of heart disease, it may give relief by helping to abstract the accumulated fluid. It must, of course, not be regarded as a "cure" in the latter condition, dropsy being simply a symptom of an underlying disease. It should be added that in a number of diseases the use of a water containing much of this salt must be avoided.

SODIUM CARBONATE.—This salt is commercially represented by the common washing soda, and, when combined with an additional amount of carbonic acid, by baking soda, the latter being sodium bi-carbonate. It is found in the body, in the blood and saliva, and these fluids are alkaline. Both these salts occur in most of our waters, usually only in very small amounts. They impart to water a greasy touch and a peculiar taste. Free acids are readily neutralized, the sodium combining to form a new salt, and for this reason these carbonates are much used in acid dyspepsia and may be of value in the treatment of gallstones. The bi-carbonate is usually prescribed. It is useful in certain affections marked by acid conditions, among which may be mentioned some of the fevers, rheumatism, gout and irritable bladder, particularly if the irritation be due to excessive acidity of the urine, the latter becoming alkaline under its use. In uric acid conditions the potassium bi-carbonate is to be preferred. In conjunction with other salts, as found in some of our mineral waters, it is frequently of service in catarrhal conditions.

A remedy which may produce good results in a proper case may, on the other hand, aggravate the difficulty in a case where it is not indicated. That sodium carbonate will derange digestion is at times shown in the case of persons who have for a long time eaten soda biscuits. The bi-carbonate originally used, under the influence of heat, is changed into the simple carbonate, the excess of the gas being liberated, "raising" the biscuit. The continued ingestion of an alkali is certainly not conducive to increased digestive power of the stomach.

Sodium Iodide.—This salt is found in some waters, at least the small amount of iodine found in a water is usually given as combined with sodium in the report of the chemist, but it does not matter in what combination the iodine may be, it will produce the same effects. Where decided results are desired the salt itself, as obtained from the pharmacist, is usually prescribed. The effects of iodine and of iodides is conveniently expressed by the term alterative. In some way alteratives hasten the disappearance of some of the abnormal tissues, such as are found, for instance, in scrofula, syphilis, goitre, etc. If too much is given or for too long a time, the vitality of the normal tissue may itself be affected and the system undermined. In some parts of the world springs are found rather heavily charged with iodides and where their peculiar effects may be brought about without the action of accompanying salts, as those of the laxative sulphates of sodium or magnesium. A small amount of iodine may have its effects increased by the presence of other salts, notably those of iron.

Sodium Bromide.—Bromine is usually associated with iodine and occurs in very minute quantities only. Bromides have a sedative effect on the nervous system, and are often given on this account. No reaction is to be looked for from the small amount that may be taken in any of our mineral waters in which it occurs. To get any effect from the sodium salt may require from a few grains up to several drams, the dose to be repeated as occasion demands.

Sodium Borate.—Boron or its sodium salt occurs plentifully in certain countries, but is rarely mentioned as occurring in our waters. The double salt, bi-borate of sodium, is known in common language as borax; it has a limited use. Boric acid, separated from its combination with sodium, is a white powder used in lotions, gargles and as a dusting powder. The presence of this salt in any of our mineral waters does not enhance their value.

Potassium Chloride.—This salt is generally associated with sodium chloride, but usually in such small quantities that its action on the body may be disregarded, or simply included with that of the latter, which it resembles in its main effects.

Potassium Sulphate.—This occurs sparingly in some of our waters, but since its action or effects on the body resemble those of the sodium sulphate and magnesium sulphate, no further mention need be made.

Potassium Carbonate, or usually the bi-carbonate, occurs in small amounts in some of our alkaline waters; its action resembles that of the sodium salt; it is an antacid and diuretic. Its solvent action on uric acid is greater than that of the other, but unless used in its pure form and in considerable amount, from five to fifty grains in a glass of water, no decided effects are to be looked for. Its presence in our mineral waters, in common with that of the other potassium salts, may be wholly disregarded as far as its medicinal effects are concerned.

The above remarks also apply to lithium carbonate, occurring in small (often exceedingly minute) amounts in some waters. There is so little of it that it can be left out of account entirely. As mentioned elsewhere, lithium forms a more soluble compound with uric acid than sodium, and for this reason it is frequently prescribed in the so-called uric acid diathesis; of this more will be said later on. If such an action, or, rather, reaction, is desired, the salt is generally prescribed in from two to fifteen grain doses of the dry powder, dissolved in a glass of water. It would be rather disagreeable to be compelled to drink a gallon of water for the sake of the few grains of lithium in it. Many of the so-called lithia waters are really very pure waters, with a trace of lithium, just enough of it so that the name can be applied, although it may require the aid of a spectroscope to show that it is present.

Calcium Carbonate is the chemical name for pure limestone. When the stone is heated, as in burning lime, the carbonic acid is driven off, leaving calcium oxide, and this, exposed to the air, gradually returns to the carbonated condition. Lime is present in nearly all of our common waters, and most of the mineral waters, as has been mentioned under calcium, and what was there said also here applies to its carbonic acid compound. It is only slightly soluble in water (about one part in 10,000 parts of pure water), but more freely so in water impregnated with carbonic acid gas. Although in itself it may have some slight medicinal properties, chiefly antacid and diuretic, yet as found in mineral waters, excepting, of course, the calcic or alkaline calcic kinds, its possible effects are wholly overshadowed by those of accompanying salts, particularly of the laxative sulphates of sodium and magnesium.

Calcium Sulphate.—The calcium in mineral waters is generally combined with sulphuric acid, and the resulting salt, the one just mentioned, is a common constituent of many waters. The amount present may be small, owing to its slight solubility, and no importance is to be attached to it in waters rich in other sulphates. It has no particular medicinal properties.

CALCIUM PHOSPHATE.—In considering, on a previous page, the chemical elements to be found in mineral waters, mention was made of phosphorus. In waters this is to be looked for in combination with calcium as a phosphate salt, and, as this is almost insoluble, only traces are to be found. No medicinal effects are to be looked for from the small amount in our mineral waters.

MAGNESIUM SULPHATE.—This is commonly known as Epsom Salt and is a most important ingredient of some springs and wells. It is a very soluble salt and may occur in large amount. Its effects on the body are similar to those of sodium sulphate, but it is less unpleasant to the palate and milder in action, and may be retained by the stomach, where the other is rejected. It is generally preferred to the sodium salt. If no action results from one dose it should be repeated.

MAGNESIUM CARBONATE.—This is given as an occasional ingredient of waters, but, because of its slight solubility (one part in about 2,500 parts of water), it may properly be excluded from the list. It is used chiefly as an antacid—in neutralizing acids—and for this purpose the dry calcined magnesia is the preparation prescribed.

IRON CARBONATE AND BI-CARBONATE.—Iron is of frequent occurrence in waters and is usually tabulated as a carbonate by the chemist. There may be only a mere trace, or, as in the case of some chalybeate springs, well-defined quantities. The importance of iron to the body has already been referred to. In many affections, notably in alterations of the blood, "iron waters" may be of decided benefit. The importance of iron will be again referred to in that part of this paper devoted to a consideration of diseases.

IRON SULPHATE.—Sometimes the iron is combined with sulphuric acid, particularly in waters of acid and sulphur springs. In this combination the iron is more astringent and less palatable than when combined with carbonic acid, although the ultimate effects of the iron on the blood may be the same.

It may be added that nowadays physicians do not depend on inorganic iron compounds to get iron into the system, into the blood cells, of their patients. They use organic compounds, usually such as are obtained from blood itself, as from that of the beef.

ALUMINUM SULPHATE is an occasional constituent, notably of some so-called alum wells or springs. The astringency of alum waters resembles that of alum itself. No special claims can properly be made for such waters, and when found in saline waters its possible effects are outweighed by the action of other salts. At times the analyst does not separate the alumina, or oxide of aluminum, from the accompanying iron in the process of analysis, and in that case he will give the combined amount of iron and aluminum oxide. Occasionally the quantity of aluminum is given as aluminum silicate.

Of the gases found in mineral waters the following two should be mentioned as the most important:

CARBONIC ACID GAS.—This is a combination of carbon and oxygen and is found in all cold waters in variable amounts. It gives a sparkle to water, and if present in considerable amount may give a pungent taste, like the carbonated water of the soda fountain. Such waters are at times very soothing to an irritated stomach and may allay nausea. Where the effects of this gas are desired, the water should be either pure or only feebly mineralized.

HYDROGEN SULPHIDE, OR SULPHURETTED HYDROGEN, is the gas with the rotten egg odor, and a constituent of many saline or alkaline-saline waters, usually associated with other sulphur compounds. Exposed to the air, such waters become milky, turbid, from a precipitation of the sulphur in the decomposition of the gas. It is doubtful if this gas, especially when the amount ingested with the water is considered, has any influence on the body or is of any marked benefit in diseased conditions. Used externally it may have some influence in certain skin diseases. Warm sulphur baths may be useful in chronic lead poisoning, as that of painters. Many of the famous sulphur waters are hot or thermal springs, and their virtues, aside from that of accompanying constituents, are often due to the manner in which they are used.

One of the anomalies connected with the application of remedies for the relief of affliction from disease, is the belief that strong smelling or strong tasting substances are "powerful medicine." A tasteless medicine may have the same influence on physical conditions, but it may not influence the mind, and this is an important factor with many persons who are constantly taking medicine for one thing or another. Frequently all that is needed by a sick man is water, pure water, water in abundance, but unless something is added to it to give it some taste or odor, it is often impossible to get him to use it as he should.

A few other salts might have been mentioned in the above list, but since they occur in exceedingly small quantities or because they lack any medicinal properties, it was not thought necessary even to mention them.

From the above list it will be seen that the number of important constituents of our mineral waters is rather limited. Compared with the number of medicinal agents or remedies used by a physician—and mostly of an organic or non-mineral nature—the number found in mineral waters seems small indeed. The reason why one water differs from another may be chiefly that the difference is a matter of quantity, the same constituents may occur in both waters. Often one constituent predominates to such an extent as to outweigh in its effects all others, giving the water its character. A water is apt to be more powerful, more effective, when the chief ingredients have similar action than when the action of one set of ingredients counteracts that of another. As a matter of fact it is often difficult to say just what the action of a water will be from the published analysis. Some waters can readily be assigned to the class to which they properly belong, while others can not.

From the preceding it will be seen that the therapeutic or curative range of action of substances ordinarily found in mineral waters is quite limited. The limitations will be still more marked if we distinguish sharply between palliative and curative effects. Although the range is limited, yet taking into consideration the prevailing affections of mankind, the common ailments of daily life, it will be found that the occasion for prescribing or for taking mineral waters is an extended one. As a general rule, when a person is ill, he feels bad all over, the whole system seems to be upset, and no one part of the body, no one organ, can be picked out and the difficulty definitely ascribed to it. Compared with the number of cases of illness, the number of cases of typical diseases is small. Very frequently a little fasting, a brisk laxative and a good night's rest is all that is needed to restore the normal or healthy condition. Mineral waters find their chief application in chronic ailments.

It should here be said that salts occurring in mineral waters can be obtained in a pure form from the pharmacist, as well as mixtures of salts resembling, in their chief effects, at least, those of mineral waters; these latter are known as "artificial mineral water salts." As a matter of fact, many of the noted waters are now closely imitated by manufacturing chemists. These combinations of chemical salts may be obtained in crystalline or in powder form or in the shape of tablets of definite strength. These tablets often contain such a mixture of acids and alkali that when they are dissolved in water, carbonic acid gas is given off, making the solution of the salts more palatable, or more closely imitating the natural water.

Now, although we may be able to determine fairly well what will be the result, the effect, when a certain salt is supplied to the body, when we come to mineral water itself we may in many instances be wholly at a loss to know beforehand what the effect will be. The most active ingredient may dominate all the other salts, as where a large amount of sulphate of sodium or of magnesium very speedily produces a cathartic effect, or where a water containing arsenic produces its peculiar, perhaps toxic, effect, outbalancing all others. That the effect varies with the dose is known to everybody. Where salts of antagonistic actions occur, their usual effects on the body will probably be neutralized, and, on the other hand, where their action is along the same line, the effects may be greatly increased.

As a general statement, it may be said of the mineral waters of Indiana that the salts most abundantly present will determine the activity of the water, and that this activity will be modified by the amount of water taken.

There are no hot mineral springs in Indiana;* all belong to the non-thermal or cold spring variety, and this fact makes some slight difference in their therapeutic application. The effect of hot water is quite different from that of cold water, irrespective of the mineral ingredients.

A chemical analysis of mineral water will show what elements are present, but not how these different elements—usually divided into bases and acids—are combined. When the chemist has completed his determinations of the kinds and amounts of each element found, he goes to work to arrange his table, combining acids with bases, according to certain chemical laws or rules, and in this form they appear in the published analyses. Analytical chemists may all find the same kinds and amounts of ultimate chemical elements and yet their views may differ on how these are combined with each other. The tendency at the present time is to greater uniformity in this respect.

If the analysis of one water approximates closely that of another, then we may infer that the waters are essentially alike, and we may look for similar medicinal effects from each—though in practice there may be found slight differences, making one water more efficient and more valuable in the treatment of diseases than the other.

Mineral waters occur in great numbers and variety, and for convenience of classification they may be grouped according to some marked constituent or some decided therapeutic or medicinal properties; a spring very rarely has any marked property aside from that of its class. To the physician it is very important to know to which class or group a water belongs, in order to enable him to properly advise his patients concerning its use. Whether a patient should be sent to the nearest spring of its kind or to a distant one with different surroundings, perhaps a different climate, from those to which

*The warm "thermal wells" with a temperature of 80° F., to which Mr. Blatchley calls attention, may merit investigation and be put to a more extensive use. There seems to be an abundant flow of water.

he has been long accustomed, are questions that must also be considered at the proper time. It is not simply a question of going to a spring, or even a spring of the same class, and drinking the water, in limited or unlimited quantities, as we shall see later on.

CLASSIFICATION OF MINERAL WATERS.

*There is little uniformity among authorities on the subject of the classification of mineral waters, and views on the proper position of any water in a given classification may vary widely.

Pliny, the old Roman naturalist, divided waters into acidulous, sulphurous, saline, chalybeate, nitrous, aluminous and bituminous. This was nearly two thousand years ago, and his classification survived for a long time, indeed, some of his terms are in use today.

A modern classification, including the various waters to be found throughout the world, is rather elaborate. The number of kinds of waters in Indiana is small and the classification of them will accordingly be brief. Based on their chief ingredients, our waters can be arranged into groups with names like the following: Carbonated, alkaline, alkaline-saline, saline, chalybeate.

Alum waters, although really saline, may perhaps best form a group by themselves.

The present writer will not attempt to refer to their respective classification the mineral waters of the State. All he desires to do in this paper is briefly to indicate, in a general way, the lines along which waters may be grouped and to give a few statements concerning indications for the use of each kind of water. Just where a mineral water from any particular spring or well belongs can be determined from the analytical tables in Mr. Blatchley's report. Often it is a difficult matter to determine just where a water belongs on account of the number of ingredients and amounts present; some waters may properly be placed in more than one group.

The indications for use in diseases or ailments will be but briefly referred to here. A more thorough consideration will be given the subject under the head of "Disorders and Diseases." The effects of individual salts have been briefly mentioned on pages 164 to 172

The following extract is from Crook's "Mineral Waters of the United States:"

"In what way do mineral waters act, and how do they produce their therapeutic effects? We may answer this query by the statement that in a general way their influence is wrought in the same manner as is that of other medicinal agents. It is easy to understand that a water densely impregnated with the sulphate of magnesia will cause alvine evacuations, and that one containing iron will increase the amount of hemoglobin in the red blood-cells; yet it must be confessed that an element of mystery still shrouds the action of many waters, and the good effects obtained from their use are difficult to explain."

Where reference is made to European waters, it is done mainly on account of their having been so long known and so fully studied. In justice to our local springs and wells we can not refer to any one as typical of a class without also naming others which would answer equally well.

CARBONATED WATERS.—Waters of this kind contain an excess of carbonic acid gas, holding in solution or accompanied by the carbonates of calcium, magnesium, sodium, and, to a less extent, by other bases. Reference was made to waters of this class under carbonic acid gas, on page 172. It may further be said that waters of this kind are often very palatable, and, other things being equal, they may be desirable for table use. The famous Apollinaris water, coming from near the River Rhine, in Germany, is essentially a very pure water, slightly alkaline, charged with this gas, each pint containing about 42 cubic inches. Some of our so-called lithia waters also come under this head.

ALKALINE WATERS.—Waters of this class contain considerable sodium and calcium carbonate and small amounts of chlorides and sulphates, with more or less free gas. If much sodium carbonate is present the water has a greasy touch. Such waters are regarded as diuretic, producing an increased flow of urine, and so may be of service in flushing the system and helping to get rid of accumulated waste products. Such waters also have an antacid effect, neutralizing the acid of the stomach, blood or urine, and in properly selected cases a favorable influence may be expected, as in hyperacidity of the stomach, in continuous flow of the gastric secretion and in pyrosis or heartburn. Continued use may possibly bring about a change in the formation of the acid itself, that is, in a diminution of the amount produced. To simply neutralize the acid is, of course, not a cure. In diseases of the liver, attended by disturbances of the biliary passages, or by gallstones, it may be of service, as well as in certain kidney and bladder disturbances. Diabetics are often greatly benefited by a prolonged stay at some alkaline mineral water resort. Theoretically, such waters are said to be indicated in many catarrhal affections—to loosen and dissolve the mucus—as in the case of ca-

NOTE.—Properly speaking, nearly all the wells and springs of Indiana whose waters are used for household purposes, certainly those of the limestone regions or of the glacial drift areas, must be classed among the alkaline mineral waters, on account of the amount of calcium they contain—held in solution chiefly by free carbonic acid gas. If this latter is driven off, as by heating the water, a deposit of limestone follows, as that in the tea-kettle, The difference in the taste of such waters from freestone waters is quite marked to persons accustomed only to the use of the latter and they may also notice some unusual effects from its use. Waters of this kind are, of course, too feebly mineralized to be of service in the treatment of diseases for which waters like those above mentioned are indicated. The possible influence of the lime where such waters are constantly used has already been referred to under "Calcium Carbonate."

tarrh of the respiratory system or of the digestive tract. The waters of Vichy and Ems are types of this class. The former contains 26 grains of sodium carbonate to the pint, with about 15 cubic inches of carbonic acid gas. For minor ingredients, present in small amounts, see the table at the end of this paper. In the water of Ems there is less carbonate and more of the chlorides; it is really an alkaline-saline of a mild type; it differs greatly from the Carlsbad water by the absence of sodium sulphate.

ALKALINE-SALINE WATERS.—These differ from the last in that they contain greater quantities of sulphates and chlorides. The well-known Carlsbad water is a prototype; its chief constituents, with amounts per pint, are as follows: Sodium carbonate, grains, 9; sodium chloride, grains, 9; sodium sulphate, grains, 20; round numbers being given.

A water of this kind in continued small doses stimulates the secretion of the gastric mucous membrane, while large doses diminish it. It increases peristalsis of the stomach and intestines, thus tending to empty the stomach and intestines. It reduces the irritability of the stomach.

In attempting a Carlsbad cure, it is necessary beforehand to ascertain the condition—the amount of acid secreted should be accurately determined. It may be added that the diet regulations at Carlsbad play an important part in the treatment of alimentary tract disturbances and diseases. The best results are obtained in cases resulting from habitual overfeeding.*

---

*According to Boas' "Allgemeine Diagnostik und Therapie der Magenkrankheiten," Carlsbad thermal waters are indicated in the following conditions:

1. In acute cases of dyspepsia, particularly those with increased acidity and moderate constipation.
2. In gastritis acida, especially if accompanied by an abnormal secretion of mucus.
3. In many (non-nervous) forms of hyperacidity, of continuous flow of gastric juice, and in hydrochloric acid pyrosis.
4. In the milder forms of atony of the gastric muscles, dependent on sedentary habits, limited diet (soups), habitual constipation and increased secretion.
5. In insufficient chemical activity and diminution of the amount of free hydrochloric acid.
6. As an after-cure following the healing of a chronic gastric or duodenal ulcer, especially in the hyperacid forms.
7. In dyspeptic disorders dependent on constipation, disturbances of the liver and while still in the sub-chronic stage.

In 1, 2, 3 and 6, large doses of the thermal waters are indicated; in the others, small doses.

Carlsbad water should not be used in the following:

1. In advanced forms of dyspepsia, particularly if free acid has disappeared.
2. In all forms of real chronic gastritis with a complete loss or disappearance of hydrochloric acid.
3. In dilatation of the stomach, whether dependent on atony of the walls or on stenosis of the pylorus.
4. In all forms of nervous dyspepsia.
5. In dyspepsia accompanied by severe constipation.
6. In suspected malignant disease of the alimentary tract.

SULPHURETTED WATERS.*—Most of the waters of this kind in Indiana are alkaline-salines, or salines charged with sulphuretted hydrogen, and they are readily recognized by their odor. Objection is rarely made to this gas, or rather to its odor, and after a few days' use it may no longer be noticed; it does not disagree with the stomach. In a general way, the action of these waters is that of other springs or wells having the same mineral ingredients, minus the gas.

These waters in Indiana play a prominent part in the treatment of disturbances of nutrition—in derangements of the stomach and kidneys. Their therapeutic or medicinal range is a wide one. Full-blooded, plethoric individuals are often greatly benefited by a prolonged stay at one or the other of these springs or wells, particularly persons living in cities, leading sedentary lives, eating too much, or too rich food, and not knowing what it means to be really hungry.

Waters of this kind do not add anything to the body—anything that is needed for its nutrition—which may not be obtained from food. Their action is in just the opposite direction; they deplete, they take away products that have accumulated by the abnormal mode of living, by the over-eating and under-exertion.

These waters are esteemed in many disordered conditions of the stomach, liver and bowels. A sallow complexion, with a coated tongue, is quickly cleared up by waters in which the sulphates predominate. The condition following the prolonged use of alcohol is speedily and beneficially modified by a short stay at one of these springs. The use of such water will again be referred to under diseases of the alimentary tract and under uric acid conditions.

SALINES, SALINE WATERS.—These waters contain large amounts of sodium chloride, with variable amounts of chlorides and sulphates and little, if any, sodium carbonate.

*There are four fairly well defined kinds of sulphur waters found in Indiana and they can be characterized in a general way about as follows:

1. Waters with very little sodium chloride and with fair amounts of the sulphates of sodium and magnesium. Waters of this kind are especially serviceable in cases of hyperacidity of the stomach and where sodium chloride is contraindicated. Some of the waters contain more or less of the carbonates of calcium and sodium, and these aid in neutralizing the acidity.

2. Waters with considerable sodium chloride and with practically no sulphates; these are indicated in conditions the opposite of those mentioned above.

3. Waters with much sodium chloride and considerable of the sodium and magnesium sulphates. These waters are indicated in conditions marked by sluggish bowel movements; they are chiefly aperient in their action.

4. Waters with variable amounts of sodium chloride but with large amounts of sulphates and having a decided action on the intestinal tract. These are essentially purgative waters.

The writer would like to mention some of the waters coming under the above heads, but in justice to others he can not single out a few.

Sodium chloride waters are said to be useful in stimulating the gastric mucous membrane, in increasing the appetite and in getting rid of excessive amounts of secreted mucus. The best results are obtained in gastritis, with diminishing amounts of hydrochloric acid, but the water must be used at least for many weeks. Chronic cases may be benefited by the continued use of such waters, as they help the digestive process. In cases with increased formation of hydrochloric acid, such waters are contra-indicated, as might naturally be inferred from the preceding.

Salines differ very much in their composition. The waters of Wiesbaden contain 52 grains of sodium chloride to the pint, those of Nauheim, mostly used for bathing, contain 110 grains. When salines contain much of the sulphates they are termed purgative. Hunyadi Janos is an example of this kind.

CHALYBEATE WATERS contain a variable amount of iron in combination with an acid, as carbonic. Waters of this class differ greatly in the amount of accompanying salts; the best waters are those in which these are in minimum quantity. A saline water may contain a large amount of iron, more than is found in a purely chalybeate water, yet little or no benefit may be received from the iron on account of the action of purgative salts. Although iron compounds, if taken in sufficient amount or for a long time, may cause constipation and may even derange the digestive system, the amount usually found in our waters is so small that their effects may be wholly disregarded.

The springs of Schwalbach, in Germany, and Spa, in Belgium, are types of good chalybeate waters.

Chalybeate springs are common everywhere, and, unless the accompanying minerals do not disturb, they are indicated in conditions of under-nutrition, with blood deficiencies.

In chronic anemic and chlorotic conditions, a prolonged stay at some distant iron spring is often beneficial; the change in scenery and climate may be of value.

OTHER WATERS.

All sorts of combinations of salts occur, in kind as well as in amount, but, medically speaking, the above list will answer the requirements of classification or grouping. All the waters of the State may be placed under one or the other of the above heads. If belonging to more than one group, it can be indicated by such combinations as saline-chalybeate, saline-carbonated, or, in still greater detail, as, for instance, alkaline-calcic-carbonated-chalybeate. It should be distinctly understood that we have no mineral waters in Indiana that stand alone, or which may not also be found in other states of the Union, or in other countries.

Just where to place any given water may be a difficult matter, as already mentioned. Sometimes it may properly be placed under two groups, and allowance has to be made in this respect. With an analysis before us, we ought, however, to be able to arrive at some satisfactory conclusion.

Whether the waters of one locality should be used in preference to those of another locality when of practically the same composition, is a question that will depend on a variety of conditions—the nature of the disease, the condition of the patient, the distance to be traveled, the hotel or home accommodations, the cost, climate, season of the year, etc., all must be considered. In the matter of health resorts as elsewhere, the best is generally the cheapest.

ARTIFICIAL MINERAL WATERS.

Although chemists can take the various chemicals or salts and add them to pure water in proper amounts and thus closely approximate the composition of mineral waters, yet the results obtained by their use may not be exactly the same, especially to the mind of the invalid, as those derived from the use of the real mineral water—even after allowing for the modifying conditions under which the waters are taken at the springs. When speaking of a "mineral water cure," we mean a journey to some certain spring and using the water as it issues from the earth.

Some invalids prefer to use a mineral water simply because, as they say, it is "prepared in nature's own laboratory," or because it is "nature's own remedy."

In many conditions physicians prefer to use pure salts, because they can be accurately weighed or dosed out to meet the indications, as in the use of a definite amount of an alkali to neutralize an excessively acid gastric juice or an acid urine. If patients prefer to use a natural mineral water, they can, perhaps, be accommodated by a water containing a suitable alkali and without any accompanying deleterious mineral matter.

THE HUMAN BODY IN HEALTH AND DISEASE.

The human body is a complex organism. It is essentially a machine for the performance of certain functions, consisting of a framework, the skeleton, with the various organs grouped around. The numerous functions are performed by differentiated organs. The real work is done by the individual cells of which the organs are composed. For instance, muscle cells contract and expand, and thus we get motion; glandular cells secrete and excrete; nerve cells control the other cells and bring the body in relation with the outside world. Of the organs, we speak of the organs of respiration, or of sight, or of locomotion, and the like, each set performing some special function.

The cells of the body correspond to the bricks out of which the house is built. Cells are alive; they are born, live and die. Cells require food for the performance of their separate functions; they grow, especially in number, as the body itself grows. Food is carried to the cells, and, in fact, to every part of the body, by the blood stream. Products of vital activity are carried off by the blood and are eliminated by the lungs, kidneys and skin. Unused parts of the food itself are directly discharged from the alimentary tract without having entered the body proper, for, strictly speaking, the inside of the bowel is outside of the body.

The human body, like animal bodies in general, breaks up organic compounds, these latter having been built up by plants from the inorganic materials, that is, from the earth, air and water. The number of chemical elements entering into the composition of the human body is quite limited, and what we need for growth and keeping the body going and to replace the wear and tear we obtain from our food. Oxygen, hydrogen, nitrogen and carbon compose approximately 95 per cent. of the human body; mineral matter, such as calcium, phosphorous, sodium, iron and several others in very small quantities, composing the other 5 per cent. Seventy-five per cent. of the body weight is water. It should be remembered in connection with the use of mineral waters that the small amounts of mineral matter needed to replenish the wear and tear of the body are supplied in our daily food.

The chief waste products of bodily activity, of metabolism, are carbonic acid, urea, uric acid and combinations of uric acid, creatin, cholesterin and several other substances in lesser amounts. In a general way we may say that the food consumed in the production of heat and force is burned up just like coal under a boiler—that is, oxidized—combined with oxygen—and the resulting carbonic acid gas is given off by the lungs. The wear and tear of the bodily organs themselves in the performance of this function is excreted by the kidneys; this is chiefly urea and uric acid, and a quantitative analysis of the urine will, in a measure, show the amount of this wear and tear.

People living in a cold climate require more food to keep the body warm—to keep up the animal heat, and the body must oxidize more food and the lungs act more energetically to supply the air and displace the carbonic acid gas. In the struggle for existence, a person with a poor digestive apparatus has a very poor show. On the other hand, people living in a warm climate require little food to keep up the bodily heat; the same may be said of persons living in warm rooms, and dressing warmly on going out. With large quantities eaten and little actually used, the body naturally stores up material to be drawn upon later—the body becomes fat.

In a general way it may be said that the materials entering into the production of heat and force are starches (cereals in general), sugars, oils and fats; they are literally burned up in the body. The wear and tear of the machinery itself—that of the body cells and tissues, is replaced from the animal food we eat—meats, milk and eggs. When these latter are habitually supplied in large quantities, the system becomes overloaded and the kidneys have to work harder to get rid of them. In the process of carrying off such products, water plays a most important part; in fact, if the amount of water passing through the kidneys is insufficient to properly carry them off, all sorts of disturbances may arise. The blood itself is mainly water, holding some substances in solution and the corpuscles in suspension. It may safely be said that, of all the substances required by the body, water occupies first place. Frequently, when the system is deranged, all that is needed to restore the equilibrium is the free use of water.

DISEASE.

Naturalists tell us that a constant struggle for existence is going on in the world among all the different kinds of life, animal as well as vegetable. We see it in the field, where strong plants crowd out the weak, and in the woods, where trees take possession of the soil to the exclusion of the smaller plants. Among animals, one lives at the expense of another; the stronger destroy the weak, and the strong themselves may fall through a combined attack of the weaker ones. Some animals live solely at the expense of vegetable life. Man himself lives at the expense of all other living things, animals as well as plants.

Man, too, has his foes that threaten his existence. There are all sorts of living things, both animal an vegetal, that are ever ready to attack and destroy him. In civilized countries the danger from large wild beasts has of course been reduced to a minimum—we are no longer in danger of being eaten by wolves and bears, but a host of small animals, parasites chiefly—worms, tapeworms and trichina, mites and amoeba, constantly assail us. At present our direst enemies are among the plants. We have all heard of the festive bacteria that are ever ready to attack and destroy us. Bacteria, belonging to the vegetable kingdom, as causes of diseases, play a most important role.

When the cause of a disease or of an injury is large enough to be plainly seen by the unaided eye, we readily take it for granted that it is the cause. For instance, a child is suffering and has a peculiar train of symptoms. What ails it? What is the cause of the illness? After a short time, several worms are passed and the child is well again, and we at once, and properly, conclude that the worms were the cause of the disturbance.

As the cause, or causes, of diseases diminish in size the difficulty in recognizing them increases. Seeing usually means believing. The smaller an object the fewer are the people in this world who are able to see it. By way of illustration, the cause of the human "itch" is a good example. Several hundred years ago a little mite was suspected to be the cause of the itch, and soon after the microscope came into use—about two hundred years ago—it was figured and described. Yet strange to relate, it was not until about seventy-five years ago that it was universally recognized as the cause.

At the present time we know positively that quite a number of diseases are due to the growth of minute forms of life, especially bacteria, in and upon the human body. It is not to be understood, however, that all diseases are due to "germs," as this is not the case. Moreover, many diseased conditions may be simply the after-effects of former attacks of such minute organisms; the original cause of the disease, or the disease process, may have utterly disappeared. It may be added that the number of diseases that may be inherited is quite small, and such inheritance occurs only exceptionally.

Nowadays we always want something definite as a cause for the production of a disease—something that can be seen, felt, weighed or measured, a something that appeals to the senses.

Disease has been defined as: "A condition of the body marked by inharmonious action of one or more of the various organs, owing to abnormal conditions or structural change."

The natural defenders of the body against the attacks of bacteria, of disease germs, are the white-blood corpuscles; they are the soldiers that fight our minute foes. They do their work so perfectly that ordinarily we are not aware of any struggle going on within us. At times, however, the struggle becomes so intense that we are led to realize that something is wrong, as when we have fever. The fever is literally the heat of the battle that is going on within our body after some disease-producing germ has gained an entrance and is trying to overrun it. When the fever or heat producing process is localized near the surface, as in an inflammation of the finger, the battle may be fought within narrow limits and the white cells that have fallen in the battle may be discharged from the surface as pus or matter—a pus corpuscle is simply a dead white-blood corpuscle.

The human body reacts in a certain manner to a given cause. In the case of diseases due to microbes this reaction is very uniform, and this is what we ordinarily call the symptoms of disease. A critical study of the symptoms may therefore tell us what the disease is, as well as its cause.

The body in relation to disease-producing bacteria may aptly be compared to a bare field ready for the seed. If no seed is sown, no crop results; if corn is sown, the resulting crop will be corn; if wheat, then wheat results. We do not expect corn when wheat is sown, nor anything else than wheat. So in diseases. If, for instance, the germ of cholera begins to grow in the body, cholera results and nothing else. If a body be in a locality where there are no cholera bacilli, there will be no cholera. The point is this: No germs, no disease—a given disease for a given germ.

In regard to bacterial diseases, it may be said that as long as the body is in good working order, the skin unbroken and the organs, especially the digestive tract, perform their functions well, then we are in good condition to resist the attacks of our enemies, the disease-producing bacteria. Occasionally some may gain an entrance and flourish for a short time, but ultimately they are dispelled—and we are well again. Where the body is in poor condition, enfeebled for some cause, it is less resistant and may succumb to an attack that a strong person would readily overcome.

Besides acute diseases due to infection and chronic diseases the result of such infection, there are many diseases or diseased conditions to which no outside, no foreign, or in other words, no bacterial, or microbic, cause can be assigned.

A sharp distinction must be drawn between *acute disease processes* —acute disease due to some infection—and the *after-effects* of such diseases. The latter may be due to impaired functioning of an organ owing to a partial destruction of its substance, or to some perverted action having been induced which is kept up after the subsidence of the acute disease—there may be some remaining chronic functional derangement, or, as we say, a chronic disease.

The kinds of diseases chiefly benefited by the use, internally or externally, of mineral waters, belong to the non-acute, or non-germ kind, mostly diseases or disorders of the alimentary tract, kidneys, blood and skin. These will be considered in some detail later on, together with the benefits to be derived from the use of a proper mineral water.

WHAT MINERAL WATERS WILL NOT DO.

Not to go into this question would practically defeat the object of this paper. It is a cardinal principle in medicine that to "know what not to do" is just as important as to know "what to do." It is just as important to know what mineral waters will not do as to know what we may reasonably expect from them.

Confining ourselves to Indiana mineral waters, we may safely say that none of them add anything to the body which may not as well be administered at home, and perhaps in a more palatable or agreeable form. We have no waters that are healthful, that is, full of health, and no sick person can drink-in health by drinking water.

Our mineral waters do not contain anything that adds to the nutrition of the body which may not be found in the daily food.

There is nothing in mineral water that will keep the body in health—nothing except the water itself. Everything that is needed by the body in health is supplied by our ordinary foods and when the body is sick it is only exceptionally that a mineral spring supplies anything that is needed to restore health, as the iron in an iron spring, for instance.

Simply to go to a health resort and drink the water in prescribed, or perhaps in unlimited, quantities, is not all of "Going to a health resort," no more than to fish is all there is of "Going fishing." Nature cures. This is a fact not to be forgotten. Doctors may help and mineral waters may help, but they help only by assisting Nature. If a patient depends on physicians or on mineral waters to make him well without his serious co-operation he will likely be disappointed. He must co-operate even at a health resort.

The belief in the efficacy of mineral waters in curing disease is almost as widespread as the belief in the healing herbs that grow somewhere—if we only knew where to find them. "Health Food" should also be mentioned in this connection. Health foods are advertised to cure many of the ills of mankind, so easily digested you know, the stomach has nothing to do but just to absorb them. It has often seemed to the writer that some one ought to "get up" a food with a minimum amount of digestible substance, a food that fills the stomach but adds little to nutrition. Many persons have a strong desire to fill the stomach, and when they do this too much is absorbed, the system is overloaded and it has difficulty in getting rid of the surplus. What persons of sedentary habit need is a food that will satisfy the craving of the empty stomach but really add little to the tissue metabolism, which, with their mode of life, should be reduced to a minimum.

A great amount of our mineral water lore has been inherited from the ancients, much of it has been found untrue; in fact many physicians question, even deny, the curative properties of mineral waters. The old books are entirely out of date and are not worth quoting at all; they contain too many general but indefinite statements about the curative action of certain waters. Much doubt has, for instance, been expressed lately as to whether saline waters influence tissue metabolism—changes among the cells and tissues or organs of the body—in the least, and yet this is a statement that has appeared in one treatise on mineral waters after another. According to the experimental researches and investigations of V. Noorden, Ludwig and Dapper, such a role must now be denied saline waters. With all the research now carried on, we will, no doubt, in the near future be able to arrive at better conclusions concerning the classes of patients, that is, the kinds of disorders and diseases that are most apt to be benefited by a longer or shorter stay at any given mineral water resort.

The writer himself is much of a skeptic when it comes to the outright curative properties of mineral waters. It may be objected that his ideas on the influence of mineral waters in the curing of diseases are too radical, too pessmistic, too iconoclastic, but if any fact is to be explained for the advantage of the proprietor of a mineral spring, he will attend to that. What some men will not claim for their waters is not worth claiming.

In this connection, the following quotation from the recently issued Cyclopedia of Medicine and Surgery, by Gould and Pyle, may be of interest: "An undue value is placed by the laity and interested proprietors upon the medicinal value of mineral waters. The benefit in most instances from them is due to the change of climate and scene, freedom from business and home cares and worry, regularity of life and diet, drinking water in quantity, and, in many instances, the substitution of water for alcoholic beverages. Those springs which are farthest removed from the patient's residence, are, as a rule, of the most value to him, as similar invalids whose homes are in the vicinity of the springs are often not benefited by its water."

If certain mineral waters possessed the properties ascribed to them by their owners or by the residents of the vicinity, then the people of that community ought to be the healthiest and longest lived individuals in the country. As a matter of fact, the health of a people of a health resort, of a mineral spring, is not apt to be better, nor are they longer lived than the people of a country with no mineral springs—conditions otherwise, of course, being equal.

We must draw sharp distinctions between being benefited and being cured. Some invalids, especially "high livers," with an accumulation of waste products in the body, may go to a health resort, drink the waters freely and in a short time feel rejuvenated. They return to their homes elated—resume their old habits and in the course of time the old difficulty returns.

We at times hear patients say: "I felt perfectly well while I was at the X Mineral Spring, but the moment I got home the old trouble returned." Some will perhaps add: "I believe I did not stay long enough to get cured, and I guess I will go back for another round." Alas for that patient. He may go again and again, and each time be benefited while at the spring and using the water, but may never be cured. The effect of the water may be simply to relieve symptoms—for instance, a gastric pain due to an excessively acid stomach, and when this is neutralized by the alkali in the water the pain subsides. In this case it is a purely chemical reaction which may not have any influence on the underlying cause for the production of the acid. Sometimes the mere drinking of water, pure water, or water only slightly mineralized, is all that is needed to a sense of wellbeing.

The final outcome of a disease or of a diseased process may differ greatly in different individuals. Some may recover promptly, others recover only after an indefinite period; there may be a long convalescence ending with ultimate recovery, or, on the other hand, functioning may ever after be impaired—the individual may be chronically ill.

The body can no more replace a lost mucous lining of the stomach or replace a lost lung than it can replace a lost arm.

To get decided lasting benefit from the use of mineral waters, the stay at a health resort should be a more or less prolonged one—weeks or perhaps months may be required to bring about a favorable influence—an influence that will last after returning home. That the waters should be carefully and properly chosen to meet the indications is of course assumed.

A story from the Fliegende Blaetter shows the faith of some men in the efficacy of a mineral water.

Mrs. Brown: "Your husband seems to be a great believer in the waters of the Gushing Mineral Springs?"

Mrs. Gray: "Yes. He ought to be."

Mrs. Brown: "Why?"

Mrs. Gray: "For the reason that it has cured his stomach trouble four times this year already."

Although the subject of mineral waters and their curative influence may not interest a person in health, it becomes an interesting one to the invalid—and each one of us may at any time become ill.

Experience has demonstrated that certain mineral waters do have curative effects when intelligently used; this may be said particularly of European waters. Americans, as a rule, have paid too little attention to the springs of their own country, and too little scientific study has been given the matter. Even at the present time, little use is made of our springs, when compared with those of European countries, although many of our waters are doubtless as valuable as those of the famous European springs.

DISEASES AND AFFECTIONS BENEFITED BY THE USE OF MINERAL WATERS.

Compared with the number of known diseases and disorders, the list of those in which mineral waters are properly applicable may seem very limited, as a matter of fact there are only a few groups that stand out distinctly—chiefly chronic conditions.

According to Gould and Pyle, "The principal affections in which mineral waters are esteemed are the following: Cirrhosis of the liver, dyspepsia, gout, rheumatism, uricacidemia, lithiasis, hepatic diabetes, constipation, strumous diathesis disorders, obesity, plethora of the pelvic organs, hypochondriasis, skin-diseases, especially those dependent on gastric derangement, phthisis, constitutional syphilis, metallic poisoning, etc. Aperient and purgative waters are useful when a prejudice exists against purgative medicine."

We shall now take up some of the chief ailments in which the use of mineral waters is indicated. This can of course be done only in a general way and without going into special details. It is not the intention to write a medical treatise.

Taken in connection with what has been said heretofore on the properties and uses of water and mineral waters, it is hoped that the present consideration of conditions, of affections, in which the use of mineral waters is advisable, will permit definite conclusions to be arrived at in any given case. In case of doubt, however, it is always advisable to apply to a physician and be guided by his advice.*

The blind or indiscriminate use of mineral waters, as of any other supposed remedy, should be discouraged, for a water rich in solids may aggravate rather than alleviate conditions or certain forms of ill-health.

CONVALESCENCE FROM ACUTE DISEASES.—Frequently after the acute symptoms of disease have passed away, a more or less prolonged state of convalescence may follow. This may be marked by a feeling of lassitude, an inability to concentrate the mind on any subject and a tendency to become irritated from slight causes. Any mental or physical exertion is apt to increase the action of the heart and it may beat very actively. Ordinary medication seems to have lost its effects, there is little improvement. In such conditions it is well for the patient to spend some time at a pleasant health resort in the country, with pure air, cheerful surroundings and enough recreation to while away the time. Waters only slightly mineralized are best in such cases. If there is an anemic or thin-blooded condition, the use of some iron spring may be indicated, the small amount of iron in the water often acting very beneficially.

ANEMIA AND GENERAL DEBILITY.—In conditions of this kind, without any well-defined symptoms of disease, and not the result of an acute disease but due to some chronic disorder or overwork, worry, sleeplessness, dissipation or deranged digestion, and marked by an indisposition to exertion, becoming easily exhausted on exertion—with perhaps ill-defined pains and aches which the idle mind magnifies—is a condition often greatly benefited by a visit to some spring with a bland or slightly saline water or to some iron spring, with a freedom from care and the worry of home life. Where the debility is due to the retention of poisonous products in the body, moderate

*When a physician can give a decidedly favorable opinion, he is only too glad to do so. The laity, as a rule, are wholly unable to judge the adaptability of a water or a resort to an individual case, and one should always hesitate before condemning a water because it did not give the expected relief, especially where the water has been chosen arbitrarily and independently of the advice of a physician.

amounts of some of the sulphuretted waters may be found advantageous.

STOMACH AFFECTIONS.—This is a large field and one difficult to treat from a popular standpoint. It may be said that the tendency at present is to make finer and finer distinctions and to differentiate between disorders that on superficial examination seem alike, this is especially the case with affections of the alimentary tract. The words dyspepsia, constipation or diarrhœa no longer stand for diseases, but simply for disease symptoms or conditions, showing that something is wrong, and these may be due to a variety of causes. The tendency now is to find the cause and remove it, if such be possible, the symptoms disappearing when the cause is removed.

By the use of test-meals, chemical and microscopical examinations, test diets and by a study of the tissue changes as revealed to a great extent by a systematic examination of the urine, much has been, and can be, learned concerning the management of affections of this kind. Often a very definite form of treatment can be prescribed, replacing the old time guesses at various appetizers, bitters, tonics, digestive ferments, laxatives and purgatives. What to eat and drink, as well as what not to eat or drink, are very important questions which can at times be answered very satisfactorily. Such an examination will show more or less clearly what the conditions are and what the patient can or can not do. There are some cases where an exact diagnosis can be made but, unfortunately, little can be done in the way of giving relief. If, for instance, the mucous lining of the stomach is destroyed, it can not be replaced. All that can be done in such cases is to give advice or suggestions how to get the most out of life under existing conditions and to reduce the disagreeable symptoms to a minimum.

Compared with other means or resources—such as diet, exercise, baths, medication, etc.—mineral waters play a minor part in the treatment of such affections. In some cases, however, especially those dependent on mental and nervous disorders or overwork, the intelligent use of mineral waters will be followed by good results.

The subject is such a vast one and so complicated that it becomes highly unsatisfactory to attempt even a few brief general statements, as almost any general statement would have to be qualified.

Acute dyspepsia is of course best treated at home. Regulating the diet and habits of the invalid, with some definitely indicated medication, are among the essentials of treatment.

Catarrhal conditions may call for the use of a suitable mineral water, of a mild alkaline or alkaline-saline type, especially at a resort with pleasant surroundings, simple diet, the avoidance of excesses, and leading an outdoor life as much as possible. A spring with a small amount of iron is beneficial in many cases. Nervous dyspepsia is greatly benefited by resorting to a distant spring, with perhaps a radical change of climate. The same may be said of some of the bowel affections.

At many of the old European springs careful attention has been given both to a proper diagnosis of the condition or disease and to the influence of the water in varying amounts and in connection with certain kinds of diet. The indications for the use of Carlsbad water have been given on page 177. Our own health resorts have been too recently established and everything is yet too primitive to enable us to draw proper conclusions as to what the waters will do when more intelligently administered. It is gratifying to know, however, that strong efforts are now being made in this direction.

Crook, in his "Mineral Waters of the United States," has well said: "It is not an exaggeration to say that at least nineteen out of every twenty mineral spring waters now in use in the United States are recommended as being useful or curative in dyspepsia. Without admitting the ofttimes extravagant claims of proprietors or others in interest, it must be admitted that a very large class of patients suffering from enfeebled digestion are materially benefited by the rational use of a proper mineral water." He then continues to say that the waters indicated for ordinary dyspepsia with gas formation, fulness after eating, etc., are those belonging to the alkaline class, with sodium and magnesium carbonates and free carbonic acid gas. To overcome the acid condition they should be taken with the food or soon after a meal. Where the gastric juice is deficient, a water with a small amount of sodium chloride may prove beneficial.

INDIGESTION is a general term covering a number of conditions and may refer to the stomach or to the intestines or both. In a general way it may be said that the digestion of animal foods—meats, milk and eggs—is carried on in the stomach and the digestion of vegetable foods in the intestine. The reaction of the one is acid, that of the other is alkaline. The derangements of the digestive tract are many, and the treatment depends altogether on the cause or nature. In the stomach one form of indigestion may require the use of acids while in another form alkalies are indicated, the amount of acid being too great. Where the amount of pepsin is deficient, or even absent, it must be supplied. The character and quantity of food taken are of the utmost importance in some forms of indigestion.

The percentage of acid in the stomach juice can be accurately determined by laboratory methods, the juice being usually withdrawn from the stomach by the aid of a tube one hour after a so-called test-meal. The salient features of the case and its treatment are generally revealed at once.

In cases with an excess of acid, the use of an alkaline mineral water is often of decided benefit, a simple calculation based on the amount of free acid in the stomach and the amount of alkali in each glass or tumbler of the water will determine about how much should be used—that too much of such a water is injurious is self-evident. On the other hand, in those forms where the secretion of acid is deficient, saline waters may be of benefit. The normal acid of the stomach is hydrochloric acid, and this acid combined with soda forms common salt, which is the chief ingredient of many saline waters, or, to be exact, of muriated saline waters.

Liver and Bile Ducts.—The liver being an important part of the alimentary tract is often affected in digestive disturbances. Occasionally the difficulty may lie in the liver alone. Congestion of the liver may occur from the free use of alcohol, from malaria, weakness of the heart and especially from habitual over-eating. The term "biliousness," formerly much used by medical men and still commonly used by the laity, may apply to a number of different conditions depending on a variety of causes for their production. Generally such disturbances are due to metabolic changes, as mentioned under uric acid diathesis, and in such cases the use of mineral waters of the sulphated alkaline type, or sulphur waters, is especially indicated. Such waters are also useful in jaundice, where there is a tendency to the formation of gall-stones, the bile becoming thinner and less likely to harden, or bile salts to crystallize out.

Abdominal Fullness, or the Full Habit.—In this condition rather strong saline or sulpho-saline waters are indicated. The full habit is one due chiefly to excessive eating and drinking, especially of malt liquors. Corpulent individuals are, of course, the chief sufferers. All bodily activities are usually sluggish, due chiefly to a sluggish alimentary tract. A discolored complexion, coated tongue, perverted taste, and constipation are among the chief symptoms. Strong active waters of the kind mentioned above are especially indicated. Many individuals do well on an occasional brisk purge, as by the use of bottled mineral waters. To reduce the condition to a minimum will, of course, require attention in the matter of food and drink also.

Obesity.—Cases coming under this head must depend mainly on dietetic treatment, although mineral waters of the sulphated and sulphated-alkaline types may be found useful. Each case must be studied separately and the general health must be maintained. To lose fat at the expense of good health otherwise is not desirable. Free purgation may react injuriously.

Constipation is a very prevalent ailment and might perhaps be considered in some detail. Without a previous study of the subject it would seem that this is a very simple affection which will readily yield to treatment. According to some, all that is required is a little medicine taken for a short time and the case is cured. The pathological ideas of some persons are very simple.

A person afflicted with constipation usually resorts to home remedies at first to get relief, after that he is apt to turn to patent medicines, taking various kinds in turn, until finally he comes to the physician at a time when, perhaps, the habit is well established. He may try one remedy after another and try one physician after another—and remain just the same. It is highly important to know just where the difficulty lies, what are the causes and how to remedy them, and then live accordingly. Sometimes all that can be done is to reduce the condition to a minimum and to cease striving after the unattainable.

It must be remembered that the stomach digests and absorbs mainly the animal foods, those of vegetable origin being passed on into the intestine where they are digested and absorbed, the residue, or undigestible portions, being passed on and out.

Some persons have a movement of the bowels every other day, while some have two or more movements a day, yet, provided there is regularity and no distress, the former may be the normal number, and suffice. The time element, the relation between the amounts ingested and excreted, as well as the consistency of the excreted matter, must always be considered in the study of a case.

A physician generally first inquires into the family history, then into the personal history of the patient, making especial inquiry into any circumstances that may have a causative relation to the disorder.

In chronic constipation a large number of causes are now recognized and these may be grouped under different heads.

Malformation or imperfect development of parts of the alimentary tract may be a cause; there may be an over or an under-development resulting in impaired functioning. The intestinal tract is about twenty-five feet long and a defect in any part may cause the condition known as constipation.

It may be the result of disease. This may be due to the healing of some inflammatory disease process, the scar tissue resulting so contracting the intestine as to narrow the lumen or bore, making the passage of the food very difficult.

There may be a tumor or cancer which may tend to close the lumen, either by pressing on it from the outside, the tumor being in some adjoining organ or tissue, or the tumor may be in the walls of the intestine itself, taking up part of the channel.

In women, the womb may at times press on the bowels in such a manner as to cause an arrest of their normal movement.

The secretions poured into the bowels may be abnormal, as in the case of liver disease where the bile may be wholly altered or diminished; or the pancreatic secretion may be altered or absent.

The peristalsis, the wormlike movements of the intestines, may be absent on account of some nervous disturbance, as in some brain or nervous diseases or some chronic forms of poisoning or after an attack of fever. There may be so-called atony, a loss of strength of the muscles of the intestines, and stomach as well. It may also be due to a congested condition of the blood-vessels, as in the case of heart or lung diseases.

The mucous membrane of the bowel may be so altered that its quantities of mucus or mucous matter.
function is greatly impaired, at times with the production of large

Having very irregular hours for going to stool is in itself a sufficient cause for constipation, as it breaks up the regularity of the work of the bowels, by not allowing them to act when ready and trying to force them when not ready.

There may be some disease of the stomach or esophagus causing great pain on or after eating, and as a consequence little food may be taken, and if most of that taken is absorbed, there may be little to reach the lower bowel and no desire to pass this until a sufficiency has accumulated. The contents of the stomach may be so excessively acid that the bowel refuses to take it, and it may require an unusual amount of activity to neutralize the acid—the reaction of the bowel being alkaline.

The cause may be a so-called reflex one. There may be, for instance, some painful inflammation or disease of some organ or part of the body in contact with the bowel, and its movement may aggravate the pain, and, to lessen this, the nervous system, perhaps unconsciously to us, lessens the movement of the intestines, and from this lessened movement constipation may result.

Improper food plays an important part, as many of us know from experience. One of the chief causes, in the writer's opinion, is intemperance in eating, especially albuminous or animal food. The body is constantly eliminating waste products generated in the organs and tissues during activity, these products being chiefly urea and uric acid, which are greatly increased while taking large amounts of nitrogenized foods—meats, eggs, cheese and animal food in general except fats, and as a consequence the urine becomes very dense or heavy, entailing additional work on the kidneys in getting rid of these substances—urea and uric acid. Whenever the urine becomes very dense, some of its components, as uric acid, tend to crystallize out, and this is apt to irritate the urinary tract. In order to prevent this, the kidneys take all the fluid, all the water, they can get, to keep the urine diluted. Now, the great reservoir of the body is the alimentary tract, particularly the intestine, and when the kidneys draw heavily on it, it becomes dry, and constipation is the result. It will readily be seen that cases of this kind are greatly benefited, they may be cured, by proper attention to the kind and quantity of food consumed and the amount and kind of fluid taken, so that the bowel has enough water to keep it moist without the kidneys being compelled to draw on it excessively.

Several other causes might be mentioned, but enough have been cited to show that chronic constipation is not such a simple matter as some seem to think, and may require considerable time and observation to ascertain what the real cause is.

After the cause has once been determined, then the question of what is best to do to overcome the difficulty should be taken up. Whether mineral waters should be used in the hope of affecting a cure is a question that must be considered in the light of the cause. It may give relief in many cases, often only as long as used, but there is a great difference between relief and cure. Palliative treatment may not be curative treatment at all.

"The various means of treatment may be classified according to their curative value, in the following order: Diet, massage, electricity, gymnastics, hydrotherapy, medicines, mineral spring water, psychic or suggestive methods, mechanic methods. The management of constipation will differ according to whether it occurs in children, in middle age, or in senile persons. It is only by a severely individualizing management that constipation can be radically cured."

The detection of the causes of constipation presents many difficulties, and occasionally it is entirely impossible. Where no definite cause can be assigned, mineral waters may be given a trial, but it must be kept in mind that "These waters do not act curatively, but simply as all other purgatives do; they produce an evacuation the day they are used, and do not affect the underlying causative condition of the constipation."

Dr. Crook, in his treatise on the mineral waters of the United States, says: "In obstinate states of this kind a course of mineral waters is frequently a valuable adjunct to the treatment, and, with proper dietary rules, will usually prove successful in obtaining relief. One of the sulphated saline or bitter waters, containing the sulphate of soda or magnesia or both of these salts, is applicable to these cases. The presence of a certain amount of the chloride of sodium and the alkaline carbonates held in solution by carbonic acid gas lends additional efficacy to the water.

"Fortunately we have many such waters in the United States, and the springs from which they flow are within easy reach of almost all sections of the country. They need not necessarily be highly mineralized. It is surprising how slight a proportion of saline ingredients will serve to give a natural water aperient properties. Such waters are usually best taken early in the morning before food, the quantity to be regulated in accordance with the strength of the water, the weight of the patient, and the obstinacy of the constipation. A brisk walk or other form of exercise after taking will expedite the action of the water. One, two, or even three, painless, watery evacuations of the bowels usually occurs soon after breakfast. If further action is desirable, a somewhat smaller quantity may be taken before each of the two following meals."

Chronic Diarrhœa and Dysentery may here be mentioned. In affections of this kind the calcic waters may be of some service in cases where the cause of the disturbance can not be found, or if found, can not be removed or overcome. A resort to the use of a limewater can be recommended only to those persons living in a freestone region with little or no lime in the water. In the glacial drift and limestone areas the spring and well waters used for domestic purposes are as a rule heavily charged with lime. A purge may sometimes remove the offending cause in an acute condition and thus act curatively.

Kidney or Renal Diseases.—Bright's Disease.—The kidneys are subject to a number of well defined disturbances, some of them characterized by the appearance of albumin in the urine. The disease process may be acute or chronic. Pure water is indicated in all cases—to wash out the impurities—but it is in chronic cases that mineral waters are most frequently used.

Just how much benefit will be derived from the use of such waters is a difficult question. It will depend on so many conditions; on the constitution of the patient, on the nature of the disease process, on the amount of alteration of the kidneys, on the diet adopted, and finally on the kind of water used.

If we were to believe the circulars of some of the owners of mineral springs we might conclude that kidney disease or Bright's Disease was easily curable by the use of their waters. As a matter of fact, physicians are very skeptical concerning the curative properties of mineral waters, and, in some kidney diseases, of any remedy. If a kidney disturbance has been going on for a long time, and this is often the case before the true nature of the affection is recognized, it may have become chronic before a sick person goes to a physician and then it may be too late to restore a normal or healthy condition. Often the best that can be done is to arrest the destructive disease process; if this can be done before too much tissue has been destroyed, there may be little, if any, impairment of function and the individual may live on to old age.

Nature produces scar tissue when she heals a wound. We see this particularly in the case of wounds on the surface of the body. Many disease processes leave a lot of scar tissue after their subsidence. We may have a scarred kidney or lung as well as a scarred skin. In the case of the kidneys, if we can stop the disease process that results in the scarring, we may be doing well.

If at any time the urine is abnormal, scanty, high-colored or very acid in reaction, the use of water is indicated and it should be used freely. Whether the water should be mineralized and, if so, whether alkaline or saline, will depend on existing conditions. No general rules can be laid down that will enable a person without a sufficient knowledge of physiology and pathology to decide the matter for himself. The best that can be said, perhaps, is to eat sparingly of animal foods and drink pure water freely. Such a course will reduce the work of the kidneys to a minimum and dilute the urine passing through them. Kidney diseases are more prevalent in cold climates because the kidneys have more work to do. In some kidney affections with an accumulation of much fluid in the tissues of the body, strong purgative waters may at times be of service in draining off the fluid.

In kidney disturbances the urine should be examined from time to time, for in no other way can reliable information be had of the intensity of the disease or of its progress.

The physician who carefully examines into the metabolism, into the tissue changes of the body, often marvels at the great quantities of excretory products—urea and uric acid chiefly—in those coming under his care or for advice.

It may be added that there are really different kinds of Bright's Disease, depending on different causes. One of the chief causes, or at least an important factor in producing Bright's Disease, is habitual over-eating and under-exercising, leading a sedentary life and the resulting accumulation of large amounts of waste products. One of the penalties of "high living" is Bright's Disease.

Many of the cases of kidney disturbance are properly placed among the uric acid diathesis, and such cases are often decidedly benefited by the use of mineral waters, as mentioned on page 201.

URINARY GRAVEL, CALCULI AND STONE IN THE BLADDER.—These are due to a variety of causes, and the substances composing them differ, perhaps the most common material being uric acid, or this acid in combination with some other substance. Where the urine is loaded with this acid or with urates or with oxalates, as in heavy eaters, there is a tendency to form crystals. This crystallization may take place in either the kidneys or the bladder. Drinking large amounts of water will dilute the urine and prevent the crystallizing out. Many of the so-called "lithia waters" are useful as pure water, there not being a sufficient quantity of lithium in solution to be of service. Lithium itself, it will be recalled, has a special solvent action on uric acid. Alkaline waters may be of service in overcoming the excessive acidity of the urine by combining with the acid to form bland and soluble salts of uric acid, thus giving relief from the bladder irritation.

CYSTITIS is the medical name for inflammation of the bladder, but is usually qualified as to kind. If due to the crystals of uric acid mentioned above, the free use of water to prevent their formation, or the use of an alkaline water to bring them into solution is indicated. Where the cystitis is due to an infection by pus germs, less benefit is to be derived from the use of waters; alkaline waters may even be contra-indicated as they favor the growth of the infecting organisms by rendering the urine alkaline.

AFFECTIONS OF THE RESPIRATORY SYSTEM.—Our habit of living in close, over-heated houses, often with a sputum contaminated atmosphere, tends to enfeeble the body and to make us more susceptible to disease. The disturbances that follow exposure to cold after having been confined to a close, hot atmosphere are mostly of the respiratory system. The skin, liver and bowels are more active in hot climates and more liable to derangement, while in cold climates or in winter lung troubles prevail. This is partly because the lungs have to supply more air, to keep up the bodily heat, which oxidizes the food, burning it up to carbonic acid gas, which is expelled from the lungs, but mainly due to the fact that the atmosphere we inhale in our homes is bad. Living in close, illy ventilated rooms, with the air often contaminated by the ground-up spittle of persons afflicted with lung diseases, makes the task of the lungs doubly hard.

Morbid processes affecting the respiratory system are not influenced by mineral waters, certainly not to a sufficient extent that they need be considered at any length. To the inhabitant of a crowded, smoky or dusty city, a change to the country, to some pleasant health resort, with a mild mineral water, may be indicated at any time. In lung diseases, the chief requirements are pure, fresh air, free from irritating dust, especially dust containing ground-up spittle, and a nutritious diet, with much outdoor life and sunshine. Nature often does wonders when the body is placed under favorable conditions. To bring a person sick with a lung affection to a dusty, smoky city for treatment is the height of folly.

Diseases and Affections of the Heart.—Affections of the circulatory system are so numerous in kind and demand such diverse treatment that no mention can be made of them in a paper like this. Where the heart disturbance is due to some other disease for which a course of mineral water treatment is indicated, there can probably at least be no harm in giving the waters a trial.

Nervous Diseases and Affections.—There is a great number of diseases of the nervous system, but only ailments due to some functional derangement can properly be considered in connection with the use of mineral waters. In cases depending on some disease process in the nervous system, energetic treatment is indicated and mineral waters may play no part at all. Among the more common functional disturbances may be mentioned headaches, neuralgias, neurasthenia, mental depression, hysteria, sleeplessness, general malaise and similar affections, which make up the bulk of complaints of daily life.

The kind of water to be used will depend on the nature of the disturbance or on its causes. In a general way it may be said that a resort removed as far as possible from the home of the patient, with perhaps a change of climate and altitude, will be most effective. If the disturbance is the result of over-work, almost any mildly mineralized water will be of service. In cases depending on an impoverished condition of the blood, a chalybeate spring will be indicated.

In most cases of over-feeding or deranged digestion or of constipation on which the nervous phenomena may depend, a saline or sulpho-saline water will be indicated. The change of diet and surroundings are powerful factors in restoring nervous patients to health.

That many of the affections mentioned above are dependent on disturbances of other organs, especially of nutrition, will readily be understood from previous remarks. Part of the nervous system is set apart simply to tell us that something is wrong, and pain is the warning signal. If we neglect to heed the gentle warnings at first, these may be followed by more strong and effective ones. The trouble with most of us is that we do not heed the warnings, but persist in doing things—in eating and drinking and general habits of life—that are reacting injuriously on the body. A holiday out in the woods now and then or a more protracted vacation in the wildwoods or at the seashore will help us to keep well. If we are not feeling well, a stay of a few weeks, or, if need be, months, at some mineral spring, with pleasant surroundings, will greatly assist nature in restoring a healthy condition of body and mind. In Europe it is quite customary for those able to afford it to spend about six weeks each summer at some health resort with a suitable water.

Blood Diseases and "Impure Blood."—These terms are in common use and are applied to a number of conditions, perhaps only symptoms of some disease process, and should be more exactly expressed by the name of the disease. They are convenient terms, but mean little to the physician. Blood diseases proper are not of frequent occurrence. The term impure blood is a very vague expression. An eruption of pimples or boils on the face is often ascribed to the blood, when, as a matter of fact, the blood may have nothing to do with it; it may be a purely local disturbance.

In diseases attended with a change, a deterioration of the blood, careful tests are made nowadays by the use of delicate instruments, giving the results in figures, doing away with a large amount of guess work. The results of the treatment are, moreover, watched from time to time to ascertain the effectiveness of the remedy. Diseases attended with a profound alteration of the blood do not get well in a few days, nor by taking "sarsaparillas" or "blood medicine."

In regard to the use of mineral waters, it may be said in a general way that chalybeate waters are indicated where the blood is below standard, while in some conditions that are ascribed to "impure blood" a saline or sulpho-saline water may be of service, as outlined under "Abdominal Fulness" on a preceding page.

Malarial Poisoning.—In former years, when malaria was very common in certain parts of the State, notably along the Wabash River, enlarged spleens and livers, resulting from the accumulation of waste materials from the destructive action of the malarial parasite, were frequently seen, but are rare at present. The free use of water, combined with a residence in a malaria-free region, will greatly assist in the recovery.

Skin Diseases.—Some mention should be made of skin diseases. There are many kinds, and most of them are difficult to diagnose correctly. Some are due to disease in other parts of the body, in some organ, and where this is the case an appropriate mineral water may be found beneficial. The sulphur, in some of the milky sulphur waters, has a curative influence in some cases when used in baths.

Uric Acid Conditions.—Reference was made to this condition, also known under the name of "Uric Acid Diathesis," on previous pages, and a more detailed discussion has been reserved until now in order that the subject may be taken up a little more fully. Conditions coming under this head constitute the great field for the application of our Indiana mineral waters.

Concerning uric acid, and urinary waste products generally, it may be said that in adult man the food taken is consumed in the production of heat to keep the body warm, and in the production of force or work. It is evident that a manual laborer, toiling hard all day, will require more food than the man who does not exercise his muscles, a brain worker, for instance, and if the laborer is working out of doors on a very cold day, an additional amount of food is required to keep up the animal heat. It will at once be seen, on the contrary, that a man who is confined to a warm room all day and who takes no exercise, requires comparatively little food to keep the bodily machinery going. The food that is consumed in the production of heat and force is oxidized, combined with oxygen, just as we see it in the case of the fuel under the boiler of an engine, and the waste products are given off by the lungs as carbonic acid gas, corresponding to the smoke from the coal under the boilers. The wear and tear of the body itself is taken away by the kidneys. According to the amount of this wear and tear, the urine will be more or less loaded with waste products. Heat and force are obtained mainly from the starches, sugars, fats and oils we use, or, we might say, from the bread and butter we eat, while the wear and tear of the machinery itself, of the bodily organs, is replaced by the animal foods, as meats, eggs and milk.

In a well regulated body the amount of intake and outgo is equal, and the body remains at practically the same weight. Just enough of what is needed is taken out of the alimentary tract. Where much is consumed, much will likely be taken out. This explains why the laborer has such a splendid appetite when he returns from his labor, and why, on the other hand, the sedentary city worker, housed up in a warm room, with almost no bodily exertion, has such a poor appetite—he has not used up much of the food eaten at the last meal.

Now, here is an important point: Whenever an individual habitually eats more food, especially animal food, than is required to replace the wear and tear, there is a tendency for certain products to accumulate in the body, which should be excreted by the kidneys. Just what these products are need not be discussed in detail, but mention may be made of uric acid, as this is one of the chief products of tissue changes in the body and which is ordinarily passed out by the kidneys—taken from the blood. It may be formed by the body itself or taken up in a somewhat different form from the alimentary tract.

Now, these waste products, or let us say in brief, this uric acid, is a very important factor in the welfare of the body—with many men it is the deciding factor between a life of health and enjoyment or one of ill-health or misery.

We all know that the sedentary city worker does not enjoy animal life—life as we see it at its best in the animals of the woods and fields, where it is apparent that simply to live is a pleasure, and that he does not enjoy it as does his fellowman who leads an active out-of-door, fresh-air life. Loss of appetite is usually the first symptom that something is wrong, yet, in spite of this, large quantities of food are forced into the stomach three times a day, in getting rid of which the digestive tract has difficulty. Instead of eating less and exercising more, the poor, misguided man resorts to the use of "appetizers," of digestives to help the stomach, of "health foods," and then to laxatives and purgatives to help to get rid of it all.

With the body constantly over-loaded with food, especially with rich animal foods, there is apt to occur a gradual accumulation of products that should have been eliminated by the kidneys from day to day. Depositions are apt to take place in the white tissues about the joints (manifested by tenderness and rheumatic pains), then in that of the blood-vessels (with symptoms, perhaps, of weak and irritable heart and headaches), and later on deposits may occur in the kidneys themselves (with gravel, stone, albumin and symptoms of

Bright's Disease). If the process continues, there will sooner or later be a general breakdown.

The "high liver" who relishes his three meals a day and eats enough for two men comes under the above heading, for besides accumulating weight in fat, he is accumulating waste products.

The experienced physician can usually pick out the individual who is over-eating and under-exercising, or, in other words, who is living under abnormal conditions of nutrition and secretion or excretion. An examination of the urine will reveal a high specific gravity, that is, a dense urine, with a high acidity. In many cases there are tell-tale swellings alongside the finger joints, with perhaps pains in the feet, knees or back.

The effects on the bowels have been referred to under constipation, the kidneys taking all the fluid they can and leaving the bowels dry and constipated.

Gout or Gouty Conditions.—There are several disorders that seem more or less closely related, especially in regard to their symptoms, and unless a case is closely studied, it may be impossible to say just what it is. One man may call it the gout, another calls it rheumatism or muscular rheumatism, other names that may be used are myalgia, arthritis, rheumatoid arthritis, lithemia and perhaps several more. Lumbago and sciatica are at times placed in the same list.*

The scope of this paper prevents going into the details, and no attempt will be made to explain even what the above names mean. In regard to gout, it may be said that it is essentially a disease of nutrition and is greatly influenced by diet. People who eat heavily and exercise little to work off, to oxidize, the food they have eaten, tend to accumulate waste products, particularly uric acid, in the system, notably in the joints, and after a time symptoms appear, and if the mode of life is persisted in, may produce considerable disturbance. There may be an attack of acute illness, marked by sharp

*Just what the relationship of rheumatic arthritis, or rheumatic inflammation of the joints, is to gout or the gouty condition is not fully established; indeed, there are a number of inflammations of the joints and the tissues about the joints that are not fully understood. As far as regards treatment, all of them may, according to Cohen, be divided into two groups:

(1) A multiple affection of the joints, or about the joints, more or less active, although generally chronic in character and occurring in comparatively young and middle-aged persons.

(2) An affection generally occurring in debilitated old persons, less active and more wasting in its manifestations. In older persons one of the larger joints is often singled out, as, for instance, in senile hip-disease, especially when some injury seems to have brought on the disease.

Mineral waters of different kinds, but adapted to the general physical condition of the patient, may be tried, as well as hot mud-baths, but the results obtained from treatment are often very unsatisfactory.

pains in a joint or in the joints, with more or less fever and general systemic disturbance. From its acute stage it may gradually develop into a chronic condition.

The condition described under the name of "Uric Acid Poisoning," known also under the names of "Uric Acidemia," "Lithemia," "Lithic Acid Diathesis," "Uric Acid Diathesis," "Lithuria" and "Latent Gout," differs from gout chiefly in the absence of swellings in the small joints, and the disturbance is not localized in any one part of the body. The chief symptoms may be briefly given as follows: Pains and aches in the back and head, sleeplessness, sluggish circulation with cold hands and feet, deranged digestion, with uncertain appetite, the urine heavy and acid, often smarting. If the condition exists for some time, a whole train of other symptoms may follow, indicating profound disturbances of many of the bodily organs.

RHEUMATISM.—This is a term that covers a multitude of affections as used by the laity, and even by many physicians. Any pain in the joints or muscles, whether acute or chronic, which can not be accounted for otherwise, or called by some other name, is likely to be called rheumatism. As the term is ordinarily used, it refers more to a condition than to a distinct disease.

"Rheumatism is a very vague term and is frequently used to include a number of different morbid conditions, some of which are probably of microbic origin, while others are the result of metabolic perversions, and still others of complex etiology."—*Cohen.*

Of acute articular rheumatism it may be said that it is now generally regarded as a specific infection and that certain remedies have a distinctly curative influence; quiet and absolute rest in bed are demanded. As the use of mineral waters plays no part in its treatment, we shall dismiss this disease with this bare mention.

So-called chronic rheumatism may be due to, or the result of, a variety of causes. Cases of this kind may resist very stubbornly all medicinal treatment. To get relief may lead both the sufferer and the physician to adopt and try all and every sort of remedy or means of treatment, and sooner or later the question of going to some mineral spring or well will probably come up.

Although mineral waters do not act quite so favorably in any one case as a person might be led to believe from reading the circulars of mineral water resorts, yet in many cases their influence is really marvelous. No doubt every one knows persons who have tried everything to get relief and failed, until they sojourned for several weeks or months, perhaps, at some mineral spring and returned home cured of their affliction. Just what brought about the good result may be a difficult question to decide, but the fact remains that many patients are restored to health, and for this reason the use of mineral waters is advisable in intractable cases where all other means have failed.

The waters especially indicated are those of the alkaline or alkaline-carbonated class. So-called lithia waters with a mere trace of alkali are less apt to exert a favorable influence than a water which contains a considerable amount of alkaline solids.

THE GREAT FIELD FOR INDIANA MINERAL WATERS.

The diseases or conditions just enumerated form the field, par excellence, for the use of our mineral waters. Whether they be called uric acid, rheumatic or gouty conditions, matters little so long as we keep the underlying causes in mind—these being chiefly the habit of over-eating and not getting sufficient bodily exercise.

The uric acid diathesis may be said to be an accompaniment of civilization; the active life of the savage precludes the accumulation of waste products in the body, and even if they did form, he would stand a poor show to survive through the wanderings of the tribe. In order that civilized man may get rid of his affliction he must for a time return to the simple life of his ancestors, live out in the country, at some health resort, perhaps, on a simple diet, with considerable exercise and the free use of water.

Water is the great remedy, and if it hold in solution certain substances, like potassium, lithium or sodium, its solvent power is greatly increased and the accumulated waste products are more speedily eliminated.

It is sometimes said that mineral waters are not indicated in an acute attack, let us say of pain-racking gout, and that they are useless. But such a statement should be qualified by saying, useless for the accompanying pain. Because mineral waters do not speedily ease the pain, there is no reason why they should not be used. They will help to remove the cause, and should be given along with the anodyne to relieve the excessive pain.

Too few of us know that pain is a good thing for the human family; if it were not for the accompanying pain we would do many things that would react very injuriously on the body. Pain is a warning that something is wrong and that we should keep quiet and allow a return to a normal or healthy condition. If we disregard the preliminary warning, the pain soon returns more severely, compelling us to desist. In the case of gout, for instance, the pain may finally assume such intensity that the poor, afflicted individual is rendered wholly helpless.

When pain is excessive, it should, of course, be assuaged, and if due to motion, the body or part of the body affected should be kept at rest until the pain subsides. Unfortunately for themselves, too many persons come to the physician simply for relief from pain—in order that they may go about as usual. If they do not get the anodyne from one physician, they go to another. One of the simplest things in medicine is to relieve pain—if not by the use of one remedy, then by another. It is true the nervous system may have to be depressed very much to get the desired relief, but to most persons that does not matter. Pain should properly be relieved by removing the cause that produces it, not by depressing or benumbing the nervous system. To relieve pain by drugs means in many cases the masking of the disease process; the absence of pain deludes the patient as well as the physician, and the disease process continues its ravages.

The pains incident to high living should, therefore, receive proper attention, not by resorting to anodynes or narcotics, but by giving attention to the diet—eating less rich food, by leading a more active life out of doors and by a more free use of water. If deposits have formed in the joints, attempts should be made to get rid of them as much as possible. We may well imitate the custom of Europeans, as previously mentioned, who every year spend about six weeks at some pleasant spring, drinking the waters freely, living on a simple diet and taking more or less lengthy foot tours. Such a life, with the freedom from home care and worry, adds considerable to a person's life, both in the amount of added time and in the degree of comfort in living.

It is, of course, not to be assumed that because a man is a high liver all his ailments are due to such a mode of life. Each case must be studied separately, and only proper cases should go to the springs, otherwise the whole question of "mineral water cures" is apt to be brought into bad repute. They are certainly beneficial in properly selected cases.

The kinds of waters that are especially indicated in conditions enumerated above are:

(1) Pure water or waters containing only a small amount of mineral matter. Many of the so-called lithia waters come under this head. Pure water used freely and at a time when the amount of rich food is reduced to a minimum will help to rid the body of the noxious material. The tendency of the body, of nature, is constantly

directed to overcoming abnormalities and to correcting deficiences, and with a little assistance it usually succeeds. Water is a great diluent, it dilutes the heavily charged fluids of the body, and, like water flowing over a rock, brings back into solution substances deposited under abnormal bodily conditions.

(2) Alkaline Waters.—Uric acid crystals go into solution when brought in contact with alkalies, and urates are formed, and these are carried away in solution. The urates of potassium and lithium are very soluble, and for this reason these alkalies are preferred to sodium.

(3) Salines and Sulpho-Salines.—In cases with torpor of the alimentary tract and where the bodily functions generally are sluggish, waters of the above type may be especially indicated; tissue changes may be stimulated at the same time with the depleting action of the waters.

Mud baths may be valuable adjuncts in helping to eliminate waste products from the body, the skin, especially when acting freely, acts vicariously for the kidneys.

The following from Cohen's "System of Physiologic Therapeutics" bears on this point: "Whether we hold that gout and gouty conditions are due to the excessive formation of uric acid and the so-called alloxuric bases, or of the latter substances only, or to deficient excretion of some or all of these substances by the kidneys, or partly to excessive formation and partly to deficient excretion, we can easily understand that baths and various hydrotherapeutic processes may be of great use by aiding in the elimination of waste products from the body. In regard to internal courses of mineral waters, the sulphated and the sulphated-alkaline waters exercise the best effect in robust constitutions with a tendency to obesity and abdominal plethora. The sulphated-alkaline waters, the simple alkaline waters, and the alkaline earthy waters * * * are recommended when there is a tendency to uric acid deposits in the urine; the sulphated-alkaline group particularly in the plethoric cases. In weaker patients the muriated, muriated-sulphurous, and simple thermal waters are of use."—Vol. IV, p. 284.

BATHS.

Hot Baths and Mud Baths.

Baths play an important part in the process of getting well. Simple cold, warm or hot baths can readily be had at home, or certainly in any town, and without going away.

To take mineral water baths, or moor or mud baths may require a long journey, and we may, therefore, briefly refer to these forms of baths.

To a person unacquainted with the structure and function of the skin it might seem that to take a bath in a mineral water might, in some manner, produce an effect analogous to that of taking the water by the mouth, or, as some express it, that it will "strike in" and in some way drive out or cure the disease. Unfortunately mineral waters have no such action or effect. They act, perhaps, wholly by the process of osmosis, dependent on the specific gravity of the fluids. The skin of the body is for the purpose of keeping out substances, and absorption through it is so slight that it may be disregarded altogether. It is true there are some institutions, as at Nauheim, in Germany, where good results are obtained, but after all the success depends on other means employed along with the baths, rather than on the mineral matter in the water used.

Mud and peat baths, especially if hot, are of service in disorders dependent on over-feeding with an accumulation of waste products in the system, and in rheumatic affections of the joints. The pores of the skin are apt to be opened freely with a profuse perspiration, which may carry off much of the waste products. There is no special virtue in the mud or peat itself, even if it were charged with certain minerals, as claimed by some. Any effects to be derived from their use must be sought in the way the heat is applied to the body by means of the peat or mud.

In cases of a kind that may be benefited by mud baths, it is always difficult to judge one case by another, for in two cases the symptoms may be almost exactly similar, yet one case may be greatly benefited by the use of the baths and the other not at all, the symptoms being produced by causes radically different. Trial alone will determine whether any benefit is to be derived from the use of the baths.

CHOOSING A MINERAL WATER RESORT—DETERMINING FACTORS.*

In the preceding pages we have outlined more or less briefly the functions and uses of water by the body in health and disease, and the influence of chemical compounds, or salts, found in our mineral waters, with indications for the use of the different kinds of mineral waters to be found in Indiana.

The subject of the proper application of mineral waters in disorders and diseases is a complex one, whether the application be made in the hope of a cure or simply for relief from pain and misery. It is often very difficult to distinguish between cause and effect, and persons habitually dealing in simple matters are likely to assume a simple relation in other things. Men as a rule are ignorant of the needs of the body when sick. Probably the best thing that a sick person can do after the idea of going to a mineral water spring or resort has once been entertained, is to consult the nearest and best physician and place himself under his observation—if not treatment—for a time at least, to enable him to find out as much as possible about the normal and abnormal functions of the body. A disease process may have a local distribution, or it may affect the whole body. In the latter case it may be spoken of as a constitutional disease. After a period of observation and after deciding what water and which spring or resort is best suited, the patient should be provided with a letter to the physician of the health resort or spring, giving the results of the observations and the probable indications for treatment. The tendency of health resorts is to group patients or invalids, to bunch them, and to prescribe a routine treatment without sufficient individualization. The patient himself should have some definite idea of what to expect from the waters used, of the influence of diet, recreation, rest and exercise, and also of the place itself. He should, of course, have a sufficient knowledge of his condition to enable him to know whether he is getting sufficiently individualized attention aside from group treatment.

*To the writer it has always been an interesting psychological question why a man selects one spring or resort in preference to another; that is, what is the final, the sufficient reason? The testimony of friends and acquaintances is in many cases the deciding factor. Only exceptionally does a patient follow the advice of his physician throughout. There is one good reason why this is so: The non-medical friend who has an opinion favorable to a certain resort or water is apt to express it unequivocally and to be very positive in his statements of the benefits to be derived, the possibility of failing to be benefited being scarcely considered. The physician, on the contrary, in the light of his greater experience with diseases and advising patients about going away, is apt to give, along with the pros, many cons, and this may lead to indecision on the part of the patient, and in his undecided state of mind the opinion of the friend carries the day, and the patient may go to a spring and use a water wholly unsuited to his condition, probably to return a sadder but a wiser man.

Among the questions that are likely to come up for consideration in the matter of going to a mineral water health resort are the following:

(1) *The condition or constitution of the invalid or patient.* He may be so enfeebled as to be unable to withstand a lengthy journey. "In sending away a patient it is not merely the disease that is to be considered, but also, and in even greater degree, the patient himself, his condition, his habits of thought and living, and his peculiarities."

Disease is not an entity, but the reaction of the individual against some abnormal condition; the reaction may differ in kind as well as in amount. Invalids differ greatly in their temperament when away from home; in fact, temperament has been described as the reaction of the individual to his environment. Some react quickly, others slowly. The terms "sanguinous," "nervous," "phlegmatic" and "lymphatic" are still in use to describe different temperaments.

"We all of us doubtless believe that the degree of prudence and intelligence shown by the invalid in regulating his life greatly modifies the result; and, further, that his general physique and his temperament are important elements in determining improvement or deterioration."

Diseases or ailments most benefited by a prolonged stay at some health resort, or some mineral spring, are those due to living under abnormal conditions, as viewed in the light of man's development from the savage state. Men are now so massed together that they neglect to take bodily exercise, fresh air, simple food and sound sleep. The sedentary brain-worker is a product of our civilization. Many persons improve the moment they leave the large city and seek the retirement and fresh air of the country, or of some sanitarium where they can find congenial surroundings.

In the case of the chronically ill, after the question where to go has once been satisfactorily decided, the invalid may return again and again, and each time be benefited.

The mental attitude in regard to going away from home must be taken into account. Some persons get very homesick in a short time and any gain derived from a stay at the resort may be offset by worrying about home. To be alone in a strange place is very depressing to some persons, and where the disease has produced an irritable temper, it may be difficult to make new friends.

The unpleasant features connected with a journey to a distant resort, such as the transportation and accommodations, the prevalence of irritating dust, doubtful drinking water, illy arranged and unsanitary hotels where stop-overs have to be made, are disagreeable features from which many shrink.

The following may be considered unsuitable for making a long journey: Weak, nervous or excitable persons; those who suffer from sea or car-sickness; the subjects of severe hemorrhages; those in the acute fever stage; the subjects of advanced organic diseases and where the disease is still actively extending.

(2) *The character of the mineral water itself must be considered.* Although such waters may be grouped under a few heads, yet there may be minor differences that will lead to the preference of one water over another, other conditions being equal.

Where the composition of the water, its contents in salts and gases is known, we can easily calculate how much of each ingredient the invalid is taking daily in the number of glasses drunk.

Many mineral waters, so-called, contain such small quantities of mineral matter that the water may be used freely, drunk in almost unlimited amount, without producing any evil effects. Others should only be taken under the advice of a physician, particularly if more than a few glasses be taken daily, or if the waters be taken for some time. If a water is a powerful one in influencing or curing a disease, it is evident that its powers for evil must also be great when used in the wrong disease or at the wrong time. Moreover, if the invalid's expectations are built on the advertising circulars of some mineral wells or springs, he may be disappointed. Many claim too much. Too many back their claims by testimonials of persons not qualified by study or experience to give valuable testimony. The simplicity of some persons in the matter of diseases and "cures" is something remarkable.

The question of what waters will do, as well as what they will not do, must be carefully considered, otherwise there may be great disappointment. Merely to drink the water or take the baths, in the expectation of being cured, may also lead to disappointment. Although the range of diseases and disorders in which mineral waters are useful is limited, the number of cases that are likely to be benefited is large.

The truth in regard to what mineral waters will do and what they will not do can not hurt any established institution that aims to conduct its business on ethical and established business principles. To exaggerate or to promise more than can reasonably be fulfilled, will sooner or later inevitably produce an unfavorable reaction. An institution that has been long established or aims to continue in business indefinitely has no need to adopt any questionable methods.

(3) *The Medical Supervision.* The invalid is apt to place the water itself in the first place, then, perhaps, the accommodations, and after that the sanatorium physician, if he gives him any thought whatever.

The personality of the medical director of a health resort plays an important part in the progress of the patient and his scientific acquirements are considered by the family physician in determining where to send his patient. If a health resort is well managed in all other respects, but has at its head a physician not properly qualified to give needed medical attention and supervision, the institution is apt to be avoided by the family physician.

One of the complaints made of some health resorts is that the physician caters more to the social side of the patient's life than to the medical needs or to the hygienic or scientific aspects of the case. Too often the holiday nature of the sojourn is given more attention than the serious business of getting well.

Sanatorium or health resort physicians are often at a great disadvantage in properly judging the constitution, the nature of the disease-process and the extent of its ravages in the body, as well as the particular needs of the patient coming under his care. Where an abnormal condition has existed for some time, has become chronic, it is often a difficult matter to properly classify the case; it may require continued observation and repeated examinations to arrive at proper conclusions.

The consulting physician at the sanatorium, unacquainted with the history of the patient during the months, or perhaps years, of suffering, can not readily classify him, but must depend on the family physician or regular attendant. Knowing what the past has been, noting the amount of exercise or apathy, worry, the appetite, the action of the body and mind generally, he can draw proper conclusions as to the needs and the progress being made while under his care and making use of the waters. *A letter from the home or family physician should always accompany the invalid,* and it is evident that a patient who has no such letter must be placed under observation and be examined for some time ere he can be placed on the proper treatment.

It is very irritating to the home physician who has long had a patient under observation and knows fairly well what is going on in the body—what should be done and what not, what foods can be eaten and which are to be avoided—to have the sanatorium physician tell the patient who comes to be benefited or cured, without having made a particular study of the case, that he or she can eat and drink all that the appetite calls for, perhaps making some arbitrary exception, as avoiding the use of coffee or tea.

The reason why some of the European resorts are so famous in the treatment of certain affections of the human body is not so much in the medicinal qualities of the water as in the personality of the medical director, the attendants, the mode of life, the diet and the general regimen. The most careful and firm supervision is maintained over every detail of the invalid's daily life. Some of the famous institutions limit themselves to the treatment of a few affections or diseases and discourage everybody else from coming. Physicians, for instance, always associate the name of Carlsbad waters with disturbances of the alimentary tract and nothing else.

(4) *The Daily Life at the Springs.* The question of what to do at the mineral springs is an important one. Where one case may demand quiet and rest and the patient readily adapts himself or herself to such requirements, many will require recreation and amusement to while away the time. One of the banes of life away from home, from the daily routine, or from business, is to while away the time, hence proper recreation at a health resort occupies a very important place in the list of essentials. To get up in the morning with no definite program—unless it be to take a drink of the water, eat breakfast, take more water, eat dinner, again drink water, eat supper and drink more water before retiring—is not an ideal life to look forward to or to lead, and a few days of such a life may cause the invalid to long for a return home. There should be something to occupy the patient's mind and time during the day. Indeed, in certain cases where a sedentary city life has induced derangements of the nervous system or of the alimentary tract, outdoor exercise is an important factor. "Active exercise, according to the patient's state, is of the greatest use in all cases. It is quite obvious, indeed, that exercise in the open air is likely to be of the utmost value in a disease, the symptoms of which are connected with defective processes of oxidation in the body." In such cases a hilly country, with shaded walks among the wooded hills and valleys, is preferable to a flat, monotonous country. Outdoor games and amusements, music, a daily bath or two, perhaps in the mineral water itself, a course of exercises on machines or Swedish treatment, or of massage, all help to fill out the time.

To be compelled to sit about idly all day, or to play cards, or to spend the time in the nearby town or village, are things not conducive to the selection of a resort that offers nothing else in the line of recreation.

The kind and amount of exercise should, moreover, be under the personal direction of the local physician. Patients left to themselves are apt to overdo the matter on one hand—as by tiring themselves trying to keep up a long walk with more healthy friends—or, on the other hand, to make no effort on their own part to get about. Often a proper mode of living adopted under the advice of a good physician at a health resort will be continued on the return home, and will greatly aid in thoroughly getting rid of the disease or in preventing its return.

Rest is an important factor, both at home and at a health resort. Often all that is needed to restore health, to restore a normal functioning, is rest. Nature repairs the damage, but she does it slowly. A disease process must be arrested before repair can take place, just as a backing train must be stopped ere it can again move forward. When we have an external wound, as a cut in the skin, which we can see, we keep the part quiet and wait until nature cures, and, as we see the repair taking place from day to day, we naturally adjust our expectations according to the rate of progress. In the case of a sore lung or a sore kidney, where we can not see the injury and do not appreciate the necessity of keeping the part quiet, of resting the body or the organ, as we do in the case of a sore arm or foot, we are apt to get impatient if we do not get well in a very short time. Pain usually is simply a warning that something is wrong, and if quiet or rest relieves it, that is conclusive evidence that the body or organ needs rest.

To get the full benefit of a mineral water cure, proper attention must be given to the diet. This does not mean that the invalid must simply avoid the use of tea or coffee, which seems to be a regulation of some health resorts—such routinism has only one merit, simplicity—but it means that the diet should be adapted to the patient, to his physical condition and to the condition of the alimentary tract. Without a proper examination of the stomach contents after a test-meal, repeated if necessary, little that is of value can be expected in the case of chronic stomach affections or disturbances, nor in cases of Bright's Disease, unless repeated urinary examinations are made. Diet in many conditions is all-important. The use of a mineral water and the regulation of the diet are complementary; the effects of the one may be enhanced or negatived by the other. Perhaps nowhere else does diet play such an important part as in the cases where the use of a mineral water is properly indicated.

The matter of pure air should also be looked after. Disease germs are found floating in the air in variable numbers, abundantly in the atmosphere of a large city and in close rooms, where many people are congregated, but sparingly in thinly settled regions, and are practically absent in the atmosphere of the ocean, on deserts and on high mountains. The air of the open country is what we may call healthy. The dust in the air is one of the chief factors to be considered in sending a patient away from home; it may in certain diseases, as of the respiratory system, outweigh all other considerations. For a person with weak or diseased lungs to spend much time in the close, dust-laden air of a ballroom in the cold season is decidedly injurious.

Other things being equal, especially the waters, as revealed by an analysis, a health resort with attractive, perhaps scenic, surroundings, is always preferable to one located in a level, monotonous country, with nothing attractive upon which the eye can rest. Only too often the nearby towns and villages, or the general surroundings of a spring or health resort, are in a dilapidated condition—fences down, houses unpainted and barns and outhouses in a tumble-down condition. Even the application of a little whitewash makes a remarkable difference. To a person who has seen the neat and well-kept houses and gardens of the health resorts of the old world, the difference is all the more noticeable, and it is no wonder that the more fastidious, the delicate and refined invalids—the ones most desirable, and able to pay the best fees—are the ones who prefer going to Europe rather than patronize many of our home resorts, whose very surroundings depress them.

Then, too, in the case of the old established resorts, there is a certain, almost indefinable, spirit which newer or more recent institutions or resorts lack. The inhabitants, the natives, as we say, are accustomed to seeing strangers with apparently nothing to do—nothing but to get well—and they are not so apt to make remarks, which are very irritating to an invalid, often heard at newer resorts. A similar spirit is manifested in old college towns, where the people are accustomed to students and student-ways, and do everything to make it agreeable to the young men and women coming among them.

The situation of some of our smaller resorts is picturesque, and interesting excursions may be made through the neighborhood. Others that are situated among uninteresting or monotonous surroundings have been rendered attractive to visitors. Many give special attention to social matters, balls, concerts, dramatic performances and the like.

(5) *The matter of climatic influence must be kept in mind,* as it may overshadow the influence of the mineral water itself. The season

of the year may have a determining influence. In mid-winter a southern resort may be chosen, in the hot summer weather a cooler northern spring may be deemed best. Sudden and severe variations of temperature often exert a depressing effect, especially in a climate with considerable moisture. The amount of moisture in the air is an important factor in the degree of comfort with many invalids. Dry hot air or cold dry air is more agreeable than moist air. Moist air is usually chilly.

Climate has an especially important relation to certain diseases. In cold climates, or in cold and damp weather, affections of the joints, as rheumatism, or of the respiratory system, as catarrh, bronchitis or pneumonia, are more prevalent. In hot climates, or during hot weather, diseases of the abdominal organs prevail. Some invalids are at their best during the prevalence of cold weather, others during hot weather; some seek to get benefit by traveling from one climate to another, by going south in the winter and north on the approach of warm weather. A health resort that may be found to exercise a favorable influence in warm weather may not do so in cold weather, but the water itself should not be condemned on account of these modifying factors.

The question of living out of doors mainly or of being confined to close, over-heated rooms, so common in this country, and responsible for "colds" and catarrhal disturbances, is an important one. Pure air in many diseases is as important as pure water or pure food. In this respect the health resorts located away from communities, as cities and villages, have a decided advantage. Those of a city are least desirable.

(6) *The matter of expense.* If an invalid requiring a certain type or kind of water can not go 4,000 miles to Carlsbad, or a thousand miles to Saratoga, he may perhaps derive just as much benefit from the use of one of our Indiana waters. Indeed, at the present time, in many affections, even the most fastidious can be accommodated to suit his taste at some of our home resorts. Springs and health resorts to suit any purse can be found.

Invalids may grumble at paying a little more for attractive surroundings and superior accommodations, but if the returns are satisfactory, they will pay cheerfully, and, moreover, they will recommend the institution to their friends.

Some of our smaller resorts, although not so fashionable as the larger ones, are nevertheless well patronized by invalids who intend to make it a business to get well. At some, the mode of life may be simple but wholesome and the food good. The matter of expense is a serious one to many, and the one at which a man is apt to pause longest ere deciding to make the trip, especially when there is much doubt as to the possible benefit to be derived.

The remark of a friend may here appropriately be quoted: "If a man can afford to spend his money in the good living which brings on a morbid affection, he ought to be equally willing to pay for getting rid of his afflictions."

(7) *For how long a time to go, and how long to stay at a health resort,* is another question that comes up for consideration.

So many factors enter into this question that no general answer can be made. In suitable cases, as in those coming under the uric acid diathesis, a short stay will do some good, while a prolonged stay may be of decided benefit. In a general way, it may be said that where a particular water is indicated, and so long as it is indicated, the benefit derived will be in proportion to the length of the stay.

Invalids, as a rule, expect immediate results from treatment. Many simply want relief from pain and suffering, and as long as there is no pain they do not care what pathological process is going on in the body. Others, again, may be aware of some slight disturbance, so slight as not to inconvenience them, and which may not tend to produce any future evil results, and yet they are continually taking some treatment or remedy. For instance, where the stomach has been acutely inflamed, there may be some peculiar sensation for a long time afterward, after the acute disease process has disappeared, but this is no reason why treatment should go on indefinitely. Where some are too indifferent about what is going on in the body, others are too much and too easily concerned about their health, magnifying slight ailments, or some slight symptom, unduly.

The distinctions made on a previous page between curative and palliative treatment, between being cured and being benefited, must be kept in mind. In certain affections all that can be claimed for mineral waters is that they are beneficial, and expectations should be placed no higher. A remedy for a disease does not necessarily mean a cure, but relief from affliction and misery is always indicated, even if there can be no cure.

To go to a health resort in too high hopes and then come back disappointed can only bring any resort into bad repute with an invalid and his friends, whereas, if the hopes are set no higher than may reasonably be expected to be realized, any benefit derived will be duly appreciated, and any failure to be even slightly benefited will not be so keenly felt.

Dr. Crook, in his "Treatise on the Mineral Waters of the United States," has well said: "It is a fact which few will deny that most persons visiting a spa during the summer months experience, almost from the beginning, an improvement in their physical condition, and in many instances return to their homes fully restored to health. This can be accounted for to a great extent by the change of air, food and surroundings and the escape from the worry and cares of business. Perhaps numerous cases would do as well at summer resorts where there are no springs; yet, after a liberal deduction for all other assignable influences, we may justly attribute a large share of the good results to the aid rendered by a properly selected mineral water. An obstinate case of chronic constipation or catarrhal jaundice is not apt to yield readily to a mere change of diet and environment, and the same may be said of protracted cases of rheumatism, uric acid gravel, and numerous other conditions. No doubt these changes and the use of the water supplement each other, and this explains the fact that mineral waters usually act with greater efficacy at the springs than when taken at home.

CONCERNING INDICATED WATERS IN CERTAIN DISEASES.

It was suggested to the writer that he add or give under the type of water, as of a saline, a list of affections that may be benefited by its use.

Such a list might be of value where the nature of the disease or the disease-process is definitely known, as well as its intensity, the amount of loss in function and the probable reaction of the body to the water, or, rather, its ingredients. It is evident that unless the indications for the use of any type of water are distinct, the proper application of the water itself will be indistinct, even though the analysis of the water is before us.

It is often said that the use of mineral water is wholly empirical and that there is little scientific basis to guide in their application. Such a view is too extreme, because in the case of mineral waters which have been properly analyzed and whose composition is known, a proper use can be made of the water in disordered and diseased conditions—assuming that these latter themselves are fairly well understood. If we do not know the nature of the water and have no definite knowledge of the disease-process, then our whole procedure becomes empirical, a trial may result in good, it may have no influence at all, or it may do evil.

THE FUTURE OF INDIANA MINERAL WATER HEALTH RESORTS.

It was a great surprise to the writer to learn on a recent tour through Europe to what great magnitude health resorts have risen and how popular they are with the people—with the masses. It is a common custom for the inhabitants of cities to "go to the baths" for four or six weeks every season, and this is a custom to be recommended to our own citizens.

The mineral springs and health resorts of Europe have long been appreciated on account of their therapeutic or medicinal properties, as well as for their financial value.

Europe has solved many problems, and as we grow older we will probably solve many of them in the same manner. Increase of population brings about changed conditions. Judging our country by the condition of affairs there, the conclusion that the sanatoria with pleasant and cheerful surroundings will be more numerous and most thoroughly equipped is irresistible.

While the United States, as a whole, abounds in all kinds of mineral springs, rivaling those of any country, yet, taking any limited portion, say a State like Indiana, it may be said that the subject of their full utilization is still in its infancy.

To people not actually ill or afflicted, it matters little where they go, whether to the seashore, mountain, hills or plain—each according to his taste or mental or bodily requirements.

After the worry of business or after a season of social functions, nothing so recuperates both body and mind as a stay at some pleasant resort; it certainly prevents break-downs and sickness.

To an invalid some greater circumspection is advisable. The term "health resort" is a very vague one, many factors must be considered, as mentioned on previous pages. In the case of a mineral water resort, the nature of the water itself is not the only question involved.

Although the distinctively curative influence of mineral waters is quite limited if confined to the use of the water alone, taken in connection with the change of scene, of diet, rest, open air exercise and recreation, a stay at a mineral water resort may be of great value. Properly conducted sanitaria or health resorts are important aids to the invalid in regaining lost health.

It would be mutually beneficial if owners of mineral springs or wells would restrict their claims of beneficial and curative properties of their waters to diseases or affections in which they are of undoubted benefit. The invalid would know better where to go, and the resort itself would gain a better reputation on account of the results obtained. A resort that encourages any and everybody to come and use its waters is apt to receive many invalids who will not be benefited, but whose condition may even be aggravated, and whose testimony on the return home will be decidedly unfavorable.

If a cure is promised, invalids go in full confidence of being cured, and unless this does occur, they are disappointed, and are apt to speak unfavorably of the institution and the treatment, while if they come merely in the hope of being benefited they will praise it for the good it has done them.

Although the kinds of diseased conditions, of affections, in which mineral waters are properly applicable are rather limited, the number of individual cases that will be benefited by their use is large. Take the uric acid condition alone, chiefly induced by a sedentary city life, and the number of individuals to be benefited by a sojourn at a properly selected spring or well is a very large one indeed.

When capitalists invest large sums of money in properly building up an institution for the accommodation of the afflicted, it shows conclusively that these men have faith in the properties of their waters and feel certain of a liberal patronage, and, most important, a return for their outlay—which they deserve. The influence for good of such institutions is not to be minimized, although to a physician the quackish methods adopted by some are obnoxious—but then they reap their own reward by not getting the good will of the family physician.

Sanatoria will increase in number and completeness in the course of time. They are accompaniments of our civilization. With a proper limitation —with a knowledge of what they can do, and what they can not do, that the impossible should not be expected—the attendance at such resorts will certainly increase in the course of time.

SUMMARIES AND CONCLUSIONS.

Water is one of the essentials of life.

Water performs a part in every vital process of the body.

Water with the addition of mineral matter may at times be useful.

Mineral waters play an important part in the treatment of certain diseases.

Mineral waters are to be taken at their true value. We now no longer expect impossibilities from their use.

The number of kinds of mineral water in Indiana is quite limited and Indiana has no mineral water not also found in other States or countries.

The term "mineral water" as commonly used applies to a water containing minerals in solution and used in the treatment of disease.

The number of kinds of diseases or disease-processes in which the use of mineral water is indicated is small, but on the other hand, the number of cases of affections and ailments of every-day life favorably influenced by the use of mineral waters is large.

The chief ingredients of Indiana mineral waters are: Sodium, magnesium, iron, calcium, potassium, aluminum, chlorine, sulphur, carbon, phosphorus; also oxygen, hydrogen and nitrogen.

Minor ingredients, as lithium, iodine, bromine, strontium, zinc, silicon, boron, with perhaps several others, occur in too small amounts to be of service in the treatment of disease.

The above chemical elements are combined with each other, generally in the form of salts.

Mineral waters add nothing to the nutrition of the body which may not also be obtained from the daily food.

Mineral waters, except iron waters, deplete, they take away.

Sulphur, in the form of sulphuric acid, is a common constituent of mineral waters; combined with sodium it forms Glauber's salt and with magnesium, Epsom salt. Both are aperient or purgative.

Sulphuretted hydorgen is the gas with the rotten egg odor. It is a common ingredient of our sulphur waters; of itself and in the small amounts present it has no marked influence on the body.

Strong-smelling or strong-tasting substances are not necessarily "powerful medicine."

The number of constituents of our mineral waters is quite limited and the action of some of the rarer constituents or those occurring in small amounts, is overshadowed by the action of the more active constituents or those present in greater amount.

Although the curative range of our mineral waters is quite limited, the number of everyday ailments in which they are indicated is large and in many of these mineral waters may be used with good results.

Sharp distinctions must be made between curative and palliative treatment, and between being benefited and being cured. In many chronic ailments a "cure" is out of the question.

An indicated mineral water may be of benefit although it may not influence the underlying cause, merely modifying the symptoms.

To use water freely is in many cases equivalent to taking less solid food. To get the best results from the use of a mineral water, the diet should be properly regulated.

Mineral waters are indicated chiefly in chronic affections, or the after-effects of acute disease processes.

The indications for the use of pure water and of water only slightly mineralized are many, those for the use of heavily mineralized waters are comparatively few.

The kinds of mineral water found in Indiana are: Carbonated, alkaline, alkaline-saline, saline, chalybeate.

Sulphur waters or sulphuretted waters may be salines or alkaline-salines; they are common in Indiana and play an important part in the treatment of affections, especially of perverted nutrition.

Waters of the above kinds do not add anything to the nutrition of the body; on the contrary, they deplete.

The conditions, par excellence, for the use of our Indiana mineral waters are those due to over-eating and under-exercising—conditions incident to a sedentary city life.

People living at a mineral water health resort are no healthier than people who have no mineral springs or wells in their midst, other conditions being of course equal.

The human body is a complex organism, a complex machine for the performance of certain functions. The machinery is kept going by the vegetable food we eat, which is oxidized in the process of producing heat and force. The wear and tear of the body is replaced by the animal food we eat.

In disease the body is working under abnormal conditions.

As a cause of disease something definite is demanded, a something that can be seen, felt, weighed or measured.

Many acute diseases are now known to be due to micro-organisms, to bacteria, but not all diseases have such a cause.

There may be permanent impairment after the subsidence of an acute disease process, with defective bodily activity, and this may be known as a chronic ailment or disease.

Many chronic conditions must be endured, they can not be cured, but palliative treatment may be indicated at all times.

Too much medicine, so-called, is taken, and in conditions where the pathological or disease process is not known, no accurate diagnosis having been made. "He who has himself for a patient has a fool for a physician."

The most important ingredient of mineral water is the water itself.

Simply to go to a mineral spring or well and drink the water is not all that is involved in a "mineral water cure."

The change of scene and perhaps of climate, the freedom from business and home cares and worry, regularity of life and change of diet, are important factors.

In addition to the use of the water at the sanitarium the aid of massage, electricity, gymnastics, and the use of certain indicated medicines are important elements of treatment.

Mineral waters are not indicated in acute diseases, these are best treated at home. In tedious convalescence from an acute disease, a stay at an indicated mineral spring may be of service.

Mineral waters may be of decided benefit in disturbances of the alimentary tract, though the difficulty lies in properly diagnosing the nature of the affection or disease and selecting the proper kind of water.

Kidney disturbances may in many cases be favorably influenced by the use of one kind or another of mineral water, especially where the difficulty is due to defective elimination of waste products.

Nervous affections of a functional nature and dependent on derangement of other organs, may be favorably influenced.

In conditions of impoverished blood, as revealed by testing the blood, the use of an iron water may do good.

So-called uric acid conditions, are the great field for our Indiana mineral waters. They may be called "perverted conditions of nutrition."

In uric acid conditions the relationship between the amount and kind of food and the amount of water taken are complementary. Lessening the amount of albuminous food gives the water a better chance to produce favorable results.

The use of baths, either simple hot water, or of mineral water, or of peat or mud baths, helps to eliminate waste products from the body by causing the skin to act more freely.

In choosing a mineral water spring, well or health resort, attention should be given to certain factors, otherwise the invalid may not receive proper benefit and the waters—good in properly selected cases—may be unjustly condemned.

Among the factors or elements that require special consideration are the following:

1. The condition or constitution of the invalid or patient: His condition should be one where the use of mineral water is indicated, and he should be able to bear the journey.

2. The character of the mineral water must be considered: What it will not do must be considered as well as what it may do for the invalid. Do not expect impossibilities from the use of a water.

3. The medical supervision at the springs: A properly qualified physician can do much to assist the invalid in regaining lost health.

4. The daily life at the springs: The question how the time is to be spent at a resort must be considered; the recreation, amusement, how to while away the time, etc. Many persons away from home, with nothing to do, tire very readily.

5. The climate influence: The seasons of the year, whether warm or cold, and the amount of sunshine or rain, have a marked influence in many cases, and an otherwise suitable water should not be condemned on account of the modifying weather conditions. A water that may be found beneficial in the summer with an outdoor life, may be held to be of no use in the winter with a life confined to close and over-heated rooms—the water itself should not be condemned on this account.

6. The matter of expense and the probable good results should be considered: If the indications for a favorable influence from the use of the water are uncertain, expectations should not be set too high or the disappointment will be keen.

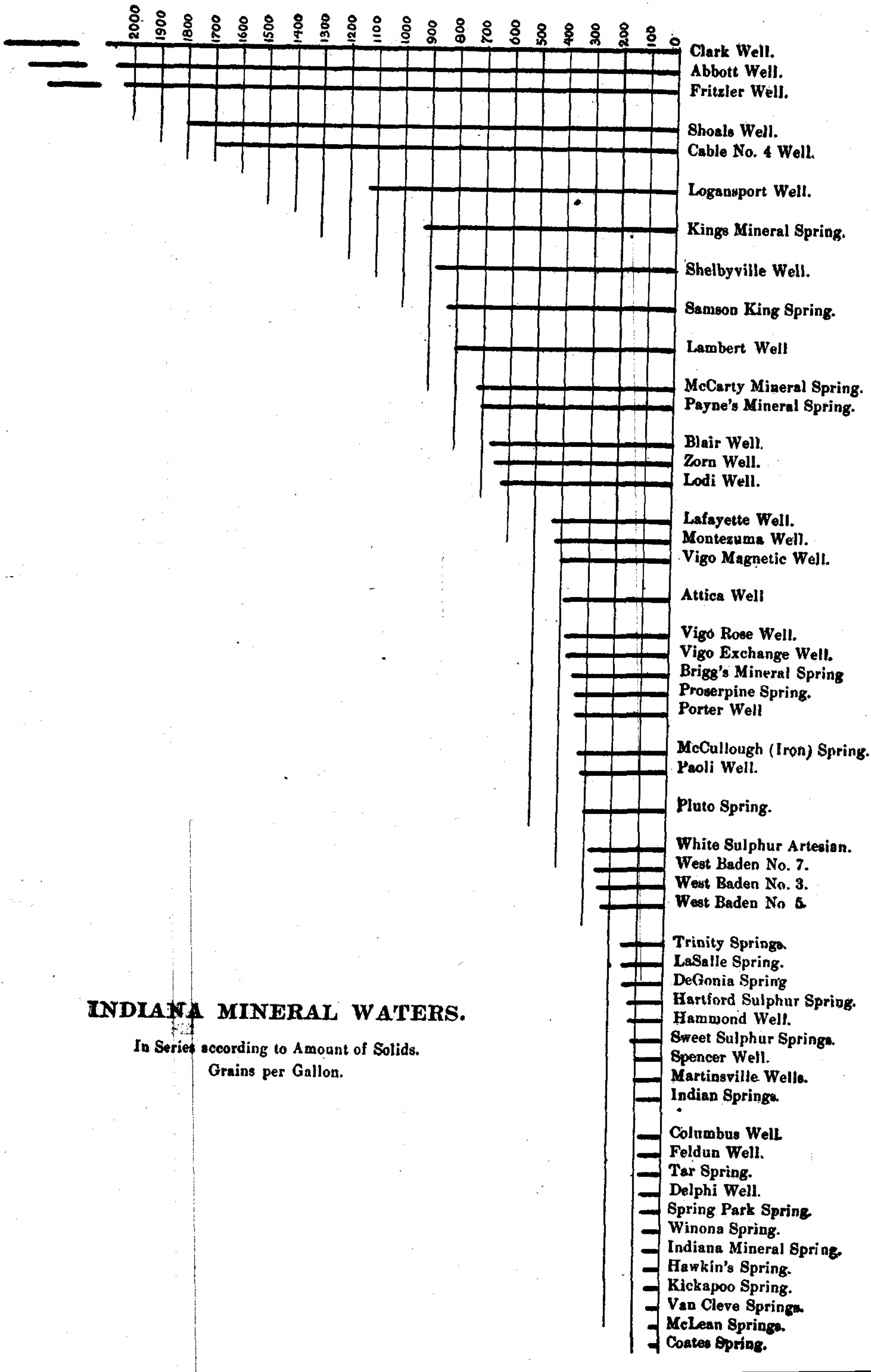
7. The probable duration of a stay at a resort must be considered before going—and how long to remain determined after having been at the spring at some time. How long to stay is a difficult question. In a general way it may be said that if the use of a water is beneficial, and continued use brings about improved conditions, the longer the stay the greater the improvement.

Our mineral water health resorts are still in their infancy. Judging by the experience of European countries, Indiana's mineral water health resorts are destined to occupy an important place in the future.

TABLE OF SOME TYPICAL EUROPEAN WATERS.

THE CHIEF INGREDIENTS ONLY ARE GIVEN. THOSE TO WHICH THE WATERS OWE THEIR CHARACTER ARE GIVEN IN **BOLD FACED TYPE.**—FIGURES REPRESENT GRAINS PER GALLON.

WATER	Vichy.	Ems.	Carlsbad.	Wiesbaden.	Nauheim.	Schwalbach.	Contrexville.	Apollinaris.	Hunyadi Janos.
NAME OF SPRING	Grande Grille.	Kessel-brunnen.	Sprudel.	Koch-brunnen.	Kur-brunnen.	Stahl-brunnen.	Pavilion.	Apollinaris.	
KIND OF WATER	Alkaline.	Alkaline-	Alkaline-	Saline.	Saline.	Chalybeate.	Calcic.	Carbonated.	(Purgative.)
Sodium carbonate	**208.00**	**84.24**	**72.48**	....	....	.88	11.44	**55.68**	**105.60**
Calcium carbonate	18.48	10.00	16.16	25.68	64.16	9.44	**39.36**	15.20	48.32
Magnesium carbonate	11.04	6.80	3.12	.64	....	7.68	12.80	**22.00**	....
Iron carbonate	.16	.16	.24	.32	1.12	**3.68**	.48	....	.64
Sodium chloride	**32.80**	**62.16**	**69.76**	**420.00**	**879.36**	.40	8.00	21.92	**92.82**
Sodium sulphate	18.32	....	**159.68**	....	....	.48	7.52	12.32	**1081.76**
Magnesium sulphate	....	....	....	....	....	....	11.04	....	**1103.84**
Calcium sulphate	....	....	....	5.52	5.92	....	**67.12**	....	....
Carbonic acid gas (cubic inches)	**117.92**	**54.24**	**62.40**	**183.60**	**249.60**	**402.16**	2.32	**342.48**	64.48



INDIANA MINERAL WATERS.

In Series according to Amount of Solids.
Grains per Gallon.

A Geologic and Topographic Section

ACROSS SOUTHERN INDIANA

From the Ohio River, at Hanover, to the Wabash River, at Vincennes, with a Discussion of the General Distribution and Character of the Knobstone Group in the State of Indiana.

BY JOHN FLESHER NEWSOM,
Stanford University, California, 1901.

LETTER OF TRANSMITTAL.

Prof. W. S. Blatchley, State Geologist:

Dear Sir—I hand you herewith my report on a geologic and topographic section across southern Indiana from Hanover to Vincennes, with a discussion of the general distribution of the Knobstone group in the State of Indiana,

And remain very respectfully yours,

J. F. NEWSOM.

CONTENTS.

INTRODUCTION.

The following paper relates to the geological formations represented in southern Indiana, especially where these are crossed by the row of townships numbered 3 north. The field work, on which the paper is based, was done in 1896-1897-1898.*

During this time a topographic map was constructed covering a strip of country six miles wide, and extending from the Ohio River in the neighborhood of Madison on the east to the Wabash River at Vincennes on the west. This section passes over the various formations exposed in this part of the State, beginning in the Ordovician rocks at the east and ending with the Merom sandstone of Carboniferous (or Post-Carboniferous age) at the west.

Some glacial deposits are also crossed by this section, but no attempt has been made to outline the glacial deposits in detail. The distribution of the other rocks in the area covered by the topographic section is shown on the geologic map accompanying it. On this sheet Plate II is a profile of cross-sections showing the general structure and sequence of the strata. These sections are taken along the middle line of Township 3 north.

The area covered by the formation generally known as the "Knobstone Group" (Lower Carboniferous) is shown on the accompanying maps, Plates III and IV. This group of strata, and the area covered by it, is taken up in more detail than the others.

On Plate I (a small skeleton map of Indiana) are shown the mapped areas on which this paper is based.

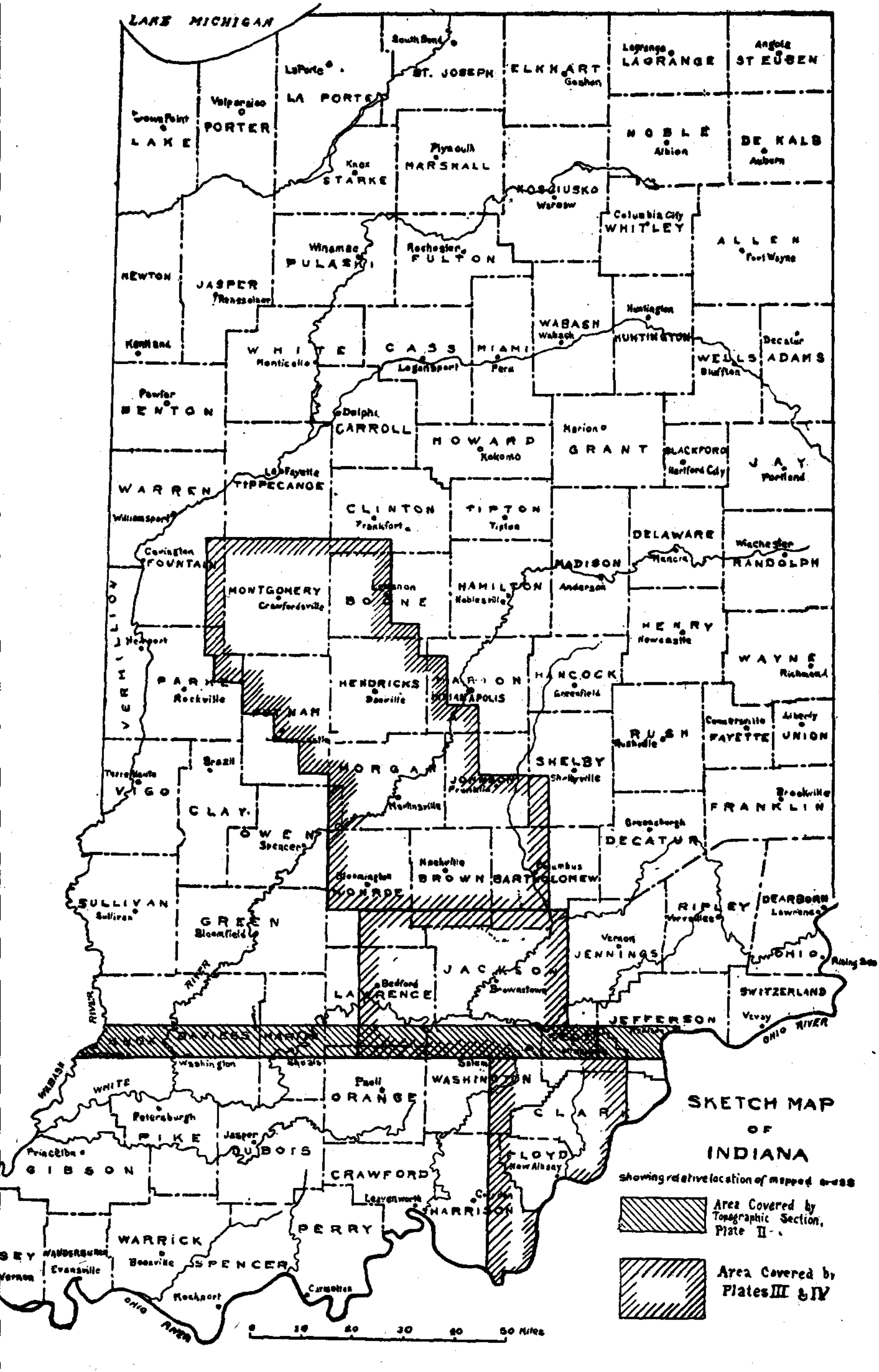
The topographic work was done by means of aneroid barometers; the aneroid readings were checked by a line of elevations run through the territory by means of the vertical arc. The elevations thus obtained are as accurate as the necessities of ordinary topography and

*Full acknowledgment is made in this place to Messrs. J. A. Price, L. F. Bennett, A. C. Veatch, B. V. Goshorn, C. G. Daily, L. F. Hunt and L. H. Jones for their work in connection with the mapping of the areas treated in the following pages.

Their field work as assistants on the Indiana University Geological Survey, under the writer's direction, covered most of the ground of the accompanying maps.

Acknowledgment is also made to Dr. T. C. Hopkins for work on the contact between the Knobstone and overlying limestones, between townships 11 and 14 north, and for data in regard to the details of that contact between townships 15 and 17 north.

Plate I.



LAKE MICHIGAN
LAKE
PORTER
LA PORTE
ST. JOSEPH
ELKHART
LAGRANGE
STEUBEN
STARKE
MARSHALL
KOSCIUSKO
NOBLE
DE KALB
NEWTON
JASPER
PULASKI
FULTON
WHITLEY
ALLEN
WHITE
CASS
MIAMI
WABASH
HUNTINGTON
WELLS
ADAMS
BENTON
CARROLL
HOWARD
GRANT
BLACKFORD
JAY
WARREN
TIPPECANOE
CLINTON
TIPTON
DELAWARE
RANDOLPH
FOUNTAIN
MONTGOMERY
BOONE
HAMILTON
MADISON
HENRY
WAYNE
VERMILLION
PARKE
PUTNAM
HENDRICKS
MARION
INDIANAPOLIS
HANCOCK
RUSH
FAYETTE
UNION
VIGO
CLAY
MORGAN
JOHNSON
SHELBY
FRANKLIN
OWEN
DECATUR
SULLIVAN
GREENE
MONROE
BROWN
BARTHOLOMEW
RIPLEY
DEARBORN
JENNINGS
OHIO
JACKSON
LAWRENCE
SWITZERLAND
JEFFERSON
WASHINGTON
ORANGE
CLARK
PIKE
DUBOIS
GIBSON
CRAWFORD
FLOYD
HARRISON
PERRY
WARRICK
SPENCER
OHIO RIVER
WABASH RIVER
WHITE RIVER
SKETCH MAP
OF
INDIANA
showing relative location of mapped areas
Area Covered by Topographic Section, Plate II.
Area Covered by Plates III & IV
0 10 20 30 40 50 Miles

geologic cross-sections demand. The levels obtained by the vertical arc were checked on the Jeffersonville, Madison and Indianapolis, and Baltimore and Ohio Southwestern railroads where these roads were crossed.

The section selected was chosen for mapping because the geologic horizons and the topography crossed by it are typical of the entire southern portion of the State.

In the following pages the different formations will be discussed in their order, beginning with the lowest. References to the literature relating to the various formations are given under the discussions of those formations. No attempt is made to make these lists complete on any subject, but the more important papers are cited in each case; neither is an attempt made to give lists of the species that have been identified from all the formations crossed by Township 3 north, as such lists would include over 2,000 species. Under the discussion of the various formations references are given to the more important papers where lists of species can be found.

GENERAL OBSERVATIONS.

STRATIGRAPHY.

ORDOVICIAN.—The oldest rocks exposed in Indiana are the calcareous shales and limestones of the Hudson River, or Cincinnati group. These beds are exposed in the southeastern part of the State, where, in the neighborhood of Madison, on the Ohio River, they have an exposed thickness of 250 to 300 feet.

SILURIAN.—Overlying the Hudson River shales and limestone is the Clinton limestone, a very persistent thin bed of limestone, having usually a reddish-brown or salmon color. Next overlying the Clinton are the limestones and shales of the Niagara group. In Township 3 north, 9 east, Section 13, near Hanover, the Niagara beds have a thickness of 68 feet.

DEVONIAN.—The Niagara limestones and shales are overlain by the Corniferous limestone, above which is the Hamilton limestone and a black shale. These three beds have an aggregate thickness of about 190 feet.

LOWER CARBONIFEROUS.—The top of the Devonian black shale (known as the New Albany black shale) is marked by the Rockford goniatite limestone (Lower Carboniferous), a bed of greenish mottled limestone, having a thickness of from eight inches to three feet. This limestone is the lowest bed of the Lower Carboniferous strata of Indiana. For so thin a bed it is an exceptionally persistent one, occurring along almost the entire line of contact between the Lower Carboniferous and Devonian rocks where this contact is exposed.

The Lower Carboniferous beds are made up of three distinct groups of strata. Beginning with the lowest these are:

First. A series of shales with overlying heavily bedded sandstones. The series has a thickness of 550 feet where crossed by the section. This series of rocks has long been known as the Knobstone group, that name having been given it by Owen.

Second. A series of limestones with interbedded cherts, with a thickness of about 375 feet. These limestones are made up of three different groups of strata as recognized by Hopkins and Siebenthal.*

*Department of Geology and Natural Resources of Indiana, 21st Annual Report. "The Bedford Oölitic Limestone." By T. C. Hopkins and C. E. Siebenthal, pp 196-199. Indianapolis, 1897.

Third. A series of sandstones and interbedded limestones with a thickness of 125 feet, and recognized by Mr. E. M. Kindle as belonging to the Kaskaskia group.

COAL MEASURES.—Overlying the Kaskaskia beds is the massive Mansfield sandstone of Hopkins, often having an underlying bed of coal. This sandstone is the base of the Coal Measures and corresponds to the sandstone so widely known as the "Millstone Grit." It has a thickness of from 100 to 150 feet where crossed by the section.

Above the Mansfield sandstone are the shales and sandstones of the Productive or Bearing Coal Measures. These beds have a total thickness of about 800 feet where crossed by Township 3 north.

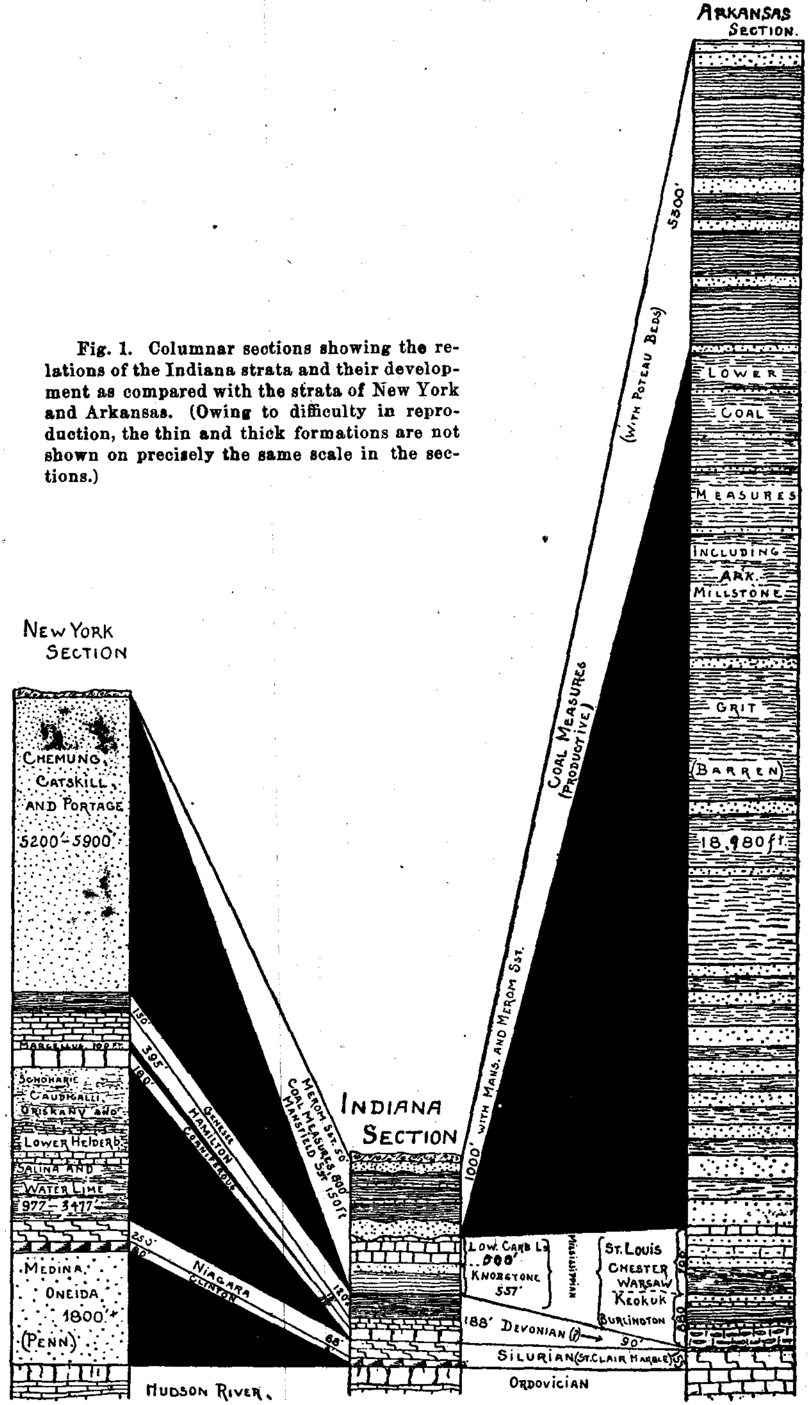
PERMO-CARBONIFEROUS.—Lying unconformably upon the Productive Coal Measures is a sandstone of Upper Carboniferous or Permo-carboniferous age. At Vincennes it has a thickness of about 45 feet.

PLEISTOCENE GLACIAL.—Overlying the Silurian and Devonian and the eastern part of the Knobstone strata at the east, and overlying the Productive Coal Measures at the west end of the section under discussion, are deposits of glacial debris. This glacial material occurs, for the most part, only on the hilltops through Townships 4, 5, 6, 7 and 8 east, having been entirely removed by erosion in the valleys. In 9 east, however, the surface is made up almost entirely of glacial material. The townships west of 3 north, 5 west, are almost entirely covered by glacial debris.

The accompanying columnar section (with sections of the New York and Arkansas strata for comparison) (Fig. 1) shows the thicknesses and relations of these various formations as they occur in Township 3 north. Where crossed by the topographic section they have an aggregate thickness of about 2,500 feet.

The sections bring out the fact that, as compared with New York, Indiana was a region of slight sedimentation from Ordovician to the end of Lower Carboniferous time. This is because the Indiana region was far removed during that time from large land masses where much erosion was taking place. Something of the importance of the erosion that took place after the deposition of the Lower Carboniferous strata is also brought out by the thickness of the sediments deposited in the Arkansas region during that time.

Fig. 1. Columnar sections showing the relations of the Indiana strata and their development as compared with the strata of New York and Arkansas. (Owing to difficulty in reproduction, the thin and thick formations are not shown on precisely the same scale in the sections.)



STRUCTURE.

The geologic structure of southern Indiana is very simple. Situated as the rocks are, at the west side of the low dome of the Cincinnati Arch, the beds all have a gentle westward and southwestward dip. There are local variations in the dip, but for the most part where seen outcropping in ledges the strata appear to be flat. Where measured in Township 3 north, the westward dip varies from 20 to 46 feet per mile. These dips are sufficient, however, to exercise a marked control over the drainage of the region.

In the coal regions many small local faults occur.*

The writer has observed only one fault of considerable extent in the State. This break has been traced more or less continuously from 3 north, 2 east, Section 1, in a northwesterly direction to 9 north, 1 east, Section 10, a distance of 36 miles. This fault is discussed under the subject of the Knobstone.

The only place in the region crossed by the topographic section at which anything approaching a distinct fold occurs is in 3 north, 8 east, along the line of westernmost exposure of the Hamilton limestone. Here the limestone and shales have a perceptible westward dip.

TOPOGRAPHY.

The topography crossed in going from east to west across the State is somewhat varied, owing to the succession of thick series of hard and soft beds. It is made up, as would be expected, from the succession of the rocks and their gentle westward dips, of three eastward-facing escarpments, and as many gentle westward sloping plateaus in various stages of dissection. The general character of the topography is illustrated by the accompanying generalized section, Fig. 2.

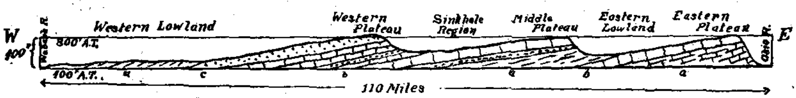


Fig. 2. Ideal east-west section in southern Indiana showing the general topographic effect of the succession of hard and soft strata.

The shales a, a, a, weather more rapidly than the limestones b, b. The limestones b weather faster than the massive sandstone c.

Owing to the exaggerated vertical scale the westward inclination of the strata appears too great.

The controlling strata are: *First*, the thick Niagara and Corniferous limestones; *second*, the thick sandstones with their capping

*Indiana Department of Geology and Natural Resources. 23rd Annual Report, pp. 53-61. Indianapolis, 1899.

cherty limestones at the top of the Knobstone group and the base of the Harrodsburg limestone; and *third*, the heavy beds of the Mansfield sandstone. The broad north-south troughs or valleys of the southern portion of the State are due to the shale beds and softer or more easily eroded limestones that lie between these controlling beds. The best marked of these broad troughs is that lying between the Knobstone at the west and the limestones at the east. It is clearly marked from New Albany to Edinburg, north of which place the topography owes its character to glacial deposits. The Jeffersonville, Madison and Indianapolis Railroad follows the bottom of this trough or lowland from Louisville to Edinburg.

The topographic maps, with their accompaning profile sections, show the relations between these different topographic features.*

THE FORMATIONS IN DETAIL.

In the following discussion the oldest strata will be taken up first:

ORDOVICIAN.

HUDSON RIVER (OR CINCINNATI) GROUP.

The oldest rocks exposed in Indiana are those of the Hudson River group.

CHARACTER OF ROCKS.—This group is here made up of a series of bluish thin-bedded limestones intercalated with bluish-green calcareous shales, which are quite soft, while at the top of the series are massive sandy limestone beds of a brownish color. These massive beds contain but few fossils, while the calcareous shales below are very fossiliferous, and the bluish limestones are in places largely made up of fossils.

The shales are often scarcely more than slightly indurated clays, and the fossils in them are well preserved. It happens, therefore, that large quantities of well preserved fossils weather out and collect in the beds of all the small streams flowing eastward and southward into the Ohio River in the neighborhood of Madison and Hanover. This is generally true of the streams that cut down as much as 150 or 200 feet into the rocks of the Hudson River group throughout southeastern Indiana.

*The topography in its relations to the structure of southern Indiana is discussed by Leverett, in Part IV, 18 An. Rep., U. S. Geological Survey, pp. 429-431. See also Journal of Geology, Vol. VI, pp. 250-256, "A Geological Section Across Southern Indiana from Hanover to Vincennes." By J. F. Newsom, Chicago, 1898.

AREAL DISTRIBUTION.—In the section under discussion the Hudson River beds outcrop only in the bluffs along the gorge on the Ohio River, where they form a strip of country from one-quarter of a mile to one and one-quarter miles wide.

DETAILED SECTIONS.—In the neighborhood of Hanover the following section is exposed, beginning with the Clinton bed at the top:

		Feet.
1.	Clinton	2
2.	Thin bedded limestones at the top with underlying massive impure limestones (Madison beds of Foerste) about	50
3.	Calcareous shales with intercalated limestones (very fossiliferous)	72

Below three the rocks are concealed at the point where this section was taken, but they are made up of a succession of calcareous shales and intercalated limestones, similar in character to the 72 feet of beds shown at the base of the section.

In 3 north, 9 east, Section 12, a total thickness of 208 feet of Hudson River rocks is exposed along the Hanover Landing Road, from the Clinton bed near the top, to the junction of the Hanover Landing Road with the river road, near the foot of the hill. This latter point is some 40 feet higher than low water in the Ohio, so these beds have an exposed thickness of 250 feet in 3 north, 9 east.

The Ordovician rocks of southern Indiana have been recently studied by Cummings, who gives* a number of detailed sections of the beds in Dearborn, Ohio, Switzerland and Jefferson counties.

The following section taken along the railroad cut north of Madison† shows well the character of the Hudson River group:

		Ft.	In.
65.	Massive white arenaceous limestone (Niagara)	2	6
64.	From a few inches to nearly a foot of pinkish or yellowish to salmon colored crystalline limestone (Clinton)	1	0
63.	Massive white arenaceous limestone	4	2
62.	Thick bedded argillaceous, arenaceous limestone	9	8
61.	Same as 62, but banded on weathered surface with pink, gray and buff	12	10
60.	One massive conspicuous arenaceous layer	3	6
59.	Thin-bedded, argillaceous, arenaceous, weathering brownish, with some calcareous layers containing Bryozoa	7	0
58.	Nothing to four inches of coarse limestone with Ordovician fossils	0	4

*Proceedings of the Indiana Academy of Science, 1900. Notes on the Ordovician rocks of southern Indiana, by Edgar R. Cummings, pp. 200-215. Indianapolis, 1901.

†Ibid., p. 212-213.

		Ft.	In.
57.	Sandstone with lenticles of limestone containing Bryozoa	3	0
56.	Argillaceous layer. *Favistella stellata*	2	0
55.	Shale	6	0
54.	*Favistella stellata*	1	2
53.	Thin layers of limestone alternating with argillaceous and sandy layers. Bryozoa (very abundant). *Rafinesquina, Hebertella*	5	3
52.	Massive soft sandstone	7	8
51.	Blue fossiliferous limestone shale and arenaceous layers	6	0
50.	Fine shale with layers of limestone, *Rhynchotrema, Hebertella, Monticulipora, Calymene, Rafinesquina*	10	0
49.	Same as 50. *Strophomena, Streptelasma, Plectambonites, Dalmanella, Platystrophia laticosta, Ambonychia*	8	0
48.	Probably shale and thin layers of limestone, covered by talus	22	0
47.	Heavy layers of limestone seen in the *west* side of the south cut, at the top	0	0
46.	Heavy layers of limestone seen in the east side of the south cut, at the top. The lowest layers in the big cut (north cut) are 24 feet above the top of No. 45 if the foot of the big cut be taken as 210 feet above the river. Part of the layers of No. 46 would therefore be repeated in 45. Allowance is made for this fact. Nos. 46 and 47 together	24	0
45.	Shale. The top of No. 45 is at the culvert, just north of the south cut	10	0
44.	Several layers of limestone with *Cyclonema, Rafinesquina, Calymene,* etc	1	2
43.	Shaly limestone. *Cyclonema*	2	8
42.	Limestone, *Ambonychia, Cyclonema, Rafinesquina, Monticulipora,* Crinoids	2	0
41.	Limestone and shale. *Ambonychia*	5	0
40.	Compact close-grained limestone, *Rafinesquina*	0	3
39.	Limestone and shale. *Zygospira, Ambonychia*	2	4
38.	Limestone. *Rafinesquina* edgewise (very abundant)	0	4
37.	Argillaceous compact limestone. *Rafinesquina*	6	9
36.	Limestone. Bryozoa	0	6
35.	Shaly limestone	5	8
34.	Limestone	0	8
33.	Shaly limestone	2	8
32.	Limestone. *Rafinesquina, Calymene, Hebertella* (?), Gastropoda, Bryozoa	0	8
31.	Shale, with occasional 2-inch to 3-inch layers of limestone	10	8
30.	Limestone. *Rafinesquina* edgewise (very abundant)	0	3

		Ft.	In.
29.	Shaly limestone. *Rafinesquina* (very abundant), *Modiolopsis* (very abundant), *Zygospira* (very abundant)	6	9
28.	Similar to 26	0	4
27.	Shaly limestone	1	4
26.	Blue fine-grained limestone. *Zygospira* (exceedingly abundant)	0	3
25.	Shaly limestone. *Rafinesquina*, etc	13	0
24.	Very compact fine-grained limestone; no fossils	0	6
23.	Shale and limestone, with excellently preserved specimens of *Rafinesquina* (very abundant)	4	2
22.	Limestone with top of layer, composed of immense numbers of *Zygospira modesta*	0	3
21.	Rather coarse shale	2	0
20.	Lumpy, shaly limestone. *Asaphus*, *Rafinesquina*	3	0
19.	Coarse to fine-grained barren limestone	0	8
18.	Lumpy, shaly limestone. *Rafinesquina* (very abundant), Trilobites (abundant), *Zygospira*, *Streptelasma*, Bryozoa	12	0
17.	Limestone, with *Rafinesquina*, *Zygospira* (very abundant), Bryozoa, *Orthoceras*	5	10
16.	Shale, with thin layers of limestone	1	0
15.	Very compact, fine-grained, blue, barren limestone	0	6
14.	Shale	0	8
13.	Compact limestone. *Calymene*, *Zygospira*, etc	0	5
12.	Limestone. *Calymene* (very abundant), Bryozoa, *Rafinesquina*, *Orthoceras*	1	3
11.	Shale with thin layers of limestone	3	8
10.	Thin argillaceous limestone with *Calymene* and Bryozoa (abundant)	1	0
9.	Massive blue limestone. *Rafinesquina*, Trilobites, Bryozoa	0	7
8.	Limestone. *Rafinesquina*, *Zygospira*, Bryozoa	2	9
7.	Thin argillaceous yellow-spotted limestone. *Platystrophia*, *Hebertella*, *Rafinesquina*, Bryozoa	1	0
6.	Limestone. *Hebertella* (very abundant), *Rafinesquina nasuta*, *Platystrophia lynx*	1	2
5.	Bryozoal limestone	0	4
4.	Covered, probably shale	1	0
3.	Limestone with Trilobites, *Zygospira*, etc	0	2
2.	Coarse crystalline limestone. *Hebertella*	0	6
1.	Covered to river level	62	0
	Total	315	9

Only that portion of Cummings' section from the Niagara beds down is quoted.

In his study of the fauna of the various sections of the Ordovician rocks of southeastern Indiana, Cummings recognizes the following faunal zones in ascending order:*

1. *Dalmanella multisecta* (200-240 feet).
2. *Rafinesquina alternata* (50-70 feet).
3. *Platystrophia* (60-80 feet).
4. *Rafinesquina alternata* var. *fracta* (100 feet +).
5. *Dalmanella Meeki* (20 feet +).
6. *Streptelasma.*
7. *Strophomena* (10 feet +).
8. *Rhynchotrema capax* (10 feet +).

The waterfalls at the heads of the ravines along the gorge of the Ohio near Hanover are formed principally by the Hudson River beds. The profile of one of these falls is shown in Fig. 3, which also indicates the character of the strata forming it.

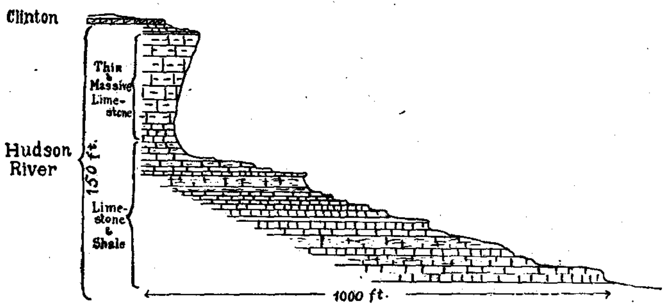


Fig. 3. Profile of falls immediately southeast of Hanover, Indiana.

The upper part of the Hudson River group has been studied in detail by Foerste.† He recognizes the following subdivisions, beginning at the top.‡

"Madison beds and their northern equivalents. Overlying the typical Madison beds are the *Murchisonia hamelli* beds and the terminal white limestone layer.

"The richly fossiliferous shales and limestones below the Madison beds. The equivalents of the Madison beds northward present the same characteristics as these lower beds.

"Gasteropod or Marble Hill bed.

"Section below not studied."

*Loc. cit., p. 215.

†Indiana Department of Geology and Natural Resources. 21st Annual Report (1896), p 213 et seq.; 24th Annual Report (1899), p. 41 et seq. (The later report contains a synonomy and many references.)

‡Indiana Department of Geology and Natural Resources. 21st Annual Report (1896). p. 218.

PALEONTOLOGY.—The Hudson River group is rich in fossils. The species described from this formation have been brought together by Kindle,* to whose list the student is referred.

SILURIAN.

CLINTON.

CHARACTER AND AREAL DISTRIBUTION.—Lying immediately above the rocks of the Hudson River group is the Clinton limestone. In Township 3 north, 9 east, it is a rather close grained rock with a salmon color. Its thickness near Hanover is about two feet. This bed comes to the surface along the gorge of the Ohio in a sinuous line, passing out around the high points and back around the heads of the deep ravines that are here cut down into the underlying Hudson River beds. The Clinton limestone usually outcrops in the stream beds a short distance above the crests of the waterfalls at the heads of the ravines just mentioned.

TOPOGRAPHY AND GENERAL REMARKS.—The Clinton varies in thickness in Indiana from a few inches to about seven feet. In Ohio it ranges from 30 to 40 feet thick, thus showing a general thinning out toward the west.

Owing to its thinness it exercises practically no control on the topography of the region in which it outcrops, neither is it of commercial importance. It is a very persistent bed, occurring at most places where its horizon is exposed. At some places, however, it is absent, and near Osgood and southwest of Versailles pebbles have been found in it. These facts have led Foerste to advance the opinion that during Clinton time there was a land mass not far west of the present line of Clinton outcrop.†

While this thin formation contains many fossils, these are usually imbedded firmly in the rock and are difficult to obtain. For lists of Clinton fossils the reader is referred to the papers by Kindle‡ and by Foerste.§

In 1883, the Clinton was recognized at Parker's Mill by Elrod,¶ but the true limits of the formation were not recognized by him else-

*Indiana Department of Geology and Natural Resources. 22d Annual Report (1897), A Catalogue of the Fossils of Indiana, by E. M. Kindle Pages 407-514. Indianapolis, 1898.

†Journal of the Cincinnati Society of Natural History. Vol. XVIII, p. 200.

‡Indiana Department of Geology and Natural Resources. 22d Annual Report (1897). pp. 408-514. A Catalogue of the Fossils of Indiana, by E. M. Kindle. Indianapolis, 1898.

§Report of the Geological Survey of Ohio. Vol. VII. Fossils of the Clinton group in Ohio and Indiana, by August F. Foerste, pp. 516-601.

¶Indiana Department of Geology and Natural History. 12th Annual Report, p. 130.

where. Foerste first called attention to the true limits of the Indiana Clinton in 1896* and has later published papers in which many Clinton localities are mentioned, and lists of collected fossils are given.†

NIAGARA.

CHARACTER.—The Niagara group in southeastern Indiana is made up of limestones and shales. In Township 3 north, 9 east, these rocks have at Hanover, in the southwest quarter of Section 12, a thickness of about 68 feet.

The section of the Niagara beds shown in Fig. 4, is exposed on the Hanover Landing Road, beginning at the top of the hill at Hanover.

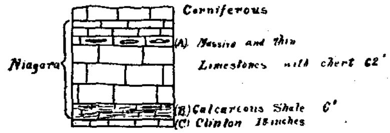


Fig. 4. Section showing the relations of the Niagara beds near Hanover.

The Niagara strata are known locally as the "cliff rock," owing to the fact that the more massive and indurated beds resist the action of the weather, and form cliffs along the ravines where they outcrop.

AREAL DISTRIBUTION.—On the accompanying map (Plate II) the narrow sinuous strip of outcropping Niagara beds is shown at the east side of 3 north, 9 east, and the west side of 3 north, 10 east. These beds form the bluffs on the high points and along the crests of the hills, on the west side of the Ohio gorge. They are always to be found also, at the sides of, and crossing, the ravines immediately above the numerous waterfalls of this locality. These hard beds frequently form low falls in the streams above the main falls of the region.

In the Niagara group of this and the neighboring localities in Indiana, where it outcrops, the following divisions have been recognized by Foerste.‡

Niagara Group—	*Feet.*
Louisville limestone and Utica lime rock	40- 55
Waldron shale	5- 10
Laurel limestone or cliff rock	35- 45
Osgood beds	15- 25
Totals	95-135

*Journal of the Cincinnati Society of Natural History, pp. 188-200.

†See the papers by August F. Foerste in the following annual reports of the Indiana Department of Geology and Natural Resources. 21st Annual Report (1896) pp. 214-288; 22d Annual Report (1897), pp. 195-255; 24th Annual Report (1899), pp. 41-80.

‡Indiana Department of Geology and Natural Resources. 21st Annual Report (1896), p. 217. Indianapolis, 1897.

TOPOGRAPHY.—Composed as it is, of shales and limestones, with the limestones generally predominating, and resisting the action of the weather, the Niagara strata often form steep slopes, bluffs and waterfalls along their line of outcrop.

ECONOMIC GEOLOGY.—In the region of 3 north, these beds are of little economic importance commercially, though some small quarries have been opened and some stone has been obtained for local building purposes. Northward, however, the Niagara rocks are in some localities hard and compact, of even texture and color, and occur in thin, easily separated layers, usually from three to ten or twelve inches thick. Under these circumstances they have proven valuable and have been of considerable commercial importance as building, curbing and paving stones. The largest quarries are in Ripley, Decatur and Franklin counties, where practically all the rock quarried is taken from the Laurel beds.*

PALEONTOLOGY.—The Niagara group is very prolific of fossils and for lists of the species the reader is referred to Kindle's Catalogue of Indiana Fossils, cited above, which contains, besides a list of the fossils, a bibliography of the writers on Indiana paleontology. The first important papers containing figures and descriptions of the Niagara group species of Indiana are those of Hall.†

DEVONIAN.

The Devonian rocks of southern Indiana have an aggregate thickness, at Scottsburg, of 190 feet, as shown in the deep well at that place. They consist of more or less pure limestones and black bituminous and arenaceous shales. So far as the author has observed these are conformable one with another, and the lowest bed lies conformably upon the Niagara limestone,‡ while the topmost bed (the black shale) is overlain by the Rockford goniatite limestone, which is

*Indiana Department of Geology and Natural Resources. 22nd Annual Report (1897), p. 195 et seq. Indianapolis, 1898.

†28th Annual Report of the New York State Museum of Natural History. The Fauna of the Niagara group in Indiana, by James Hall, pp. 99-210. Plates I to XXXIV. Albany, 1879.

Indiana Department of Geology and Natural History. 11th Annual Report, pp. 217-345, Plates I to XXXVI. Indianapolis, 1882.

Also, 12th Annual Report, pp. 272-275 and accompanying plates. Indianapolis, 1883.

‡A slight unconformity exists between the Niagara and overlying Devonian limestone in southern Shelby county. See 25th Annual Report Department Geology and Natural Resources, p. 557 and Plate XVI.

also conformable with it. The accompanying section, Fig. 5, indicates the relations of these Devonian strata.

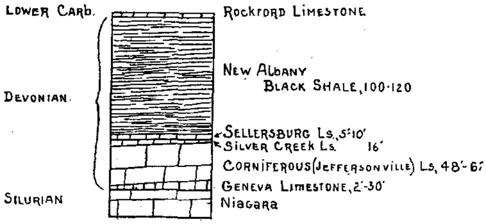


Fig. 5. Section showing the character and relations of the Devonian strata of southern Indiana.*

THE LIMESTONES.

Of the Devonian limestones there are two distinct series of beds. These two series were originally grouped together as Upper Helderberg by Hall.†

Afterwards they were recognized as having distinct characteristics, and the lower beds were recognized as the *Corniferous* limestone, while the upper division was correlated with the Hamilton of New York. These two divisions of the Devonian limestones of Indiana are recognized by Dana.‡

In 1899 Kindle§ suggested for the lower of the two divisions the name of Jeffersonville limestone, owing to its development in the neighborhood of that city; while for the upper beds he has suggested the name of "Sellersburg beds," owing to the development and exposure of these rocks at the town of that name in Clark County.

In 1900 Siebenthal subdivided the Sellersburg limestone, retaining the name Sellersburg for the white and gray crystalline limestone lying between the cement rock and the New Albany black shale, and naming the underlying cement rock the Silver Creek Hydraulic limestone.||

*The Pendleton sandstone, which, further north, lies between the Niagara and Corniferous, has not been recognized as far south as township 3 north, and it is therefore omitted from the section.

†American Journal of Science. 1843. Vol. 45, p. 158.

‡Manual of Geology. By James D. Dana. Fourth edition, pp. 580, 592. 1895.

§Bulletin of American Paleontology, No. 12. The Devonian and Lower Carboniferous Faunas of southern Indiana and central Kentucky. By E. M. Kindle, p. 8. Ithaca, New York, 1899.

||Indiana Department of Geology and Natural Resources. 25th Annual Report (1900), pp. 332-393. See pp. 339 and 345. Indianapolis, 1901.

Corniferous or Jeffersonville Limestone.

Character and Thickness.—The Corniferous limestone varies in color from gray to bluish and buff. Where very pure and crystalline it usually has a bluish gray color. In thickness it varies from 20 feet to about 60 feet. At the Falls of the Ohio its thickness, according to Kindle,* is at least 20 feet. At Scottsburg, in Township 3 north, 7 east, where the Corniferous and Hamilton limestones are penetrated in a deep well at a depth of 172 feet, the combined thickness of the two formations is reported to be 68 feet. The total thickness of the Corniferous was not observed at any one place in 3 north, but the variations from 20 to 50 feet may be taken as about correct for it.

Areal Distribution and Topography.—The Corniferous rocks outcrop along a belt of country ranging in width from two to six miles in Township 3 north. The eastern margin of these rocks is along the bluffs at the west side of the gorge of the Ohio River; the western margin is on a comparatively level tableland. Lying between the Jeffersonville and Niagara limestones in the extreme southern part of the State is a thin bed of buff or brownish colored magnesian limestone to which the name "Geneva limestone" was given by Collett in 1881.† Thin and unimportant in the region of the Ohio River, this limestone becomes thicker to the northward, reaching in Bartholomew and Shelby counties a thickness of from 20 to 30 feet, and apparently replacing the Jeffersonville and Sellersburg beds as recognized farther south.

The Corniferous (with the Geneva limestone) strata lie immediately above the Niagara limestones in the region of township 3 north and protect those beds from erosion. The escarpment along the Ohio River in the region of Madison is due to the combined influence of both the Corniferous and Niagara beds. The topography of the Corniferous area is shown on Plate II. On that map the Corniferous and Hamilton areas are shown together.

The Hamilton Limestones (Sellersburg and Silver Creek Limestones).

Character.—The Hamilton rocks of southern Indiana vary in thickness from 6 to 20 feet.‡ They are made up for the most part of

*Bulletin of Amer. Pal., Loc. cit., p. 23. Ithaca, New York, 1899.

†Indiana Department of Geology and Natural History. 11th Annual Report (1881), p. 63, Indianapolis, 1882.

‡Bulletin of American Paleontology, No. 12. The Devonian and Lower Carboniferous Faunas of Southern Indiana and Central Kentucky. By E. M. Kindle, p. 8. Ithaca, New York, 1893.

a fine grained siliceous limestone, with a buff color, and conchoidal fracture. Overlying this impure limestone is sometimes a thin bed of purer limestone, which is in turn overlain by the New Albany black shale.

AREAL DISTRIBUTION.—In township 3 north the Hamilton beds outcrop along a narrow strip just east of the eastern margin of the New Albany black shale. They are here usually concealed by glacial drift, and the actual line of contact between them and the Corniferous beds was not traced.

The head waters of Hog Creek and Woods Fork have cut down through the black shale in township 3 north, 9 east, in sections 18, 30 and 31, respectively, Plate II, exposing the underlying Hamilton and often the Corniferous limestones. The limestones thus exposed extend down stream for five or six miles, being exposed all along Woods Fork, Hog Creek and their tributaries, and along Stucker's Fork in the neighborhood of Lexington and for two miles below that town. They finally disappear below the surface in 3 north, 8 east, sections 19 and 29, along a general northwest-southeast line; the rocks along this line have a perceptible southwestward dip.

Silver Creek Hydraulic Limestone.—The Silver Creek Hydraulic limestone is a fine-grained stone which has hydraulic properties. It is usually massive, and ranges in thickness from a few inches in Township 3 north, to over 15 feet in the Silver Creek region in Clark County. It breaks with a sub-conchoidal fracture, and in color varies from buff on weathered surfaces to bluish drab on freshly exposed surfaces.

The following analyses* show the composition of this limestone:

	Ohio Valley.	Speed's.	Belknap's.	Black Diamond.	Hausdals.
Insoluble in hydrochloric acid	25.90	18.68	12.75	13.03	21.26
Lime (CaO) soluble in acids	30.41	34.55	29.40	29.08	33.99
Magnesia (MgO) soluble in acids	8.48	7.97	16.71	15.70	7.57
Ferric oxide (Fe_2O_3) soluble in acids	.47	.43	.85	1.15	.39
Alumina (Al_2O_3) soluble in acids	.27	.30	.25	.80	.32
Loss on ignition	33.46	36.65	40.47	39.29	35.16
Total	98.99	98.58	100.43	99.05	98.69

The insoluble portions consist principally of silica (SiO_2) and alumina (Al_2O_3). The ratio of the alumina to silica varies in the

*Loc. cit., p. 366.

different samples from 1 to 3.89 in the Ohio Valley stone, to 1 to 5.56 in the Belknap stone.

Just north of the center of the southeast quarter of Section 21, Township 3 north, 8 east, 14 inches of hydraulic limestone is exposed at a spring house; it is here overlain by three feet of shaly limestone, and underlain by blue compact limestone. To the south it becomes thicker, reaching a thickness of five feet one mile east of Lexington, and continuing to thicken further south, till it reaches its maximum in the region of Silver Creek. To the north it becomes thinner, and finally disappears altogether in Section 16, Township 3 north, 8 east, north of which place it has not been observed.*

For detailed information regarding the Silver Creek and Sellersburg limestones throughout the southern Indiana region the reader is referred to Mr. Siebenthal's paper on that subject, cited above.

Sellersburg Limestone.—The Sellersburg Limestone lies between the cement rock and the black shale, and where the cement rock is absent in southern Indiana includes the beds from top of the Corniferous to the overlying New Albany black shale.

It is not always present between the cement rock and black shale, but is usually to be found where its interval is exposed. In Township 3 north it varies in thickness from 2½ to 5½ feet. At the Spring house in the southeast quarter of Section 21, Township 3 north, 8 east, it is three feet thick and is overlain by the New Albany black shale.

Further south in the Silver Creek region it reaches a thickness according to Siebenthal† of from five to ten feet, rarely reaching the latter thickness.

ECONOMIC GEOLOGY.—The Silver Creek hydraulic limestones, of the Hamilton, are valuable as cement producers, and are quarried for that purpose at Sellersburg. North of that place the northernmost exposure of the rock which is suitable for the manufacture of cement and thick enough to be worked is about one mile east of Lexington, where the bed is from five to six feet thick. A good cement is said to have been made from samples of this rock, but it has not been quarried here for that purpose.

TOPOGRAPHY AND STRUCTURE.—The Hamilton beds exercise no marked control over the topography of the country over which they outcrop. They have a dip from Big Spring, Township 3 north, 9 east, Section 16, to Section 20, in 3 north, 8 east, of 231 feet, or a little over 33 feet per mile. This dip is not constant, but varies from

*Ibid., p. 359.
†Ibid., p. 341.

20 to 46 feet per mile, and is in every respect sufficient to cause the westward flow of the streams.

PALEONTOLOGY OF THE DEVONIAN LIMESTONES.—The Devonian limestones are prolific in fossils and many lists of them have been published. The completest are those of Kindle.*

Most of the lists of Hamilton limestone fossils in Indiana have the species all grouped together, regardless of whether they come from the cement rock or overlying strata. Siebenthal, however, in his report upon the cement rock cited above, gives separate lists of the fossils he found in the Sellersburg, Silver Creek and Jeffersonville limestones. Many of the Corniferous corals were listed and figured by Hall in the 12th Annual Report of the Department of Geology and Natural History of Indiana.†

NEW ALBANY BLACK SHALE.‡ (Genesee.)

CHARACTER.—Lying upon the Hamilton limestones is a bed of black bituminous and arenaceous fissile shale known as the New Albany black shale, and often referred to simply as "the black shale." After exposure to the weather it usually loses its jet black color, and weathers to a drab. After weathering it also shows its finely laminated structure which is not always apparent in unweathered fragments. At some places it contains enough bituminous matter to cause it to burn when thrown into a fire. This fact, coupled with its jet black color in southern Indiana, has led to much misguided search for coal. In the northern part of the State it does not have the jet black color that it has in the Ohio River region. In Indiana it rests conformably upon the underlying limestones; in Kentucky there is an unconformity between the black shale and the underlying limestone.§

The thickness of the New Albany black shale is 120 feet at Scottsburg, where its top lies 52 feet below the surface; at Salem, where it occurs at a depth of 627 feet, it has a thickness of 103 feet; at New Albany its thickness is 104 feet; at Lafayette it is 120 feet thick,

*Bulletins of American Paleontology, Vol. 3, No. 12. The Devonian and Lower Carboniferous faunas of southern Indiana and Kentucky. (Ithaca, 1899.) Also, Indiana Department of Geology and Natural Resources. 22nd Annual Report, pp. 407–488. (Indianapolis, 1898.)

†Pages 275-318, Plates XV-XXIV. Indianapolis, 1883. See also the 35th Annual Report of the New York State Museum of Natural History, pp. 421–464, Plates XXIII-XXX. Albany, 1884.

‡The New Albany black shale is generally referred to in this paper simply as the *black shale.*

§Bulletin of American Paleontology, No. 12. The Devonian and Lower Carboniferous Faunas of southern Indiana. By E. M. Kindle, p. 8. Ihaca, New York, 1899.

while its thickness at Bloomington, where its top is 755 feet below the surface, is 155 feet. Eleven miles northwest of Columbus at the well of J. W. Johnson, in Section 11, 10 north, 3 east, it is 110 feet below the surface and has a thickness of 195 feet. These thicknesses at widely separated points in the State show a remarkably even distribution for this formation.

STRATIGRAPHIC POSITION.—The stratigraphic position of this shale has long been a matter of discussion among geologists who have worked in Indiana. In 1837 it was classed by Owen as a member of the Sub-Carboniferous group, which included those beds lying below the Carboniferous or coal-bearing formation.* Later, in 1843, 1844, it was regarded by Owen as the equivalent of the Marcellus shale of the New York section.† This view was held also by Dr. A. Clapp‡ in 1841. Hall and Rogers also concurred in this correlation. In 1848 Edward de Verneuil correlated the black shale of Indiana, Ohio and Kentucky with the Genesee shale of New York.§ This correlation was accepted by Meek and Worthen in 1861.‖ This conclusion was reached also by Whitfield from a study of the black shale fossils in 1874.¶ In 1879 Hall came to regard it as the equivalent of the "shales succeeding the Hamilton group of New York."** This view has been generally accepted since 1874.

The only local name that has been applied to this formation is that given in 1873 by E. T. Cox, State Geologist of Indiana, where, in speaking of the black shale of Ohio and Indiana, he says, "I have thought best to speak of it in this State as the New Albany black slate."†† In the same volume§§ W. W. Borden, in his report on Clark and Floyd counties uses this name, and says, "The black slate is largely exposed at New Albany, and on that account I propose to designate it in this report as the "New Albany black slate."

Since that time the name New Albany "black slate," or black shale, has been continuously applied to this formation, and in strati-

*Report of a Geological Reconnaissance of the State of Indiana made in the year 1837 in conformity to an order of the Legislature, by D. D. Owen, M.D., State Geologist. American Journal of Science, Vol. XXXIV, 1838, pp. 193, 194.

†American Journal of Science. Vol. XLV, 1843. p. 152.

‡Proceedings of the Philadelphia Academy of Science. Vol. I, 1841. pp. 18, 19.

§American Journal of Science. Vol. V. 2d series. 1848. p. 370.

‖Remarks on the age of the Goniatite limestone at Rockford, Indiana, and its relations to the "Black Slate" of the Western States, and to some of the succeeding rocks above the latter; by F. B. Meek and A. H. Worthen. American Journal of Science. Vol. XXXII. 2d series. pp. 167-177.

¶Sixth Annual Report of the Geological Survey of Indiana, made during the year 1874. p. 181. Indianapolis, 1875.

**Natural History of New York. Paleontology. Vol. V, Plate II, p. 152. Albany, 1879.

††Fifth Annual Report of the Geological Survey of Indiana, made during the year 1873. p. 102. Indianapolis, 1874.

§§Ibid., p. 158.

graphic position, it is regarded as the equivalent of the Genesee shale of the New York section.

The Devonian stratigraphy is discussed, many detailed sections are given and the fossils are described and figured by Kindle in an excellent paper in 1900,* to which the reader is referred for more detailed information regarding the various localities where the Devonian rocks outcrop in Indiana.

Areal Distribution.—The black shale comes to the surface in southern Indiana in the low north-south trough immediately east of the high eastward facing escarpment formed by the Knobstone group and the limestones overlying it. South of an east-west line drawn through Edinburg its western margin is near the bottom of this trough, while its eastern margin is from 10 to 25 miles further east, at a higher altitude and usually in a country that is somewhat rolling.

North of the east-west line above referred to the black shale area widens out, but is generally deeply buried under glacial debris. From Edinburg to New Albany the Jeffersonville, Madison and Indianapolis Railroad runs parallel to the upper contact of this shale and not far from it.

In township 3 north the black shale outcrops over a strip of country about fourteen miles wide. The easternmost point at which it occurs is in 3 north, 9 east near the center of the east half of Section 27. The contact between the black shale and the underlying limestone is not often seen in the south half of 3 north, 9 east because this township is for the most part covered by several feet of glacial clay. The line of contact can be seen, however, just south of Big Spring near the center of the north half of Section 16. From this place it can be traced to the point where it crosses the north line of the township, a half mile west of Kent Postoffice, near the northwest corner of Section 6. This lower contact crosses Township 3 north in a general northwest-southeast direction, almost at right angles to the dip of the strata.

Passing westward from its eastern edge the shale is carried successively lower by its westward dip. Notwithstanding the westward dip of the strata the creeks in 3 north, 8 east, viz.: Stucker's Fork, near Lexington, and Woods Fork and Hog Creek, farther north, have cut down through the shale, exposing the underlying limestones. The bottoms of the valleys of these creeks are therefore limestone, while the adjacent hillsides and hilltops are of black shale, of which a thickness of from 50 to 60 feet is often exposed.

*Indiana Department of Geology and Natural Resources. 25th Annual Report (1900), pp. 529-758. Plates I-XXXI. Indianapolis, 1901.

The westernmost exposures of these isolated limestone areas, which are surrounded by the black shale, are in Sections 29 and 18 along a line almost parallel with the eastern edge of the black shale.

The western edge of the black shale, i. e., its upper contact with the rocks of the overlying Knobstone group, crosses the south line of 7 east a little east of the center of the south line of Section 34. The line of contact from here northwestward is marked by the overlying goniatite limestone, and can be seen occasionally in gullies and on the hillsides, until a point is reached about one mile east of Scottsburg near the west line of Section 20 where the limestone and shale outcrop. Northwest of Scottsburg the contact passes through a low flat country and is usually overlain by from 40 to 50 feet of clay. By means of well sections the line of contact was approximately determined; it passes just east from Scottsburg, and thence in a northwesterly direction, to the west line of Section 7, crossing the north line of Township 6 east immediately west of the northwest corner of Section 1.

TOPOGRAPHY.—Most of the country underlain by the black shale is quite rolling. The topography through Townships 3 north, 6, 7, 8, and 9 east may be taken as generally typical of this formation, with the exception that to the northward the eastern margin of the formation occurs in a country usually more broken than that shown on the map, because the streams that cut across it are larger in that region, and have cut out deeper valleys.

The western margin of the black shale where not covered by glacial debris, is in a region of low hills.

In 3 north, 9 east the extreme eastern edge of the black shale is quite thin. On Plate II it will be observed that a number of westward flowing streams have their sources from a mile to two miles west of this eastern contact. This is a region in which dissection has scarcely begun.

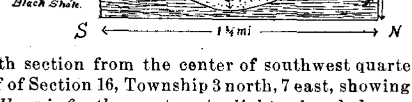


Fig. 6. North-south section from the center of southwest quarter of Section 21, to the center of the west half of Section 16, Township 3 north, 7 east, showing silted up valley. The soil of the silted up valleys is for the most part a light colored clay.

Further west in Township 8 east and the eastern part of Township 7 east, the streams have cut valleys from 60 to 100 feet deep. In 7 east, Stucker's Fork and its tributaries flow through flat silted up valleys. These valleys have been filled at least 45 feet in some cases.

At Scottsburg the valley has been filled to a depth of 48½ feet, which probably represents about the amount the valleys of this general region have been filled.

Owing to this silting up of the valleys, the hills at the west side of the black shale area, formerly full as high, or higher than those at the center of that area, are now much lower and have gentler slopes than do those further east.

ECONOMIC GEOLOGY.—The black shale is of small economic importance. It is used locally as a road metal, when nothing better can be had. It has been tried as a roofing material, being ground, mixed with tar and spread upon felt. It was found to crack upon long exposure and was thus worthless for this purpose and its use was discontinued.*

The character of the black shale and the results of experiments in distilling oil and gas from it are discussed by Mr. Hans Duden in the 21st Annual Report of the Department of Geology and Natural Resources.†

LOWER CARBONIFEROUS.

The Lower Carboniferous rocks of Indiana consist of shales, sandstones, limestones and some cherts, and aggregate 1,050 feet where crossed by Township 3 north.

At the base of this series of strata lies the Rockford goniatite limestone, resting conformably upon the Genesee shale. The Lower Carboniferous strata are overlain unconformably by the massive Mansfield sandstone, which lies at the base of the Productive Coal Measures.

The different strata making up the Lower Carboniferous group lie conformably one with another. The following section (Fig. 7) shows the relations between these strata.

THE ROCKFORD GONIATITE LIMESTONE.

CHARACTER AND DISTRIBUTION.—The Rockford goniatite limestone, which is the lowest of the Lower Carboniferous strata recognized in Indiana, is a thin but remarkably persistent bed. It is a close grained rock with a conchoidal fracture. Upon a freshly broken

*Fifth Annual Report of the Geological Survey of Indiana, made during the year 1873, p. 159. Indianapolis, 1874.

†Indiana Department of Geology and Natural Resources. 21st Annual Report (1896), pp. 108-119. Some notes on the black slate or Genesee shale, of New Albany, Indiana. By Hans Duden. Indianapolis, 1897.

surface it usually shows a mottled greenish color; upon weathering it turns brown.

Below it is the black shale, and immediately above is the light greenish argillaceous shale, forming the base of the Knobstone shales. While this limestone is usually less than two feet thick, it is rarely entirely wanting in southern Indiana where its horizon is exposed. At New Albany it outcrops along the creek at the north and west edges of the town, and has a thickness of two feet. In Lot 62 of the

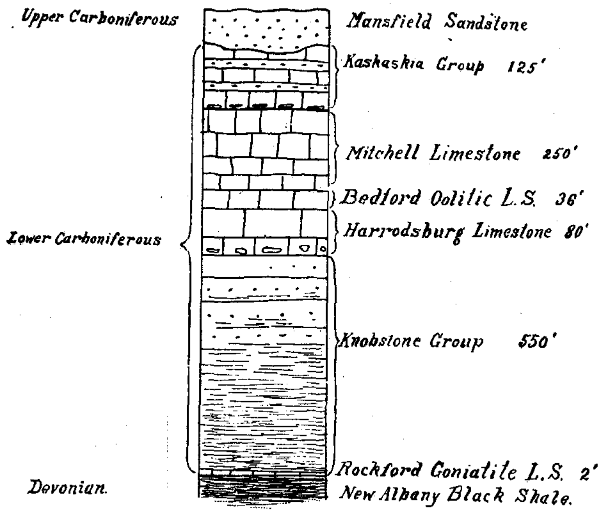


Fig. 7. Section showing the relations of the Lower Carboniferous strata, along the middle line of Township 3 north.

Illinois Grant, Clark County, about a quarter of a mile west of the center of the east line, the goniatite limestone is 18 inches thick, and in a space of 100 feet it thins down to a feather edge. At this place the contact between the upper and lower beds is well exposed and the

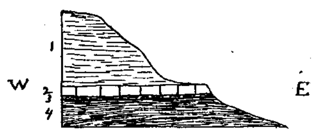


Fig. 8. Profile showing the occurrence of the Rockford goniatite limestone a quarter of a mile west of the center of the east line of Lot 62 of the Illinois Grant. (1) 20 feet of greenish argillaceous shale, typical of the base of the Knobstone group. (2) 18 inches goniatite limestone. (3) 6 inches of soft shale, resembling that overlying the limestone. (4) New Albany black shale.

occurrence is shown in the accompanying profile section (Fig. 8). The occurrence shown in Fig. 8 is typical of this limestone, so far as the writer's observations have gone, except that the underlying thin greenish shale is not always present. Near the west side of Township 3 north, 7 east, Section 21, near Mr. Munden's house, one mile east of Scottsburg, the limestone has a thickness of 18 inches.

The northernmost exposure of the Rockford limestone, known to the writer, is in the bed of White River at the village of Rockford. It is reported to have been exposed in a cut on the Jeffersonville, Madison and Indianapolis Railroad about one and one-half miles north of Rockford on the west side of White River.

North of this locality the Rockford limestone horizon is covered over by glacial drift. It occurs about 11 miles northwest of Columbus, where it is struck in the well of Mr. J. W. Johnson, 10 north, 4 east, in the southwest quarter Section 11. At this place it lies 106 feet below the surface and is reported to be four feet thick. The following section (beginning at the surface) is reported from this well; it shows that the stratigraphic relations of the beds in 10 north, 4 east are precisely the same as at exposed localities further south:

	Feet.
Yellow clay (glacial)	56
Clay shale (Knobstone)	50
Limestone (goniatite)	4
Black shale (Genesee)	195
Limestone (Hamilton and Corniferous)	50

Four miles southeast of this place, in 10 north, 5 east, the southwest quarter Section 20, Mr. W. S. Bevis has a well in which the goniatite limestone is 79 feet below the surface, and has a thickness of two feet. Its relations to the overlying and underlying beds at this place are identical with those given in the above section.

STRATIGRAPHIC POSITION. — The stratigraphic position of the goniatite limestone has long been a question of controversy among American geologists. Occurring as it does at the top of the Devonian it has been regarded as belonging to the Devonian by some writers, notably by Hall, while others place it with the Lower Carboniferous. The latter view is the one generally accepted at the present time.

In 1861 the Rockford limestone was correlated by Hall with the Marcellus beds of the New York section.*

In 1862 Hall regarded this limestone as "parallel with the Chemung group,"† which view he did not change. In 1861 Meek and

*Thirteenth Annual Report of the Regents of the University of the State of New York. p. 95. Albany, 1860.

†Fifteenth Annual Report of the Regents of the University of the State of New York. p. 81. Albany, 1861.

Worthen correlated the Rockford limestone with the Chouteau of Missouri.* In 1898, Kindle summed up the discussions relative to the age of this limestone and arrived at the conclusion that it is the equivalent of the Lithographic or Louisiana limestone of Missouri.† Kindle bases this correlation on stratigraphic evidence, and points out that the stratigraphic position of the Rockford limestone relative to the black shale, as well as its lithologic character, agrees almost exactly with that of the Lithographic limestone of Missouri, while the paleontologic evidence on which Meek and Worthen made their correlation with the Chouteau is not sufficient to justify that correlation.

In the writer's opinion Kindle's views are correct. There is certainly no member of the Lower Carboniferous group in Indiana that is lower than the Rockford limestone, while there is a very close correspondence between the Missouri section from the Hamilton up to the Burlington limestone, and the southern Indiana section from the Hamilton up to the Harrodsburg limestones of Hopkins and Siebenthal's section of the Lower Carboniferous limestones. Kindle, however, omits the Rockford limestone from his generalized section,‡ in which section that limestone falls between the "black shale" and the "argillaceous blue and green shales," thus holding a position identical with the Lithographic limestone of the Missouri section. This stratigraphic correlation is much strengthened by the fact that *Prodromites gorbyi* occurs both in the Rockford limestone, at Rockford, and in the Louisiana (Lithographic) limestone at Sedalia, Missouri. This species is found also in the Kinderhook at Burlington, Iowa.§

PALEONTOLOGY.—The following species have been identified from the Rockford limestone in Indiana:

PROTOZOA.

Palæacis enormis Meek and Worthen.

CŒLENTERATA.

Amplexus ? rockfordensis Miller and Gurley.

Zaphrentis ida Winchell.

ECHINODERMATA.

Synbathocrinus oweni Hall.

*American Journal of Science. 2d series. Vol. XXXII, p. 167.

†Bulletins of American Paleontology, No. 12. The Devonian and Lower Carboniferous Faunas of Southern Indiana and Kentucky. By Edward M. Kindle. pp. 91, 92, 93. Ithaca, New York, 1889.

‡Bulletins of American Paleontology, No. 12. The Devonian and Lower Carboniferous Faunas of Southern Indiana and Kentucky. By Edward M. Kindle. p. 92. Ithaca, New York, 1899.

§*Prodromites*, A New Ammonite Genus from the Lower Carboniferous, by J. P. Smith and Stuart Weller, Journal of Geology, Vol. IX, No. 3 (1901), p. 255.

BRACHIOPODA.

Ambocœlia gregaria Hall.
Chonetes geniculatus White?
Cryptonella ? inconstans Herrick.
Reticularia cooperensis Swallow.
Rhipidomella ocassus Hall.
Rhynchonella obsolescens Hall.
Spirifer maroonensis Shumard.
Spirifer rostellatus Hall?
Spiriferina solidirostris White.

LAMELLIBRANCHIA.

Aviculopecten tenuicostis Winchell
Anatina leda Hall.
Cardiopsis radiata Meek and Worthen.
Cypricardia ventricosa Hall.
Nucula hians Hall.

GASTEROPODA.

Bellerophon cyrtolites Hall.
Bellerophon lineolatus Hall.
Euomphalus lens Hall.
Murchisonia limitaris Hall.
Platyceras haliotoides Meek and Worthen.
Pleurotomaria mitigata Hall.
Pleurotomaria vadosa Hall.
Straparollus lens Hall.
Straparollus spirorbis Hall.

PTEROPODA.

Hyolithes aculeatus Hall.

CEPHALOPODA.

Brancoceras ixion Hall.
Cyrtoceras rockfordense Winchell.
Goniatites lyoni Meek and Worthen.
Gyroceras gracile Hall.
Gyroceras ? rockfordense Meek and Worthen.
Munsteroceras oweni Hall.
Munsteroceras parallelum Hall.
Nautilus rockfordensis Meek and Worthen.
Nautilus trisulcatus Meek and Worthen.
Orthoceras heterocinctum Winchell.
Orthoceras icarus Beecher.
Orthoceras indianense Hall.
Orthoceras marcellense Vanuxem.
Orthoceras whitei Winchell.
Prodromites gorbyi Miller.

Prodromites præmaturus Smith and Weller.
Soleniscus rockfordensis Miller.
Solenochilus rockfordensis Miller.
Trematodiscus trisulcatus Meek and Worthen.

ARTHROPODA.

Phillipsia rockfordensis Winchell.
Prœtus doris Hall.

PISCES.

Orodus multicarinatus Norwood and Worthen.

ECONOMIC GEOLOGY AND TOPOGRAPHY.—Owing to its thinness the Rockford goniatite limestone has no economic value, and neither does it exercise any control upon the topography of the region in which it outcrops. It outcrops for the most part in a gently rolling region, the relief of which is determined entirely by the overlying and underlying beds.

THE KNOBSTONE GROUP OF INDIANA.

INTRODUCTORY.

Overlying the goniatite limestone, and where that formation is absent, lying upon the black shale, is a series of clay shales, and friable, arenaceous shales and sandstones, containing in some places thin limstone beds.

This series of strata ranges in thickness from 440 to 650 feet.* In 1859 Owen gave it the name *Knobstone Group*, because "these siliceous strata weather into peculiar conical knobs or hills."† This grouping was based on lithological evidence, and the name was suggested by a topographic characteristic. This name has become so well established in the literature of Indiana geology, however, and the series of rocks to which it applies is so well known that, though other names have been suggested, their adoption would result only in multiplying names, and in confusing rather than simplifying the subject. The name "Knobstone" is therefore retained as applying to the same strata to which this name was applied by Owen. Owing to the importance of the Knobstone group in Indiana, and also to the fact that the strata composing it have never been treated as a whole this group of rocks will be taken up somewhat in detail and the area covered by it in the State will be discussed.

*It is 650 feet thick at Bloomington, as shown by the deep well drilled at that place.

†Report of a geological reconnaissance of the State of Indiana, made in the year 1837, p. 21, by D. D. Owen. Indianapolis, 1859.

CHARACTER AND THICKNESS OF THE ROCKS.

The Knobstone group in southern Indiana is made up of three terranes of somewhat distinct lithologic characteristics.

THE NEW PROVIDENCE SHALE. — Overlying the goniatite limestones is a series of soft clay shales, usually of a greenish or bluish color, with a thickness of from 50 to 120 feet. This shale has been designated by Borden* as the New Providence shale. It attains its greatest thickness in the neighborhood of New Albany, and thins out to 50 feet or less at the south side of Scott County. In Township 3 north, and northward from that township, this basal knob shale, or New Providence shale, can not be easily distinguished from the overlying shales, and, if it occurs at all, is of small importance.

THE UPPER KNOBSTONE SHALE.—Overlying the basal knob shale is a series of soft light-gray or greenish shales. This second series of shales varies in composition from soft clay shale toward the bottom to an impure fine grained sandstone at the top. This series of beds which may be called the upper knob shales grades upward into the more or less massive knob sandstone. Owing to this gradation, the line of demarkation between the shales and the overlying sandstones is not easily distinguished, and the line of contact is therefore a more or less arbitrary one. The upper knob shale has a thickness of 200 feet in 2 south, 6 east, Section 10. Its thickness in Township 3 north, is about 250 feet. To the northward in Jackson, Brown and Bartholomew counties the upper knob shale contains a larger proportion of sand than at the extreme southern portion of the State.

THE KNOBSTONE SANDSTONE.—The Knobstone group is capped by the Knobstone sandstone which is not a single sandstone bed, but is rather a series of more or less pure, and usually soft, sandstones intercalated with which are sandy shales. In the southern portion of the State these uppermost beds of sandstone and intercalated shales have a thickness of from 75 to 100 feet, which represents approximately their thickness in Township 3 north. Further north, in Jackson, Brown, Bartholomew and Monroe counties, the sandstones become of more importance and are from 350 to 450 feet thick. Owing to the slight dip, and the wide area covered by the sandstone beds in this latter region, it is not possible to accurately measure their total thickness.

To the northward from Brown County the whole Knobstone group is more or less covered by glacial material, and where exposed at all only the uppermost beds are to be seen.

---

*Fifth Annual Report of the Geological Survey of Indiana, made during the year 1873, p. 161. Indianapolis, 1874.

One of the northernmost exposures of this group of rocks is at Riverside, in Warren County, where it has been quarried for building purposes. Owing to its occurrence at this village, it has been called "Riverside Sandstone" by Hopkins.*

TRANSITION BEDS.—At the top of the Knobstone strata and below the overlying limestones, are transition beds varying in thickness from 5 to 30 feet. These beds are sandy, impure limestones, usually containing intercalated chert bands and geodes. These transition beds are grouped with the overlying limestones. They occur, therefore, immediately west of the western limits of the Knobstone strata as outlined on the accompanying maps (Plates III, IV).

The three divisions of the Knobstone group, as outlined above, can be best recognized in the extreme southern part of the State, where the shales predominate, and where the entire group has its least development.

Further north, however, in Jackson, Brown and Bartholomew counties, the entire group is made up of alternating impure sandstones and clay shales in which the sandstones predominate.

Where the Knobstone strata outcrop along Sugar Creek, near Crawfordsville, the bluish massive sandy shales predominate.

The type sections (Fig. 9) show the general character and relations of the beds composing the Knobstone group in different parts of the area covered by that formation.

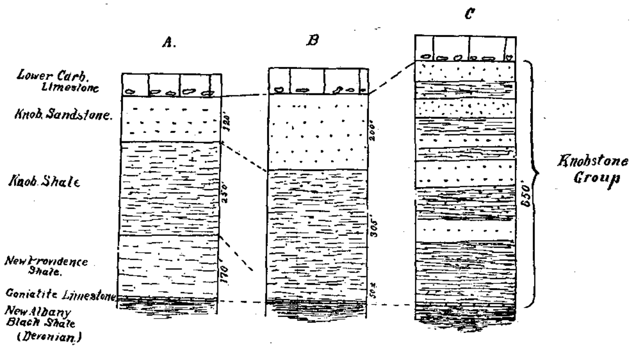


Fig. 9. Three type sections of the Knobstone group.

A. Section in Floyd County, just west of St. Joseph postoffice.
B. Section on the middle line of Township 3 north.
C. Section on the north line of Township 8 north, adapted from Bennett's cross section.

THICKNESS OF THE KNOBSTONE GROUP.—Section A., Fig. 9, shows the entire group to have a thickness, as determined by aneroid barom-

*Indiana Department of Geology and Natural Resources. 20th Annual Report, p. 317. Indianapolis, 1896.

eter, of 550 feet. At St. Joseph postoffice, where this section is taken, the Knobstone outcrops over a strip of country three and one-half miles wide.

At Section B., along the middle line of Township 3 north, the thickness is 550 feet, as determined by the vertical arc, allowing 26 feet per mile as the average dip. Along this line the strip covered by these strata, from the upper contact to the lower, is 12 miles wide.

At Section C., along the north line of Township 8 north, the thickness (as shown in the deep well at Bloomington) is 650 feet. The strip of country covered by these strata is here 28 miles wide.

At Rockville, Parke County, the Knobstone was shown by a deep well drilled there to have a thickness of 530 feet. Just west of New Albany its thickness is 471 feet. From the foregoing it is seen that the thickness of this series of strata varies from 471 feet near New Albany, to 650 feet at Bloomington, while at Rockville, in Parke County, it has a thickness of 530 feet. These variations in thickness are remarkably slight when the distances between the points at which the measurements are made are taken into consideration.

AREAL DISTRIBUTION.

The Knobstone strata outcrop over a strip of country extending in a general northwest-southeast direction, from south of New Albany, in Floyd County, to the neighborhood of Crawfordsville, in Montgomery County. They crop out also along the Wabash River in Warren County, and probably underly the western part of Tippecanoe County, but in this region they are deeply covered by glacial drift and little is known of their distribution. The areal distribution from the north side of Township 19 north, Montgomery County, southward to where the group is cut across by the Ohio River is shown on the accompanying maps (Plates III and IV). From these maps it will be seen that the area covered by these strata narrows down to a strip less than four miles wide in some places at the south, while to the northward it rapidly widens out until in Jackson, Monroe, Brown and Bartholomew counties, the strip covered ranges from 25 miles to over 38 miles in width.

This narrowing down of the Knobstone area to the south, and widening out to the north has been generally ascribed to a corresponding thinning and thickening of the strata themselves.

This, however, can not be the cause, for, with other conditions remaining the same, the difference of 100 feet in thickness would not account for a difference of about 25 miles in the width of the strip covered, as displayed in the profile section at St. Joseph, in Floyd

County, and along the north line of Township 8 north, from Columbus to Bloomington.

This increased width is considered to be due to two causes as follows:

1. In Jackson, Brown, western Bartholomew and eastern Monroe counties, almost the entire group is made up of alternating sandstones and shales, with the sandstones predominating. These alternating sandstones and shales have not succumbed to erosion as readily as have the strata further south, where the shales predominate, and where the sandstones occur only at the top of the group, thus allowing soft shales below to be worn away as rapidly as exposed by the removal of the overcapping sandstones.
2. Near the western margin of the Knobstone area, parallel to it, and extending at least from Unionville, in 9 north, 1 east, Section 10, in Monroe County, to 3 north, 2 east, Section 1, in Washington County, a distance of 36 miles, is a fault with the upthrust on the east side. The displacement of the rocks along this fault has not been measured throughout its extent but it is more than 100 feet in several places, and it is probable that, in so long a fracture the displacement may reach 200 to 300 feet or more.

   Whether this displacement be large or small, its effect is to reduce the westward dip of the beds lying east of it. This lessening of the dip of the Knobstone strata, combined with the alternating sandstone and shale beds which occur in the area of greatest width would be sufficient to account for this increased width.

The following sections, partially after Bennett* (Fig. 10) taken

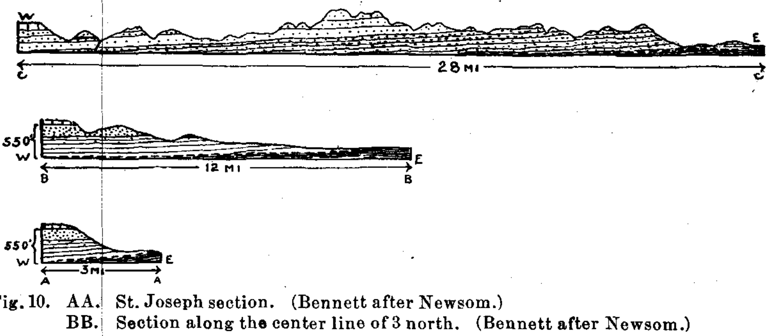


Fig. 10. AA. St. Joseph section. (Bennett after Newsom.)
BB. Section along the center line of 3 north. (Bennett after Newsom.)
CC†. Generalized section along the north line of 8 north. (Adapted from Bennett.)
The overlying limestone and underlying black shales are shown in each case.

*Proceedings Indiana Academy of Science, 1897, pp. 258–262.
†The fault shown in section C is not shown on Bennett's section.

near St. Joseph, along the middle line of Township 3 north, and along the north line of Township 8 north, illustrate the variations in distribution of these strata.

The accompanying map sheets show the location of the fracture here referred to, and also the location of the cross-sections shown in Fig. 11. On the maps these cross-sections are designated A-A, B-B and C-C, respectively.

It might be remarked that the fracture here mentioned is at the west side of the Cincinnati Arch, and that the line of fracture is at right angles to the prevailing dips of the rocks of this region.

It occurs, therefore, in the exact position that would relieve the tension produced in the strata in this locality by the gradual uplifting of the rocks to the east and it probably originated in this manner. This fault is further discussed under the subject of "Structure," p. 274.

Details of the areal distribution will be seen on the accompanying map sheets and need not be referred to in this connection.

In tracing out the upper contact of the Knobstone group, the transition beds, especially the chert layers, and residual chert masses, even when not occurring in the original unweathered beds, were classed with the overlying limestones. Thus, the line showing the eastern margin of the overlying limestone on the map will often be *east* of the real line of undecomposed limestones as they occur in the field.

Attention should be called to the fact, also, that north of Monroe, Brown and Bartholomew counties (Plate IV), the Knobstone strata are more or less covered by glacial debris, the thickness of this covering increasing generally to the northward.

From the northwest corner of Bartholomew County, southward to the Silver Hills at the south side of Scott County, the glacial debris laps up against the foothills of the "knobs" or Knobstone escarpment to the west, showing that the ice sheet encroached upon this area, and that it was crowded close up against the eastern slope of the Knobstone hills.

TOPOGRAPHY.

In the region north of Township 3 north, sandstones are the predominating strata as shown in Section C., Fig. 9. In the region south of Township 3 north, the shales predominate. In both of these districts, however, the shales are more abundant at the bottom of the group than they are at the top, and throughout the area, where unaffected by the glacial drift, the conditions (i. e., resisting strata overlying softer and more easily eroded beds) are therefore favorable for the formation of steep hillsides and narrow ravines.

The hills resulting from the erosion of the Knobstone strata present the most important topographic feature of southern Indiana. They usually stand from 250 to 500 feet above the lowlands lying east of them, and above the drainage level of the surrounding country.

Topographically the Knobstone area may well be divided into three parts:

First, the *southern district*, embracing the country lying between Township 3 north, and the Ohio River; second, the *central district*, extending from Township 3 north, to the northern edges of Monroe, Brown and western Bartholomew counties; third, the *northern district*, embracing that portion of the area lying north of Monroe, Brown and western Bartholomew counties, in which the topography is greatly modified, and for the most part controlled, by thick deposits of glacial debris.

THE SOUTHERN DISTRICT.—As is indicated on the map (Plate III), the outcropping Knobstone strata between the Ohio River and Township 3 north, present a bold, continuous eastward facing escarpment, with occasional more or less detached outlying points or "knobs" a short distance east of the main escarpment. From 5 south, to 3 north, this escarpment is cut through at only one place, viz.: In 1 south, and one north, 5 east, where it makes a sharp detour to the west and where the head waters of Muddy Fork of Silver Creek, and small tributary of Blue River have cut down through it, forming the narrow pass through which the Monon Railroad runs. South of Muddy Fork there are practically no foothills east of the main escarpment. North of this creek the foothills extend from one to four miles east of the main escarpment and finally merge into the lowlands of the black shale area to the eastward.

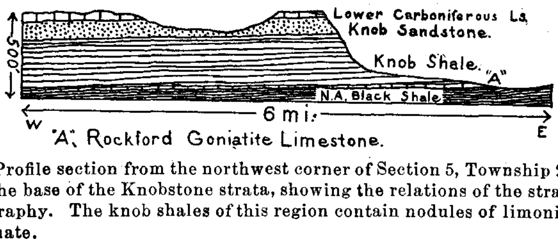


Fig. 11. Profile section from the northwest corner of Section 5, Township 2 south, 6 east eastward to the base of the Knobstone strata, showing the relations of the strata and the resulting topography. The knob shales of this region contain nodules of limonite and lenses of iron carbonate.

The profile (Fig. 11) in 2 south, 5 east, extending from the northwest corner of Section 5 eastward across the entire Knobstone area at that locality, shows the topographic and structural relations of this general region.

The Knobstone escarpment is trenched by numerous small eastward flowing streams, forming deep, narrow V-shaped valleys, varying in length from one-half mile to four or five miles. Seen from the low country to the east the high points between these valleys present the appearance of knobs, similar to the few outlying hills.

The divide between the short eastward flowing streams, and those flowing westward is usually at the very crest of the escarpment. The country westward from this crest is a comparatively level or gently rolling plateau, over which the streams flow with a grade which, except in their upper courses, is somewhat less than the dip of the strata. These features are well seen in the eastward and westward flowing streams south of Muddy Fork of Silver Creek.

Where the Lower Carboniferous limestones, which are really the protecting cap rocks of the Knobstone group, have been cut through, as by the headwaters of Indian Creek in 1 and 2 south, 5 and 6 east, the country is quite rolling, because, when once the limestones are worn through the underlying sandstones are readily attacked by the streams, with the result that considerable valleys are soon cut out. Streams of corresponding size flowing over the limestones only, have much shallower valleys.

The differences in the gradients of the eastward and the westward flowing streams of this extreme southern portion of the Knobstone area, where the overlying limestones more nearly approach the eastern face of the escarpment than anywhere else in the entire area, are shown in the accompanying profile (Fig. 12). This profile is taken along the course of a small tributary of Indian Creek, from Georgetown up to Edwardsville, at the south side of 2 south, 5 east. Thence

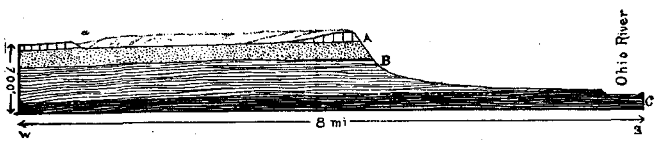


Fig. 12. Section from Georgetown to New Albany showing the plateau character of the country west of the Knobstone escarpment; and the differences in gradients of streams flowing eastward across the dip, and westward with the dip of the strata. The limestone which is barely cut through by the stream dips westward at the rate of 33 feet per mile. At *a* the stream, whose gradient is shown from *b* to *a*, turns aside; the section is prolonged slightly to show the general plateau character of the region. A=Lower Carboniferous limestone, B=Knobstone group, C=New Albany shale.

it extends eastward over the divide and down the eastward flowing stream that reaches the alluvial bottoms of the Ohio just west of

New Albany. It shows very well the differences in the topography produced by these eastward and westward flowing streams.

The above remarks apply more particularly to the region south of Muddy Fork of Silver Creek. They apply also to the region between Muddy Fork and Township 3 north, with the exception that in this latter region the overlying limestones have been entirely worn away several miles west of the escarpment face; because of this denudation the valleys west of the escarpment are somewhat deeper than are those further south which are similarly situated.

In Township 3 north, the Knobstone area is drained by streams leading northward into White River. The Knobstone plateau has been very perfectly dissected by these streams, which with their small tributaries from intricate dendritic systems of valleys, as is shown on the topographic sheet (PlateII) in 3 north, 2, 3, 4 and 5 east.

It will be noticed that these streams, after having cut through the overlying limestones, have in all cases quickly cut down to their present base levels of erosion, and that the main streams, especially Rush and Delaney creeks, flow through flat bottomed valleys. As their topography indicates, these are silted up valleys in which the alluvial filling is from 20 to 40 feet thick.

This silting up has been brought about by a depression of the land from a former higher elevation, when the valleys were eroded more deeply than at present. With the depression of the surface the streams gradually became checked and the valleys filled. All of the main tributaries of East White River in southern Indiana flow through valleys that have been filled in this manner from 20 to 60 or 75 feet. The accompanying section (Fig. 13) shows this feature.

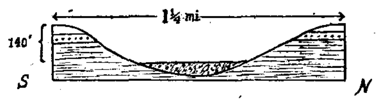


Fig. 13. North-south section across Rush Creek Valley in 3 north, 3 east, Sections 5 and 8.

The Central District (north of Township 3 north).—In the area north of 3 north, or more properly speaking, north of the Muscatatuck and East White rivers, the topography developed in the Knobstone area is quite different from that south of those streams.

As pointed out, south of Township 3 north, the region immediately west of the Knobstone escarpment, which is continuous and abrupt, is a gently westward sloping plateau which is but slightly dissected by the westward flowing streams. In 3 north, this plateau is completely dissected owing to the nearness of White River (the master stream of this section) combined with the fact that the streams flow partially across the dip of the beds.

North of East White River dissection has advanced much further than in the southern region. In Jackson, Brown and western Bartholomew counties the Knobstone plateau is perfectly dissected by the tributaries of East White River, Salt Creek and Bean Blossom Creek. In these counties the area of the Knobstone is made up of high ridges and steep sided V-shaped valleys. These valleys are unproductive, except where bottom lands have been formed in them by the silting up process. In this region the descent from the highest Knobstone hills to the lowlands to the east is gradual, and across rolling foothills which merge into low glacial hills, and finally into the low bottom lands of East White River.

The complete dissection of the Knobstone plateau north of East White River has been made possible by the early removal of the overlying limestones. Whether the early removal of these protecting limestones was due to their having been originally quite thin or to their having been more elevated and exposed in this locality than further south is not known; either of these causes, or the two combined would account for the present topographic conditions.

The preponderance of sandstone strata, in conjunction with the fault mentioned on p. 265, and the probable decreased westward dip caused thereby have kept the westward retreat of the eastward facing escarpment from keeping pace with the retreat of the overlying limestones.

The Northern District.—North of the northern edges of Monroe, Brown and western Bartholomew counties the Knobstone area is usually covered by glacial debris, and the strata are exposed only in the stream valleys. Where the strata are cut through by the larger streams, bluffs are often formed. Such bluffs are to be seen along West White River about Martinsville, and along Sugar Creek above and below Crawfordsville; at both of these localities are excellent exposures of the Knobstone strata. This northern portion of the area presents a glacial topography almost entirely and will not be discussed in this paper.

TOPOGRAPHIC FEATURES COMMON TO BOTH CENTRAL AND SOUTHERN DISTRICTS.

The effect of the gentle westward dip of the Knobstone and overlying limestone strata is not noticeable as affecting the topography, further than has been suggested in relation to the escarpment south of Township 3 north.

This westward dip has been sufficient to control the initial drainage of the country, however, and it is thus indirectly responsible for the topography of both the southern and central areas. It is also responsible for the arrangement of the main drainage lines that cross it, with the exception of the lower course of the Muscatatuck and the middle course of East White River.

The generally narrow V-shaped valleys cutting the country in all directions, apparently without systematic arrangement, form the most noticeable and important topographic characteristic of the Knobstone area. In the central area particularly, the valleys are well developed. Here they have the tangled dendritic arrangement common to flat plateau countries, where folds and faults are absent.

Differential Weathering of the Knobstone Strata.—It is a noticeable fact that throughout the whole Knobstone area where unaffected by glacial material, and where the valley systems are well developed, the south hillsides have gentler slopes than those facing northward, i. e., that erosion is further advanced on the south-sloping hills than on those sloping northward.

This feature is most noticeable along the east-west valleys. In north-south valleys the gentler slope, when one is gentler than the other, is usually on the east side of the valley, i. e., on the westward sloping hillside. The difference in the angle of slope between east and west hillsides is not so noticeable as that between north and south slopes.

Fig. 14 is a profile taken across a typical east-west valley showing this feature of differential weathering.

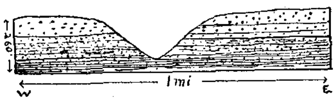


Fig. 14. North-south section across a typical east-west Knobstone valley, showing the difference between north and south slopes.

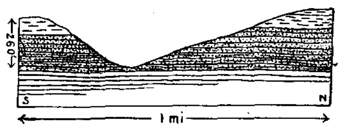


Fig. 15. East-west section across a typical north-south valley in the Knobstone area from west half-mile corner to center of east half of Section 23, Township 3 north, 3 east.

Fig. 15 is a profile across a typical north-south valley.

Fig. 16 shows the topography of a main east-west valley, with small tributaries. It will be noticed that the north side of the valley has a very gentle slope, while the south side is quite steep. There is no marked difference in the angle of slope of the sides of the small valleys entering the main valley from the south.

This differential weathering of the slopes is attributed to the effect of temperature changes, especially of freezing and thawing, upon the rocks. Changes in temperature probably have a more potent effect in breaking up these rocks than has any other agent.

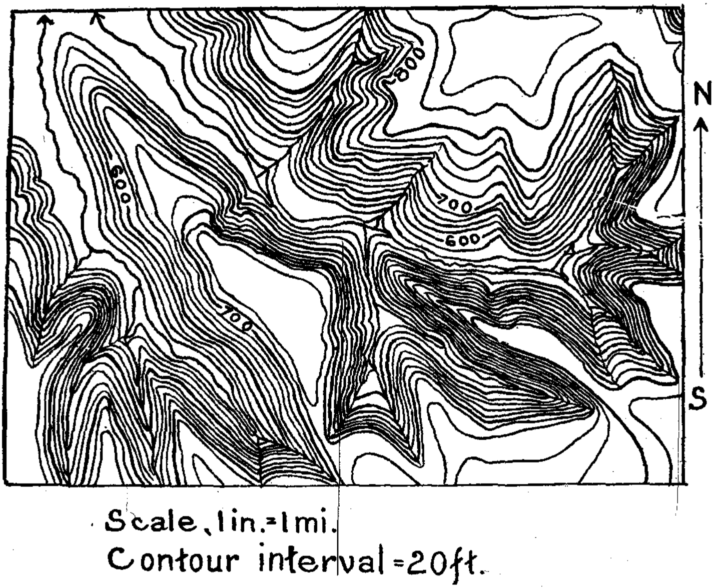


Fig. 16. Topography of the upper portion of Delaney's Creek valley, 3 north, 4 and 5 east showing the variation in north and south slopes.

The Knobstone strata, being soft, absorb water easily, although they do not permit the free passage of water through them. Owing to their property of absorbing much moisture, they are easily disintegrated by frost action.*

The south hillsides are exposed to many more changes of temperature in the course of a year, and especially in the winter time, than are the hillsides facing northward. During the winter months in this region the nights are cold, often for weeks at a time, freezing a crust over the ground, which next day is thawed out on the south-sloping hillsides. The north slopes, however, being sheltered from the sun's rays, are frozen, or covered with snow, and remain so almost the whole winter long. Thus while the rocks of the south slopes will be successively frozen and thawed out many times during the winter, the

*It is owing to this fact that the sandstones of the Knobstone group have been failures as building stones wherever they have been tried.

corresponding north slopes may be frozen and thawed only two or three times.

One has only to cross this country on a warm winter's day after a cold freezing night, and to see the muddy streams flowing down from the south hill slopes while the north slopes remain solidly frozen, to realize the importance of this process in the wearing away of these rocks. Both the climate and the structure of the rocks are peculiarly favorable for this class of erosion.

There is considerable difference also in the quantity of heat that reaches east and west slopes, the westward slopes receiving more heat than those facing eastward, owing to the fact that the afternoon is the warmest part of the day. Because of this the westward slopes are sometimes more gentle than those facing eastward. These slopes are not so noticeably different, however, as are the north and south hillsides.

These differences can not be due to the gentle south-westward dip of the beds, because if they were so controlled, the westward slopes would certainly be the most gentle of all, as the prevailing dip is westward.

The effect of temperature change upon the disintegration of the Knobstone strata may be seen at the falls at the Shades of Death, in Montgomery County. These falls are in the typical massive sandy shales of the Knobstone group. The influence of protection against changing temperature is here most strongly brought out because the protection is afforded by running water, ordinarily the most important of all the erosive agents. Instead of having the ordinary horseshoe-shaped brink, these falls belly out at the brink and the water passes over the protuberance. At either side of the protuberance the rocks are worn away more rapidly than over the protuberance itself. The accompanying illustrations (Plates V and VI and Fig. 17) show the character of one of these falls.*

Plate V is a view of the fall from below, looking up toward its brink.

Plate VI is a view of the fall from the side. Fig. 17 is a contour sketch showing the plan of the fall.

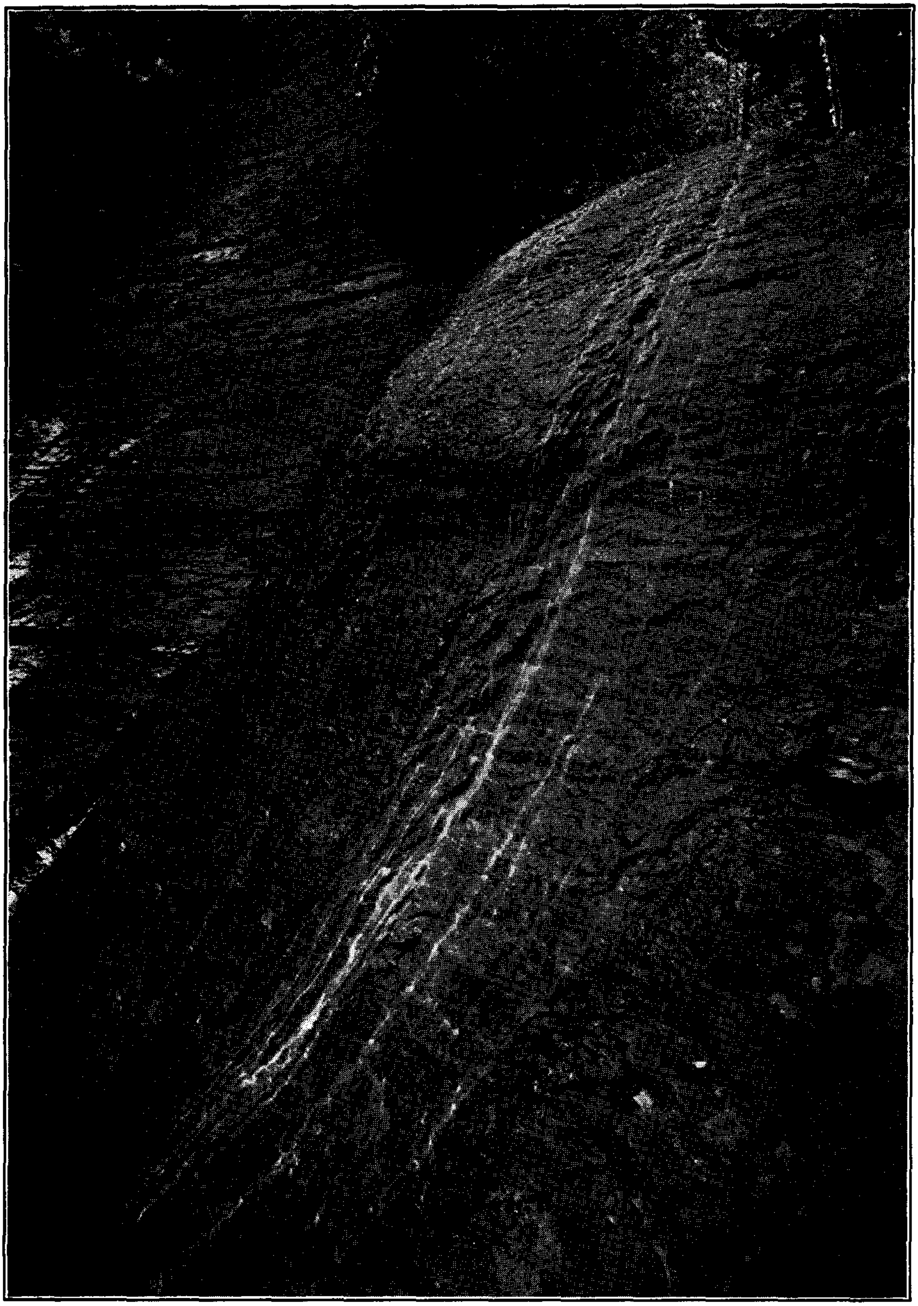
The explanation of this characteristic in these falls is as follows: The water pours over the falls in a thin stream. It is largely supplied by springs and does not carry much material in suspension, and has, therefore, but little erosive power. In the winter time the water protects the rocks from changes in temperature. The rocks at the

*These plates are from photographs which were obtained through the kindness of Prof. C. R. Dryer, of Terre Haute.

PLATE V.

View of the Fall at the Shades of Death, Montgomery County, looking up from near the bottom.

PLATE VI.



Side view of Fall shown in plate V.

sides are unprotected and are therefore subjected to many changes in temperature in the course of a winter, causing them to exfoliate more rapidly than the protected portion. This goes on until the stream at the brink of the fall is diverted to one side or the other, when the newly protected portion ceases to recede. In this way an equilibrium is maintained, the protuberance probably always having about the form shown in the illustrations.

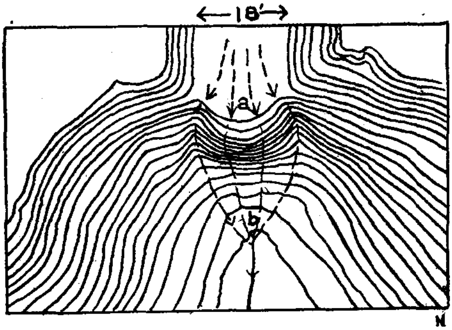


Fig. 17. Topographic sketch of the fall shown in Plates V, VI. The brink of the fall (a) is about 55 feet higher than the point (b).

This feature of the weathering at the falls of the Shades of Death is dealt with in some detail at this place because it emphasizes the fact that change of temperature and not running water is the agent of primary importance in the breaking up of the Knobstone strata.

Exfoliation.—Throughout the Knobstone area, where the massive clayey sandstones and sandy shales are exposed in bluffs, they weather largely by exfoliation, large slabs, often cutting across many bedding planes, becoming loosed by frost action. The tendency towards exfoliation is seen at the right and left sides of Fig. 17.

It should be remarked also that the occasional drying out of the Knobstone strata at their exposed surfaces may play no inconsiderable part in weathering them.

STRUCTURE.

Dips of the Strata.—The structural features of the Knobstone strata are very simple: The beds have a gentle southwestward dip, conforming in this respect to the overlying and underlying strata. Near Bloomington they have a dip, according to Kindle, of 64 feet per mile. In 3 north, 3, 4 and 5 east, the westward dip is 26 feet per mile. At the south side of 2 north, 5 east, the westward dip, as shown by the elevations of the Louisville, Evansville and St. Louis Consolidated Railroad is 33 feet per mile.

No folds of more than local extent occur. There are, however, occasional low undulations in the strata. One of these undulations is the cause in part at least, of the exposures of Knobstone along Indian Creek in 2 south, 4 and 5 east.

FAULT.—But one fault has been observed in the Knobstone area. It is called the "Unionville Fault," from the village of that name in Monroe County, which is located about one-half mile west of the line of fracture. The line of faulting has been traced more or less continuously from this point in 9 north, 1 east, Section 10, to 3 north, 1 east, Section 1, in the north edge of Washington County, a distance of about 36 miles. The fracture probably extends both north and south from these points, but its location beyond these limits is not known. On the map sheets (Plates III, IV) the location of this line of fracture is indicated.

The following figures (Figs. 18, 19) show the structural relations along this fault:

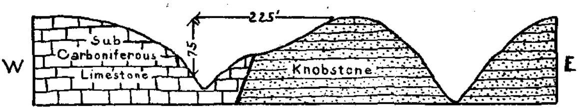


Fig. 18. Section in Township 9 north, 1 east, Section 10. (Price after Newsom.)

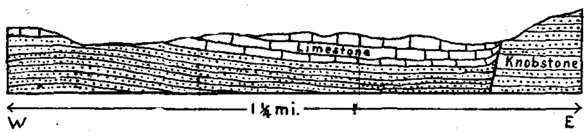


Fig. 19. Generalized east-west section across the Unionville fault, showing its effect upon the areal distribution of the limestone immediately west of the line of fracture.

It is observed that the downthrow is on the west side of the fracture. The displacement is over 50 feet in several places, and at one place, in Section 26, Township 4 north, 2 east, it is about 200 feet; it is probably greater than this at places, if not through most of its extent. The data by which the extent of displacement can be measured are usually lacking.

There is usually a strip of limestone from one-half to one and one-half miles wide immediately west of the fracture. West of this strip the Knobstone strata sometimes come to the surface in the highest ridges, though often the lower layers of limestones and cherts are continuous along the very tops of the ridges, connecting the more or less isolated limestone strip with the main limestone area to the west.

This limestone remnant (see Plates III, IV, Townships 5, 6 north, 1 east, and 4 and 5 north, 2 east) has been called the "Heltonville limestone strip"* by Siebenthal, who outlined its limits, and who suggested both faulting and unconformity as possible explanations for its occurrence east of the main mass of lower carboniferous limestone.

The line of fracture of the Unionville fault may be observed when it crosses the creek and cuts the Knobstone strata near the town of Leesville, in Township 5 north, 2 east, near the southeast corner of Section 22.

No fault has been observed at the west side of the Heltonville limestone strip, the structure and relations of which are indicated by Fig. 19, a generalized section across the area.

Some sections and notes on this area were published by Mr. J. A. Price in 1897.†

The possible effect of this faulting upon the areal distribution of the Knobstone to the east of it has been mentioned above, p. 264.

UNCONFORMITY.—No unconformity is known to exist between the Knobstone strata and the underlying Devonian. Neither is there an unconformity between the Knobstone strata and the overlying lower carboniferous beds. There is, however, an important denudation interval at the top of the lower carboniferous limestones which has entirely removed these beds and also part of the Knobstone sandstones and shales at the north end of the Knobstone area. In the west edge of Montgomery County the Mansfield sandstone (or basal Coal Measures sandstone) rests unconformably upon the Knobstone sandstones and shales; this unconformity may be observed along Sugar Creek and at many other places, as pointed out by Hopkins.‡

At the north, viz., in northern Putnam and Montgomery counties, and northward therefrom, this interval of erosion has been sufficient to remove the Lower Carboniferous limestones, which probably formerly extended over this region. It probably removed also much of the Knobstone strata of Tippecanoe County, though whether these strata ever extended far north and east of their present limits in that region can not be known. To the southward the same unconformity exists between the Coal Measures sandstones and the Lower Carboniferous beds, but here these latter have not

*Indiana Department of Geology and Natural Resources. 21st Annual Report, p. 390. Indianapolis, 1897.

†Proceedings of the Indiana Academy of Science of 1897, pp. 262-266. Indianapolis, 1898.

‡Indiana Department of Geology and Natural Resources. 20th Annual Report, Plates IX, X, and accompanying text. Indianapolis, 1896.

been entirely removed. They become successively thicker in passing southward from the north side of Putnam County.

The erosion interval occurred at the end of Lower Carboniferous time. From the amount of denudation that took place, it is evident that the interval was long and important.

The erosion interval in Indiana between the Lower and Upper Carboniferous strata corresponds with the erosion interval that is generally recognized through the northern Mississippi valley between those formations. It corresponds also with a period of deposition in the southwest during which, in the Arkansas region, at least, as much as 18,480 feet of sediment were deposited, as shown by a cross section run by the writer in the Arkansas River Valley.*

ECONOMIC GEOLOGY.—The strata of the Knobstone group have but little economic value. The shales will in many places undoubtedly make good vitrified bricks. They have been used for this purpose near New Albany, but no data are at hand regarding the character of the bricks produced.†

*In the American Journal of Science, Fourth Series, Vol. II, pp. 229-236, Dr. J. C. Branner discusses the thickness of the Paleozoic sediments of Arkansas, and calls attention to the section mentioned.

Later attention has been called to the Arkansas sediments and their probable correlation with the above mentioned erosion interval by Keyes. Bulletin of the Geological Society of America, Vol. XII, pp. 173-196.

†A large deposit of Knobstone shale, located at "Blue Lick," Jackson County, a switch on the B. & O. S. W. Railway in the northeast quarter section 6 (5 north, 5 east), is now being utilized as the clay ingredient in the manufacture of Portland cement by the Lehigh Portland Cement Company, of Mitchell. It has been found highly suitable for that purpose. Similar deposits occur near Freetown, close to the Southern Indiana Railway, and on the land of D. M. Hughes, near Medora. Chemical analyses of two of these Knobstone shales suitable for cement manufacture are herewith given:

ANALYSES OF KNOBSTONE SHALES FROM JACKSON COUNTY, INDIANA.

	"Blue Lick," Per Cent.		*Hughes, Per Cent.*	
Silica (SiO_2)	59.64		64.59	
Titanium oxide (TiO_2)	1.05		.30	
Alumina (Al_2O_3)	19.14		16.37	
Combined water (H_2O)	4.36		3.71	
Clay base and sand		84.19		84.97
Ferric oxide (Fe_2O_3)	3.39		5.37	
Ferrous oxide (FeO)	4.20		1.59	
Lime (CaO)	.26		.16	
Magnesia (MgO)	2.31		1.56	
Potash (K_2O)	3.53		4.24	
Soda (Na_2O)	.80		.97	
Fluxes		14.49		13.89
Carbon dioxide (CO_2)		.35		.43
Total		99.03		99.29

It is probable that the Knobstone shales in many places will be found suitable for Portland cement manufacture. Care must be taken, however, to secure the true shales, and not the shaley sandstones of the transition beds or upper strata of the Knobstone, as the latter are too high in silica to make a good cement.

W. S. B.

Many nodules of limonite of considerable size are found in the knob shales, and these are sometimes found thickly strewn over the surface. Their manufacture into iron has been advocated at one time and another, but they do not occur in sufficient quantity at any place to be valuable for that purpose. When these limonite concretions are broken up and worn into creek gravels, however, they make an excellent road metal, for which purpose they are used in the neighborhood of New Albany.

The sandstones at the top of the series have been used for building purposes. They can be worked easily, but unfortunately they absorb much moisture and invariably spall off when exposed to extreme atmospheric changes. Upon weathering they also become much stained by the oxidation of the iron contained in them. For these reasons they are unsuited for building purposes.

The soils derived from the decay of the Knobstone strata are unproductive sands and clays. For this reason the region lying wholly within the Knobstone area is one of the poorest in the entire State.

Although the Knobstone strata absorb water easily they are practically impervious as far as circulating waters are concerned, for which reason springs are rarely found in them. Drinking water is mostly obtained from wells, and this is ordinarily of a very poor quality. At the top of these impervious strata, however, and at the base of the overlying pervious limestones is a natural spring horizon, and along this line of contact springs are abundant.*

Stratigraphic Position.—The lower shales of the Knobstone group were correlated with the Chemung of New York by Hall in 1841,† while the sandstones above he regarded as Sub-Carboniferous.‡

De Verneuil grouped these beds with the Carboniferous.§

Owen classed them as Sub-Carboniferous in 1856.‖

The final correlation of the Rockford goniatite limestone at the base of the Lower Carboniferous limestone, where it undoubtedly belongs, established the Knobstone in the Carboniferous also. The lower layers of the group probably correspond to the Kinderhook, of Illinois, and the middle Waverly, of Ohio. The Kinderhook beds

*A number of springs issuing from the New Providence shale in Clark, Floyd and Brown counties produce mineral water which is quite extensively used for medicinal purposes. The waters of these springs are mentioned in detail in a preceding paper on "The Mineral Waters of Indiana," in the present volume. *W. S. B.*

†Reports of the first, second and third meetings of the Association of American Geologists and Naturalists, 1840-1842, p. 280. Boston, 1843.

‡Ibid., Vol. I, p. 28.

§American Journal of Science, second series, Vol. 7, p. 46.

‖Kentucky Geological Report, Vol. I, p. 89.

especially are lithologically similar to the lower beds of the Knobstone.

The tracing out of the contact of Knobstone and the overlying limestones has established beyond a reasonable doubt that the characteristic Keokuk crinoid beds of Crawfordsville are in the Knobstone strata. These crinoid beds are in shale containing lenses of limestones, that resemble, lithologically, the beds that are found further south, from 100 to 200 feet below the top of the Knobstone group. The crinoid beds are certainly in the Knobstone group, which, therefore, must be of Keokuk age in its upper portion.*

It should be remarked in this connection that the geodes usually so abundant in the Keokuk rocks occur to some extent in the upper Knobstone strata.

The following species have been identified from the shales at the base of the Knobstone group in Indiana:†

	Kinderhook.	Burlington.	Keokuk.	St. Louis.	Kaskaskia.	Coal Measures.
Cœlenterata.						
Zaphrentis dalei E. and H.	....	×	×	×	....	×
Brachiopoda.						
Athyris lamellosa L'Eveillé	×	....	×	....	....	....
†*Chonetes illinoisensis* Worthen	....	×	....	....	....	....
†*Chonetes logani* Norwood and Pratten	×	×	....	....	....	....
Derbya keokuk Hall	×	....	×	....	....	....
†*Orthothetes crenistria* Phillips	....	LC	....	....	....	....
Productus arcuatus Hall	×	....	....	....	....	....
†*Productus gracilis* Winchell	×	....	....	....	....	....
†*Productus semireticulatus* Martin	×	....	×	×	....	×
†*Porductella shumardana* Hall ?	×	....	....	....	....	....
Rhipidomella oweni Hall and Clarke	×	....	....	....	....	....
Spirifer lateralis Hall ?	....	....	....	×	....	....
†*Spirifer mortonanus* Miller	....	....	×	....	....	....
†*Spirifer suborbicularis* Hall	....	....	×	....	....	....
†*Syringothyris texta* Hall	×	....	×	....	....	....
Lamellibranchiata.						
†*Palæoneilo bedfordensis* Meek	....	W3	....	....	....	....
Cephalopoda.						
‡*Remeleceras clarkense* Miller and Gurley	KS	....	....	....	....	....

*The upper portion of the Knobstone group was referred to the Keokuk by Worthen in 1866. Geological Survey of Illinois, Vol. I (1866), pp. 116-117.

†In the following lists names preceded by a † are of fossils that have been found both in the Knobstone shales and the sandstones: L. C. = Lower Carboniferous; W = Waverly; W 1 = Lower Waverly; W 3 = Upper Waverly.

‡Cited from Knobstone near Clark County, Indiana, by Miller and Gurley. Illinois State Museum of Natural History, Bulletin 12, p. 49, plate IV.

Following is a list of species from the Knobstone sandstones:

	Kinderhook.	Burlington.	Keokuk.	St. Louis.	Kaskaskia.	Coal Measures.
ECHINODERMATA.						
Catillocrinus bradleyi Meek and Worthen	....	....	×	....	....	....
BRACHIOPODA.						
Athyris incrassata Hall ?	....	×	....	....	....	....
Camarotœchia sappho Conrad	×	....	....	....	....	....
†*Chonetes illinoisensis* Worthen	....	×	....	....	....	....
†*Chonetes logani* Norwood and Pratten	....	×	....	....	....	....
Chonetes planumbonus Meek and Worthen	....	....	×	....	....	....
Cryptonella ? eudora Hall	×	....	....	....	....	....
Eumetria marcyi Shumard	....	....	....	×	×	....
Lingulodiscina newberryi Hall	×	....	....	....	....	....
†*Orthothetes crenistria* Phillips	LC	....	....	....	....	....
†*Orthothetes umbraculum* Hall and Clarke	LC	....	....	....	....	....
Productus alternatus Norwood and Pratten	....	....	×	....	....	....
Productus burlingtonensis Hall	....	×	....	....	....	....
†*Productus gracilis* Winchell	×	....	....	....	....	....
Productus newberryi Hall	×	....	....	....	....	....
Productus punctatus Martin	....	....	....	....	....	×
†*Productus semireticulatus* Martin	×	....	×	×	....	×
Productella pyxidatus Hall	×	....	....	....	....	....
†*Productella shumardana* Hall ?	×	....	....	....	....	....
Reticularia pseudolineata Hall	....	×	×	....	....	....
Reticularia tenuispinata Hall	×	....	....	....	....	....
Spirifer keokuk Hall	....	....	×	....	....	....
†*Spirifer mortonanus* Miller	....	....	×	....	....	....
†*Spirifer suborbicularis* Hall	....	....	×	....	....	....
Spiriferina depressa Herrick ?	×	....	....	....	....	....
Spiriferina subelliptica McChesney (Kentucky)	....	....	×	....	....	....
†*Syringothyris texta* Hall	×	....	×	....	....	....
LAMELLIBRANCHIATA.						
Grammysia ventricosa Meek	×	....	....	....	....	....
Myalina keokuk Worthen	....	....	×	....	....	....
†*Palæoneilo bedfordensis* Meek	....	W3	....	....	....	....
Schizodus chemungensis Herrick	×	....	....	....	....	....
Streblopteria media Herrick	W1	....	....	....	....	....
GASTROPODA.						
Bellerophon galericulatus Winchell	×	....	....	....	....	....
Platyceras herzeri Winchell (Kentucky)	×	....	....	....	....	....
Platyceras lodiense Meek (Kentucky)	×	....	....	....	....	....
PTEROPODA.						
Conularia micronema Meek	×	....	....	....	....	....
Conularia newberryi Winchell	W1	....	....	....	....	....
CEPHALOPODA.						
Goniatites greenii Miller	KS	....	....	....	....	....
Triboloceras degonum Meek and Worthen	....	....	×	....	....	....
CRUSTACEANS.						
Proetus missouriensis Shumard	W	....	....	....	....	....

To the lists given above should be added the names of those fossils* that have been found in the shales and sandstones, with intercalated limestones that crop out along Sugar Creek near Crawfordsville, as the beds from which the typical Keokuk fauna of this place come are undoubtedly the equivalents of the Knobstone further south.

*For lists of the Crawfordsville fossils, see The American Geologist, Vol. I, pp. 407-412. The Keokuk Group at Crawfordsville, Indiana, by Charles S. Beechler.

Also, Indiana Department of Geology and Natural History. 16th Annual Report, pp. 65-70; 340, et seq.

LOWER CARBONIFEROUS STRATA EXCLUSIVE OF THE KNOBSTONE GROUP AND THE ROCKFORD GONIATITE LIMESTONE.

Overlying the Knobstone group are the Lower Carboniferous limestones, with interstratified sandstones at the top of the series. The sequence of these beds is shown in the columnar section, Fig. 7. Their thicknesses were not measured in Township 3 north; the thicknesses given are those given by Siebenthal and Kindle.*

THE HARRODSBURG LIMESTONE.

CHARACTER AND THICKNESS.—With the Harrodsburg limestone are included those transitional beds of cherts and limestones that lie immediately above the Knobstone. Masses of chert fragments at the surface, resulting from the decay of these lowest beds are included (Plates III, IV) with the Harrodsburg limestone, and consequently the line of contact as shown on the maps between these beds and the lower strata is often some distance east of the real eastern edge of the undecomposed limestones.

The Harrodsburg limestone is made up of massive and thin beds, with occasional shales and cherts intercalated. According to Siebenthal, it is from 60 to 90 feet thick.†

As already remarked, these beds lie conformably upon the Knobstone strata.

AREAL DISTRIBUTION.—On the map sheet (Plate II) the Oölitic and Harrodsburg limestone areas are shown together. The area covered by them has a width of from half a mile to two or three miles, passing in a sinuous line around the heads of the northward flowing streams, and capping the high ridges in Townships 1, 2, 3, 4 and 5 east.

The Harrodsburg limestone is the cap rock that protects the softer Knobstone below, and to its protecting influence the bold, unbroken escarpment presented by the Knobstone strata south of East White River is largely due. In 3 north this limestone has a westward dip of 26 feet to the mile.

TOPOGRAPHY.—Much of the drainage from the Harrodsburg limestone is underground; for this reason small sink holes are numerous

*Indiana Department of Geology and Natural Resources. 20th and 21st Annual Reports. Indianapolis, 1896 and 1897.

†Indiana Department of Geology and Natural Resources. 21st Annual Report, pp. 296–298. Indianapolis, 1897.

in the area underlain by it. These sink holes are never as large or deep, however, as are those a few miles further west in the Mitchell limestone area, where there is a greater thickness of limestone.

The Harrodsburg limestone outcrops, for the most part, at the tops of steep-sided hills and ridges, whose lower portions are composed of Knobstone strata. The tops of these hills form a more or less even plateau, sloping gently to the west. (See Plate II, 3 north, 2, 3, 4 and 5 east.)

The Harrodsburg limestone is probably correlative with the upper or Keokuk portion of the Augusta limestone of Keyes.

THE BEDFORD LIMESTONE.

CHARACTER.—Lying conformably upon the Harrodsburg limestone is the formation known as the Bedford limestone. It has a bluish or buff color, and is an extremely homogeneous bed. In thickness it varies from 25 or 30 feet to about 100 feet. In Township 3 north its thickness is from 25 to 36 feet or more.

The stone is sometimes of fine texture; sometimes it is coarse, depending upon the size of the shells of which it is made, and also upon the degree to which these have been pulverized.

AREAL DISTRIBUTION.—The oölitic limestone outcrops in a sinuous band ranging usually from 100 yards to one-fourth mile wide, lying between the Harrodsburg and Mitchell limestones.

TOPOGRAPHY.—Its thickness is not sufficient to develop a topography of its own. Where the bed is thickest, however, and the strip covered the broadest, the slopes on which it outcrops are gentle, and the country, so far as it is controlled by the Bedford limestone, is gently rolling.

ECONOMIC GEOLOGY.—Next to the coal beds of Indiana the oölitic limestone is the most important geological formation in the State from a commercial standpoint. Owing to the ease with which it may be worked in any direction, its freedom from bedding planes, and its general uniformity in color, coupled with its crushing strength, and its power of resisting the action of the weather, it makes an ideal building stone, and has long been recognized as the standard among the limestones of the country.

Its fauna shows that Bedford limestone belongs to the St. Louis group.

THE MITCHELL LIMESTONE.

CHARACTER.—Lying conformably upon the Bedford limestone, and underlying the lowest beds of the Kaskaskia group, is the Mitchell limestone, a series of close-grained limestones, shales and cherts. It varies in thickness from 150 to 250 feet, and is regarded as belonging to the upper part of the St. Louis group. Owing to its low dip and the width of the area covered by it, its thickness could not be accurately measured in Township 3 north.

AREAL DISTRIBUTION.—In Township 3 north the Mitchell limestone outcrops over a strip of country about 20 miles wide. To the northward it is usually much narrower than this, while further south it becomes somewhat wider.

TOPOGRAPHY.—This limestone forms for the most part a fairly level plateau, which is pitted with great numbers of sink holes. These sink holes lead to underground water channels, which form the true drainage lines of the country. The sinks vary in depth from a few feet up to 50 or 75 feet, and cover from a quarter of an acre and less to 200 or 300 acres.

Where the underground drainage is best developed there is scarcely any surface drainage. The notable absence of surface streams in 3 north, 1 and 2 west and 1 and 2 east (see Plate II) is due to highly developed underground drainage systems. This underground drainage is made possible, not by the Mitchell limestone alone, but by these beds in conjunction with the underlying Bedford and Harrodsburg limestones, making a thick series of beds which are more or less jointed, and easily attacked by underground waters.

This combination of strata, coupled with the fact that the drainage level of the country in which the beds occur is usually from 200 to 300 feet below the general level of the plateau made by the Mitchell limestone, affords favorable conditions for the formation of underground caverns.

The character of the topography of the Mitchell limestone area is shown on Plate II, Townships 1 and 2 east and 1 and 2 west. It is not possible on a map of the small scale of Plate II to show the great number of small sink holes that pit the surface of the country in Townships 1 and 2 east.

ECONOMIC GEOLOGY.—Except for the manufacture of lime, the Mitchell limestone is of small economic importance. It often resembles lithographic limestone, but at no place has this stone been found free from veinlets and of such quality as to be useful for lithographing.

The soil resulting from its decay is a stiff clay, which does not compare in fertility with the glacial and bottom lands of more favored portions of the State.*

THE KASKASKIA GROUP.

CHARACTER.—Overlying the Mitchell limestone is a series of limestones and sandstones, regarded by Kindle as belonging to the Kaskaskia group.† This group is made up of three limestone beds and two beds of sandstone. The limestones are designated by Kindle as the Lower, Middle and Upper Kaskaskia limestone, and the sandstones as the Lower and Upper Kaskaskia sandstone. The aggregate thickness of the Kaskaskia group in 3 north is about 125 feet.

The Lower and Upper Kaskaskia sandstones vary in texture from very fine grained to coarse grained rocks. In color they are usually buff or gray. In some places they carry concretions of limonite and thin beds of coal.

In all three of the Kaskaskia limestones occur chert lenses, which are usually thin and of small lateral extent.

AREAL DISTRIBUTION.—In 3 north the Kaskaskia area extends from the east side of 1 west to the middle of 4 west. Owing to the gentle dip of the rocks, the different beds composing the group outcrop in successive bands, the lowest bed forming the most easterly band.

The lower contact of this group, as shown on the map, Plate II, can be regarded as only approximately correct. The Lower Kaskaskia limestone resembles the Mitchell limestone closely; outcrops in the region of the contact between these two formations are not plentiful; these conditions, coupled with the fact that this region is pitted by thousands of sink holes, extending through the Kaskaskia beds, and down into the Mitchell limestone, make it well-nigh impossible to correctly locate the line of contact between the two formations.

TOPOGRAPHY.—The topography of the Kaskaskia beds is more rugged than that of the lower limestones to the east. This is due in part to the beds themselves, and also to the thick Carboniferous sandstones that overlie them. Passing westward from the east side of 3 north, 1 west (i. e., from the east side of the Kaskaskia area)

*The Mitchell limestone is a very pure carbonate of lime, and is now being utilized by the Lehigh Portland Cement Company, of Mitchell, as the carbonate of lime ingredient in the manufacture of Portland cement, 2,000 barrels or more being the daily output of the factory, which was completed in August, 1902. Two other large cement factories will soon be erected near Mitchell, and will use the limestone for the same purpose. *W. S. B.*

†Indiana Department of Geology and Natural Resources. 20th Annual Report. The Whetstone and Grindstone Rocks of Indiana, by E. M. Kindle, pp. 328-368.

the hills become gradually higher until the rugged hills in Townships 2, 3 and 4 west are reached.

Most of the drainage from the Kaskaskia area in 3 north is subterranean. The sink holes of this region are much larger than those further east, valleys sometimes three or four miles long and two or three hundred feet deep being drained through underground channels. This gives rise to confusing systems of hills and valleys, though the topographic map brings out certain well-defined drainage lines, or valleys, which are themselves usually made up of series of sink holes.

ECONOMIC GEOLOGY.—The Kaskaskia limestones afford a good lime and are often burned for that purpose. In some localities the Kaskaskia sandstones make excellent whetstones. They are quarried for this purpose in Orange County.

UPPER CARBONIFEROUS.

Lying unconformably above the Kaskaskia group are the rocks of the Upper Carboniferous, with beds of possible Permian age at their top. Taken as a whole, these strata may be broadly grouped as follows, beginning at the bottom:

(a) Mansfield sandstone. (Basal sandstones often accompanied by some shale and one or two thin beds of coal.)
(b) The Productive Coal Measures.
(c) The Merom sandstone; a sandstone of Carboniferous or Permo-Carboniferous age lying unconformably upon the topmost Coal Measures beds.

MANSFIELD SANDSTONE (THE BASAL SANDSTONE).

CHARACTER.—The Mansfield sandstone lies unconformably upon the Kaskaskia beds, and is overlain unconformably by the beds of the Productive Coal Measures. It was designated as the "Millstone grit" and "conglomerate sandstone," by writers on Indiana geology until 1896, when it was given the name Mansfield sandstone by Hopkins.

The Mansfield sandstone has a thickness in 3 north of about 150 feet, as exposed in the bluffs along White River above Shoals, in Martin County. It varies in texture here from a moderately fine grained sandstone to a coarse stone, in some places becoming conglomeritic. It is yellow to brown in color and often has distinct cross bedding planes. At the base of the Mansfield sandstone a shale bed, with one or two thin beds of coal, often occurs. In places this shale has a thickness of 20 feet.

AREAL DISTRIBUTION.—The Mansfield sandstone outcrops in 3 north over a strip of country about 22 miles wide. Its easternmost outcrop is near the middle of the east line of 2 west, where its base is near the tops of the hills. Westward from this it is the cap rock of the high hills through 2, 3 and 4 west, being carried gradually lower in the hills by its gentle westward dip.

Its base finally passes beneath the drainage near the center of Township 5 west (Plate II).

TOPOGRAPHY.—The topography of the Mansfield sandstone area is quite rugged (see Plate II, Townships 3, 4 and 5 west). The valleys are arranged in the intricate dendritic systems. The hilltops are protected by the heavy sandstone capping them, while the streams have cut down through the underlying softer beds, making of the area a thoroughly dissected plateau. The hills at the west edge of the Mansfield sandstone area are less rugged than those at the east simply because in this region the beds have been brought near to their base level of erosion (the level of East White River) by their westward dip.

ECONOMIC GEOLOGY.—In some localities the Mansfield sandstone is an important building stone. Where it occurs with an even, sharp grit, as it does in some portions of Orange, Martin and Dubois counties, it makes excellent grindstones and whetstones, and is used for these purposes.

The coal beds found at its base are of small commercial importance. At its base there is often a bed of kaolin, which may prove of future commercial importance.*

*This kaolin is a very pure silicate of alumina, its chemical composition, determined by Noyes, being as follows:

ANALYSIS OF KAOLIN FROM NEAR HURON, LAWRENCE COUNTY, INDIANA.

	Per Cent.
Silica	44.75
Alumina	38.69
Water	15.17
Ferric oxide	.95
Lime	.37
Magnesia	.30
Potash	.12
Soda	.23
Total	100.58

This kaolin was used for years in the manufacture of alum sulphate for sizing paper. Lack of transportation facilities caused the abandonment of the enterprise. The principal beds are located four miles from Huron, a station on the B. & O. S. W. Railway. Thousands of tons are in sight in the four slope shafts which have been opened. It is not plastic, but very refractory, and is suitable, when mixed with a small quantity of plastic clay, for making high-grade refactory wares, ultramarine, etc. *W. S. B.*

THE PRODUCTIVE COAL MEASURES.

CHARACTER AND AREAL DISTRIBUTION.—The Productive Coal Measures consist for the most part of shales and sandstones, with beds of coal. Fire-clays and some beds of limestone also occur in them. All of the important coal beds of the State occur in this group of strata, between which and the Mansfield sandstone is a slight unconformity. This division of the Upper Carboniferous is subdivided by Ashley* into Divisions II to VIII, inclusive. These divisions are more or less arbitrary and are made for convenience in the discussion of the geology of individual localities in the coal region.

In thickness the Productive Coal Measures strata vary much in different parts of the State. In Township 3 north they have a thickness of 800 feet where penetrated by a bore hole at Vincennes. Except when covered by glacial debris, these strata, with the overlying Merom sandstone, outcrop over a broad strip of country, extending from 3 north, 4 west to the Illinois line at Vincennes.

TOPOGRAPHY.—The topography of the Productive Coal Measures of Indiana is almost always gently rolling or quite flat. The general character of the topography is best seen on the accompanying map (Plate II), from 3 north, 4 west, on westward.

The low relief of the Productive Coal Measures area is mainly due to the glacial covering over it, coupled with one of two causes, depending upon previous conditions, as follows:

1. The beds of the Productive Coal Measures may have been thicker originally than they are at the present time. If such conditions obtained, then these formerly thick strata were removed by erosion prior to glacial times until their present level was approximately reached, giving the low relief of the present time. The strata being made up of soft and easily eroded sandstones and shales would have made this possible.
2. The Productive Coal Measures may never have been elevated much above their base level of erosion, i. e., above their present level. In such event the present relief would, of course, be the inevitable result.

ECONOMIC GEOLOGY.—The Productive Coal Measures are the chief source of the State's coal, fire-clays and shale for the manufacture of vitrified bricks.

*Indiana Department of Geology and Natural Resources. 23rd Annual Report, p. 89, et seq. Indianapolis, 1899.

The Merom Sandstone.

Lying above the Productive Coal Measures and separated from them by an unconformity is a sandstone with a thickness at Vincennes of from 40 to 50 feet. This sandstone has been known as the Merom sandstone, owing to its good exposures at the town of Merom.

In general appearance it resembles the Mansfield sandstone, for which it has sometimes been mistaken. Whether it is of Carboniferous or later age has not been satisfactorily determined.

As indicated in Fig. 1, the Merom sandstone is overlain by glacial and alluvial deposits.

TERTIARY AND PLEISTOCENE.

Tertiary.—Gravels of possible Tertiary age occur in Township 3 north, 1 west on the ridge just north of the center of the southeast quarter of Section 10. These gravels may occur on other ridges west of this point, but they were not observed elsewhere by the writer.

Pleistocene.—In 3 north, glacial gravels, sands and clays, ranging from one to over one hundred feet in thickness, are encountered from Township 6 east eastward to the Ohio River, and from Township 5 west westward to the Wabash River. No attempt is made to outline the limits of these glacial deposits on the maps. In character these deposits are similar to the glacial deposits found generally in the Mississippi Valley near the southern limits of the glaciated area.

DRAINAGE OF SOUTHERN INDIANA.

INTRODUCTION.

Only those features of the drainage of southern Indiana which are dependent upon geological structure and are not controlled primarily by glacial drift are here discussed. This limits the discussion to that portion of the State that lies south of a line running from Indianapolis east to the Ohio State line, and from Indianapolis southwestward along the course of West White River to the mouth of that stream.

While the eastern tributaries of West White River from Indianapolis to the mouth of Bean Blossom Creek and the tributaries of East White River in northern Shelby and Johnson counties owe their positions largely or entirely to the drift,* the main streams of the area referred to are controlled by the underlying strata.

The driftless region of southern Indiana is an irregularly triangular area, with the base of the triangle along the Ohio River, reaching from Mt. Vernon to a point a few miles above Jeffersonville, a direct distance of 135 miles, and the apex of the triangle near the northeast corner of Monroe County, 135 miles northeast of Mt. Vernon and 85 miles slightly west of north from Jeffersonville.

Over most of the region both directly east and west from the unglaciated area the covering of drift is comparatively thin. In the region to the east especially the drift covering is rarely as much as 100 feet thick, and many of the streams have cut down through it and into the underlying rocks. In some cases these streams occupy preglacial channels; in others the valleys have been cut out entirely since glacial times, leaving the drift in remnants only upon the hilltops and uplands.

The thin mantle of drift that covers that portion of the State east of the driftless area lies on strata that dip gently to the southwest, and on an old surface whose general contour prior to the deposition of the drift was similar to that of the present time. Therefore, while the minor lines of drainage have been modified by the drift, the general south and southwest drainage of the country is such as would be logically developed in a country of such combinations of hard and soft southwestward dipping strata as southern Indiana possesses, and it is practically the same now as it was in preglacial times.

There are, in southern Indiana, three thick series of shale beds, between which are groups of harder and more resisting limestones and sandstones. In going from east to west across the State these groups are as follows: (1) the Hudson River shales, along the east side of the State; (2) the resisting Niagara limestone, and limestones at the base of the Devonian; (3) the New Albany and Knobstone shales, all soft and easily eroded beds; (4) the Knobstone sandstones and overlying Lower Carboniferous limestones, which are in turn overlain by the sandstones at the base of the Coal Measures;† (5) the soft Coal Measures shales and sandstones of the west side of the State.

*These small streams are not included in the following remarks regarding the drainage Neither are the streams between West White and the Wabash rivers discussed, although those streams are shown on the map, Plate VII.

†The Lower Carboniferous limestones are eroded more easily than the beds lying both east and west of them (see page 282), but their denudation has not been so great as to form a separate drainage basin in the area underlain by them.

The softer groups of strata, viz., 1, 3 and 5, form drainage areas discussed below as the eastern, central and western drainage areas, that are more or less separate from each other in each case, while the harder groups, 2 and 4, form the divides, or watersheds, between those areas.

The strata that form the different drainage areas and the watersheds between them in the southern part of the State, extend northward under the glacial mantle for some distance beyond the boundary of the accompanying map (Plate VII). Therefore, it might be expected that the preglacial relief of the country underlaid by those strata was similar to the present relief in the unglaciated area to the south. Well records show this to be the case as regards the central drainage area or trough and its eastern rim at least. In preglacial time this trough and its eastern rim certainly extended as far north as the north side of Clinton County, while the highlands west of it certainly extended as far north as northern Montgomery County.

This preglacial topography makes it seem quite probable that the preglacial drainage of this trough was from the eastern rim down the dip of the underlying limestones to the southwest, along lines generally parallel with those of the present streams further south, which are in accordance with, and are controlled by, the geologic structure.

The relations of the different drainage areas and the structure controlling them is shown by the cross sections on the drainage map, Plate VII.

It will be seen, therefore, that the drainage of southern Indiana may be treated in accordance with the groups of strata that are the controlling features.

An examination of the geology in its relation to the drainage shows that there are the three following general drainage areas:* (1) the eastern area covered by rocks of the Hudson River group, and including some short streams that rise on the Niagara strata and flow eastward into the Hudson River area; (2) the central area, covered by the strata from the base of the Niagara up to the Knobstone sandstone; (3) the western area, covered by the rocks from the Knobstone sandstone to the top of the Coal Measures. This last area includes the entire southwestern part of the State, and in the eastern part of it the streams have in many places cut down through the limestones and Knobstone sandstones and into the

*These areas can not be regarded as basins in the proper sense of the term, for each area is drained by many different streams.

Knobstone shales. These shales, however, have had no part in the formation of the western drainage area, which, while largely underlain by sandstones and limestones, has its eastern watershed along the Knobstone escarpment within a few miles of the lowest part of the central area.

From each of the watersheds, viz., between the eastern and central, and the central and western areas, the streams that flow east across the dip of the strata are short and have steep gradients (see Fig. 12), while those that flow west, with the dip of the strata are long and have low gradients.

The larger streams of southern Indiana flow through filled valleys similar to that shown in Fig. 6, p. 254. The depth to which the valleys have been filled varies from a few feet to over 100 feet.

The different drainage areas will be taken up in their order, and the features of their drainage so far as these seem to depend upon the structure of the underlying rocks will be pointed out. The boundaries between these areas do not follow exactly the outcrops of the strata which form the divides between them, for short streams which belong to the area underlaid by Hudson River beds, for example, may rise in the Niagara beds and flow westward across the dip of those beds for a short distance before entering the area of the Hudson River strata. The same is true of streams belonging to the central basin, which rise at the top of the Knobstone escarpment. On the other hand, the streams flowing westward sometimes cut down through the hard strata that formed the watershed, exposing the underlying softer strata. These facts must be kept in mind in treating the general drainage areas in accordance with the underlying strata.

The Eastern Drainage Area.

While the highest points in the eastern area are almost as high as the watershed at its western side, the streams of this area have cut out valleys from 100 to 400 feet deep in the soft Hudson River strata, and the average level of the country is, therefore, considerably lower than that of the country immediately west.

The Hudson River strata are almost horizontal and the streams flow, with few exceptions, more or less directly to the Ohio River.

Attention should be called, however, to the upper courses of the Whitewater River,* Laughery and Indian creeks.

The upper courses of these streams are almost in line. They flow nearly due south, parallel with the watershed formed by the Niagara

*Whitewater River flows through a preglacial valley below Connersville.

strata, and only a few miles east of that watershed.* Excepting those of Indian Creek, the tributaries of these streams from the east and north are comparatively long, while those from the west, which rise in the Niagara strata and flow eastward across the dip, are short.

The main drainage lines and their relations to the controlling beds to the west are shown on the drainage map (Plate VII).

Indian Creek, which drains portions of Ripley and Jefferson counties, flows southward parallel with the watershed at the west, but, owing to its shortness and its proximity to the Ohio, this is the course that would be expected of it, regardless of the dips of the rocks of the area.

It should be noted also that when the Ohio strikes the region of outcropping Niagara limestone at Madison it makes an abrupt turn to the south, and flows south for about 18 miles before turning to the southwest and cutting through the Niagara strata.

It is seen, then, from what has been said above, that the area of the Hudson River strata has its main drainage lines parallel with its western rim; that for the most part there are southward flowing streams in the area immediately east of and practically all along this rim; that the tributaries from the west are short, while those from the east are long, and that these features of the erosion are probably due to the gentle westward inclination of the strata at the west edge of the area.

As the streams approach the Ohio their relations to the watershed at the west are lost, as is seen by the abrupt eastward turn of the Whitewater in northeast Franklin County, and of the Laughery Creek in southeast Ripley County.

The Central Drainage Area.

The central drainage area has its eastern watershed formed by the Niagara and Devonian limestones, while its western watershed is formed by the Knobstone sandstones and overlying limestones that form the crests of the hills known as the Knobs.

The east-west profile of this area, and its geological relations are shown on that portion of the cross section and topography, Plate II (see also Plate VII), extending from the Niagara strata to the Knobstone sandstones. The east side of the basin has a gentle slope to the west, while the west side has a steep slope to the east.

The shape of the central drainage area is shown on Plate VII, where its streams are shown in blue. This area is about 55 miles

*It seems probable that these streams have been shifted to these positions by the westward inclination of the beds, although this inclination is very slight.

across in its widest part at the north, and narrows down until it is less than a mile wide along the Ohio River at the south.

On Plates II and VII this trough, the axis of which extends from near Edinburg (A, Plate VII) slightly east of south to the Ohio River near New Albany, is shown. From Edinburg to the Ohio the axis is followed approximately by the line of the Jeffersonville, Madison and Indianapolis Railroad. The central area, in which the control of the structure upon the drainage is more clearly marked than in either the eastern or western areas, is made up of two districts: A southern district, from which the streams flow directly into the Ohio River, and a northern district, drained by East White River and its tributaries into the Wabash.

The Southern District.—After cutting through the Niagara and Devonian limestones the Ohio River flows west and southwest across the southern district until it reaches the strata of the Knobstone group west of New Albany. Here it is deflected to the south and runs close under the bluffs formed by the Knobstone sandstone and overlying limestones for about 18 miles to Taylor Township, Harrison County, where it turns to the west and cuts through the Knobstone sandstones and overlying limestones (see Plate III). The southern deflection of the Ohio west of New Albany is very similar to its southern deflection by the Niagara and Devonian limestones just west of Madison.

The streams that enter the Ohio from the west below New Albany are short and have steep gradients. Most of these streams have noticeable southern deflections where they enter the Ohio bottom lands, their mouths having been shifted down stream by the deposition of sediments on their up-stream sides.

Above New Albany, Silver and Fourteen Mile creeks are the principal streams. Silver Creek rises in the Knobstone hills at the south side of Scott County and flows almost due south until it reaches the Ohio above New Albany. Muddy Fork, one of the tributaries of Silver Creek, rises well over in the Knobstone area near the west edge of Clark County and flows eastward for 15 miles, across the dip of the strata, before entering the main stream and turning south to the Ohio.

Fourteen Mile Creek rises in the southwestern part of Jefferson County, flows slightly west of south with the dip of the strata and enters the Ohio three miles southeast of Charleston. In its lower portion Fourteen Mile Creek cuts down into the Hudson River strata. Other shorter streams have their sources in the area covered by the Niagara limestones, or the Devonian strata and flow more or less directly into the Ohio across Hudson River strata. While the general courses of these streams are such as might be expected from the structure of the underlying strata (with the exception perhaps of Muddy Fork of Silver Creek), the influence of that structure on them is by no means so clearly marked as it is on the streams in the district next to be considered.

The Northern District.—It is in the northern district, drained by the East White and Muscatatuck rivers, that the effect of the structure upon the drainage is most clearly seen.

The streams that drain the northern district rise for the most part near the watershed which separates this from the eastern drainage area, within a few miles of the main drainage lines of the eastern area, and flow westward down the gentle slope that owes its inclination to the dip of the underlying beds. In their upper portions most of the streams have gradients greater than the dip of the underlying beds and have consequently cut down from newer into older strata. In their lower courses the gradients are less than the inclination of the strata, and the streams pass across successively newer beds.* The streams that rise on the western rim of the northern district and flow eastward are short and have steep gradients.

Except for the course of East White River below Seymour (with which is included the lower course of the Muscatatuck) the drainage lines of the central area are evidently controlled by the geological structure of the country. The effect of the structure upon these streams is well shown in the case of Ramsey Creek, a tributary of the Muscatatuck, which rises near the northeast corner of Township 3 north, 9 east, within one and one-half miles of the Ohio River, and 360 feet above that stream. The waters of Ramsey Creek flow into the Muscatatuck, then through East and West White rivers, and the lower Wabash, and finally empty into the Ohio at the extreme southwestern corner of the State, a direct distance of 170 miles from the source which was within one and one-half miles of the Ohio.

From Edinburg to Rockford, a distance of 27 miles, East White River flows southward, parallel to the Knobstone hills and but a few miles east of them. Its tributaries from the west are short and have steep gradients. Those from the east and northeast rise at the watershed formed by the Niagara strata and flow with the dip

*This feature is well shown by the tributaries of Stucker's Fork, in Townships 3 north, 8 and 9 east. These streams rise in the Devonian shale area, flow westward with the dip, but cut down through the shale, exposing the underlying limestones for a distance of about six miles, and then, the fall becoming less than the dip of the underlying beds, again pass out into the shale area. See Plate II.

down the southwestward slope of the country. The sources of some of the eastern tributaries of East White River are but a few miles west of the Whitewater River—the main drainage stream of the eastern area.

The asymmetry of the area drained by East White River is shown by the accompanying drainage map (Plate VII).

One of the most interesting features of the drainage of the central area is the course of East White River below Rockofrd (C, Plate VII). From Edinburg to Rockford this stream flows south along the bottom of the trough formed east of the Knobstone hills. But while this trough extends on southward to the Ohio River and is apparently the line along which White River could have most easily developed its course, that stream, instead of following the valley (A., C., B., Plate VII) to the Ohio, turns to the west at Rockford and flows through broad bottom lands until it is joined by the Muscatatuck, at the south side of Jackson County. Just below the mouth of the Muscatatuck it enters a comparatively narrow valley (Plate III), which has been cut down through the Knobstone strata, the overlying Lower Carboniferous limestones and the Mansfield sandstone. This valley varies in depth from less than 50 to over 250 feet; its length is about 75 miles. In width, the bottom of the valley (which is filled with alluvium from 50 to 75 feet or more), varies from one-half mile to over one mile.

Thus it is seen that instead of carving out a valley along the strike of easily eroded strata, southward from Rockford directly to the Ohio, a distance of 50 miles, it turns to the west, flows through a valley cut across hard strata, and finally reaches the Ohio through the Wabash at a point over 150 miles from Rockford.

Two hypotheses may be advanced in explanation of the course of East White River below Rockford.

The first is that the present is approximately the original course of the river; that as this region was first elevated the drainage from the land at the east was deflected to the south parallel with the Knobstone sandstones, and behind (i. e., east of them) or else that it shifted itself to this position during its early history; that in the vicinity of the present village of Rockford the drainage turned to the west, cutting across the edges of the strata, and that it deepened its valley in this position as the strata were elevated—gradually establishing itself in approximately the position now occupied across the Knobstone, the Lower Carboniferous limestone, and the Mansfield sandstone. Even though this entire region may have been partially base-leveled since the original drainage was established, elevation subsequent to the base leveling would have reëstablished the main drainage along its original lines.

The width of the valley throughout its length from the Muscatatuck to the Coal Measures suggests an age greater than has elapsed since the ice invasion and makes the above explanation seem probable. The present course of the stream through its gorge below the mouth of the Muscatatuck can not be explained by stream capture, if it be supposed that East White River originally entered the Ohio in the neighborhood of New Albany. If it originally entered the Ohio near New Albany its course below Rockford (C, Plate VII) would have been along the strike of easily eroded shales, and directly to the Ohio, a distance of 50 miles from Rockford. It is 150 miles southwest from Rockford to the mouth of the Wabash, through which East White River at present reaches the Ohio, and one-third of this distance is across the strike of resisting limestones and sandstones. It is obvious, therefore, that East White River could not have been captured at or below Rockford by a stream which flowed to the southwest across those hard strata. Moreover, there is no evidence to show that the former course of the stream was directly into the Ohio at New Albany.

Reversed drainage owing to elevation of the strata to the east and northeast is not regarded as a probable explanation of the lower course of White River, even if it be supposed that the original course of that stream was towards the east, north or northeast.*

The second hypothesis is as follows: It presupposes that prior to the ice invasion the upper portion of East White River (viz., east of the present mouth of the Muscatatuck) flowed either north or northeastward, or possibly emptied directly into the Ohio at New Albany,—in any event that it flowed generally parallel with the Knobstone hills, east of those hills, and did not cut through them; that short tributaries of this main stream entered from the west, occupying about the courses of the East White and Muscatatuck rivers for 15 miles above the junction of those streams, but flowing in the opposite direction; that these short eastward flowing streams formed the triangular *cul de sac* in the Knobstone hills, in the center of which stand the Brownstown Knobs (see Plates III and VII) with the Silver Hills of Scott County projecting east of the main line of hills; that west of the Knobstone escarpment the general drainage to the southwest was the same as at the present time† and that a

*The details of the preglacial drainage north and east from Rockford are obscured by the drift. The general preglacial contour of this part of the country, however, must have been about the same as that of the present time.

†In Monograph XXXVIII, U. S. Geological Survey, Plate IX, Mr. Frank Leverett shows the preglacial westward drainage of this region.

low pass was formed between the westward flowing streams and those flowing eastward which formed the corner of the *cul de sac* above referred to.*

During the glacial period the ice passed immediately east of the Knobstone hills in western Bartholomew County, through Jackson, and crowded up against the projecting knobs known as the Silver Hills in Scott County (see Plate VII). If the suggested conditions existed at that time the triangular *cul de sac* in the Knobstone hills would have had its eastern outlet completely shut off by the ice, and the basin thus formed would have filled with water from the melting ice until it poured over the pass into the westward flowing streams; the pass would have been cut down, and finally the stream would have become established in its new course, and into this it would have led the waters of its entire drain basin as the ice retreated.

The shape of the *cul de sac*, in which the Brownstown hills stand (E, Plate VII), with the eastward projecting Silver Hills (D, Plate VII), against which the ice was pushed to the south, makes this second hypothesis seem probable. The principal objection to it is found in the general width of the valley of East White River below the mouth of the Muscatatuck. There are no *narrows* in the cañon to correspond with the position of the original divide between the east and west flowing streams. The bottom, or present flood plain, of the valley varies in width from one-half mile to over one mile, and would certainly seem to antedate the ice invasion, and the writer believes that explanation of the present conditions is to be found in the first hypothesis, given above.

The Western Drainage Area.†

The main drainage lines of the western area are such as would be developed by the structure of the country, and they are practically the same at the present as they were in preglacial times. The Knobstone sandstones, with their capping of limestones, rise in an eastward facing escarpment, unbroken except where cut through by East White River, from the Ohio River at the south side of Harrison County to the northeast corner of Brown County. This escarpment

*A condition of affairs quite similar to that hypothecated here exists at the present time in Townships 1 south and 1 north, 5 and 6 east, where Muddy Fork of Silver Creek forms a triangular valley opening out to the east, while the divide between this stream and Blue River, which flows west, is quite low.

†The drainage of southern Indiana, in its relations to the glacial period, is discussed and mapped by Leverett in Monograph XXXVIII, U. S. Geological Survey, p. 97, et seq.

See, also, Mr. Leverett's discussion in Part IV, 18th Annual Report U. S. Geological Survey, pp. 446–458.

rises from 200 to 400 feet above the lowlands of the central drainage basin immediately east of it, while to the west the country is rolling and descends gradually. The streams rising near the escarpment at the east, flow down the gentle slope to the west and finally enter the Ohio, White or Wabash rivers.

The control of the structure upon the drainage lines of this area is best seen immediately west of the Knobstone escarpment between East White and the Ohio rivers (Plate II). North of East White River apparently only the general course of the drainage is controlled by the structure; in a general way the longest tributaries of the streams are those coming in from the east and northeast. This feature is by no means clearly marked, even in the area underlain by the comparatively hard Lower Carboniferous limestones and Mansfield sandstone. It is noteworthy that the streams of the western area, which flow across both the area underlain by the Lower Carboniferous limestones and that underlain by the (Mansfield) sandstone at the base of the Coal Measures, are not deflected as they pass from the limestone into the sandstone area.

The Mansfield sandstone is often massive, and forms a rugged topography in the region in which it outcrops, and it might be expected that the streams would be deflected to the north or south by it. However, no such change in their courses occurs; instead of being deflected they pass directly from the limestone area across the sandstones, through which they have cut deep valleys (see Plate II, Townships 3 north, 2, 3, 4 west) until they reach the comparatively flat region underlain by the soft Coal Measures shales and sandstones at the west side of the Mansfield sandstone. These conditions lead to the conclusion that the streams from the land at the east cut directly across the Mansfield sandstone as that sandstone was first being elevated above the water, and thus early established themselves in approximately their present courses. In the region underlain by the soft sandstones and shales of the Productive Coal Measures the only systematic arrangement noticeable in the streams is that of their general southwest directions.

Attention should be called in this connection to the sudden southward deflection of the east and west forks of White River, where these streams after passing through the Mansfield sandstone areas, strike the area of the Productive Coal Measures in Martin (D, Plate VII) and Greene (E, Plate VII) counties.

The deflected portions of these streams are in a line with the south course of Anderson River between Spencer and Perry counties (F, Plate VII) in the extreme southern part of the State.

The coinciding deflections of these streams are suggestive, as they occur in a line approximately parallel with the position that must have been occupied by the shore line during a portion, at least, of Productive Coal Measures time, and the suggestion is made that these streams had their courses turned parallel with the old shore line at that time, and that the streams have occupied approximately that position ever since. In this connection the south deflection of the Wabash near Covington and its due south course from Covington to Terre Haute parallel to the above mentioned portions of the two forks of White River and in a line with the southward deflection of West White River near northeast of Vincennes (D, Plate VII) is of interest, and suggests the same causes.

The general absence of surface drainage systems through the region underlain by the Lower Carboniferous limestones owing to the cavernous nature of those limestones, and the well developed underground drainage has already been remarked upon (page 282).

East White River flows from the central across the western area and forms one of the principal streams of the western area.

North of the north line of Monroe and Brown counties the tributaries of West White River flow through glacial debris and are left out of the discussion, as are also those streams that flow across the Productive Coal Measures west of West White River.

SUMMARY.

In summing up the discussion of the drainage systems of southern Indiana attention is called to the following points:

1. The drainage in the region but thinly covered with drift, as well as in the driftless region, is controlled by the geologic structure.

   The drainage (except in the eastern area) is towards the southwest, with the dip of the strata, and is such as would logically develop from a gradual elevation of a land surface beginning at the east part of the State, and a corresponding recession of the water towards the southwest. The evidence points to the conclusion that the present drainage has developed from such ancient initial drainage, and the writer believes this to have been the case.

2. The writer is unacquainted with any evidence in southern Indiana that the drainage has ever been towards the north and east.*

*See the Ohio State Academy of Science, special papers No. 3, p. 68, et seq. Preglacial drainage conditions in the vicinity of Cincinnati, by Gerard Fowke. Evidence is produced to show that the Ohio flowed northeastward in preglacial time from near Madison.

If the preglacial drainage of southern Ohio and southeastern Indiana (the eastern area of the present discussion) was formerly towards the north and east, as is believed by some to be the case, then the watershed between such northeastward drainage and the southwestward drainage of Indiana was the highland formed by the Niagara and Devonian limestones, i. e., the present watershed between the eastern and central drainage areas of southern Indiana.

How far north this watershed may have extended can not be conjectured, but it probably extended at least as far north as Clinton County (see Plate I).

3. It is believed that that portion of the State in which the preglacial topography and structure were similar to the present topography and structure of the driftless region, had also preglacial drainage systems parallel in a general way with the present drainage systems of the driftless region, and this includes most of that region which lies west of the southwestward dipping Niagara and Devonian limestones.* By "driftless region" is here meant that region in which the drainage systems are not controlled primarily by the drift.

CONCLUSIONS.

The study of the strata of southern Indiana brings out the following facts:

First. Between the Hudson River epoch and the end of Carboniferous times there were the following general periods of deposition:

1. From the Hudson River epoch to the end of the Hamilton was a period during which the sea was shallow or only moderately deep, and the conditions were favorable for the deposition of limestone and calcareous shales.
2. From the Genesee to the end of the Knobstone epoch was a period during which, with the exception of short intervals, the sea carried much sediments. During this period of muddy seas the New Albany shale and the Knobstone strata were deposited.
3. At the end of the Knobstone epoch there was a general reversion to clear seas and conditions favorable to marine life, and to the deposition of limestones. During this period the Lower Carboniferous limestones were deposited.

*The drainage through the north end of the central area—i. e., in the region of Clinton County and northwest of there—may have been towards the northwest so far as the structure is concerned, but the writer knows of no reason for supposing that it was in that direction.

4. In the area of western and southwestern Indiana Upper Carboniferous time was marked by alternating shallow sea and inland basin conditions. The waters, whether salt or fresh, were heavily charged with sediments during this time, and sandstones, shales, and coal beds were deposited.

Second. From Lower Silurian to the end of Lower Carboniferous time the sea that covered southern Indiana was shallow or only moderately deep, with the possible exception of a portion of Lower Carboniferous times. Shallow water conditions prevailed also during Upper Carboniferous time.

Third. Except for the pebbles found in the Clinton (cited on page 244) and the absence of that formation in certain localities, and the slight unconformity between the Niagara and Devonian limestones (cited on page 246), there is no evidence to show that the rocks were raised above the surface of the sea for an important interval at any time between Lower Silurian and the end of Lower Carboniferous time; the unconformity between the New Albany shale and underlying limestone of Kentucky has not been recognized in Indiana.

Fourth. At the end of Lower Carboniferous time the sea floor was raised above the surface and following this elevation was a long period of denudation. The elevation of the land was greater in the northern (i. e., in the region about Crawfordsville and Lafayette) than in the southern portion of the State during this period. This is the *first denudation interval* which is certainly known to have interrupted the deposition of strata in southern Indiana.

Fifth. Following the *first denudation interval* was a period of subsidence. The depression of strata was sufficient to completely submerge what is now the western and southwestern part of the State, i. e., that portion of the State that is covered over by the Mansfield sandstone. As the sea encroached upon the land during this period of subsidence the Mansfield (Basal Coal Measures) sandstone was deposited along the shore lines.

Sixth. After the deposition of the Mansfield sandstone the rocks were again elevated above the sea, and a period of denudation followed in which the Mansfield sandstone was in part removed. This is the *second important denudation interval* certainly known to occur in the southern Indiana section.

Seventh. After the second interval of denudation there was a subsidence, followed by many oscillations of the strata. During this period that portion of Indiana which is at present covered by the Productive Coal Measures was alternately below the sea, and near to or above the surface of inland fresh waters. The Productive Coal Measures were deposited during this time.

After a period of erosion at the end of the Productive Coal Measures time there was a submergence of the strata during which the Merom sandstone was deposited. Probably only the western part of the area covered by the Coal Measures was submerged at this time.

Eighth. After the deposition of the Merom sandstone there was an elevation of the entire region of southern Indiana. Evidence that indicates that the region has been submerged since Carboniferous times is cited in the next paragraph.

Ninth. The evidence that indicates that the area of southern Indiana has been submerged since Carboniferous times consists of gravels of supposed Tertiary age that occur on some of the high hills in the southern part of the unglaciated area of the State. In the region crossed by Township 3 north, this evidence is very meager indeed.

Tenth. While there have been a number of changes in elevation during the past geologic history of the region under discussion these changes have been of the nature of broad uplifts and depressions, as is shown by the fact that no sharp local folds were produced.

Eleventh. That the southern part of Indiana formerly stood at a higher elevation than at the present time, is indicated by the filled valleys that are the rule in that region.

Twelfth. The Crawfordsville Crinoid beds (regarded as of Keokuk age) are the equivalents of strata that belong to the Knobstone group further south. The latter must therefore be, in part at least, of Keokuk age, if the correlation of the Crawfordsville beds be correct.

In regard to the topographic features of Indiana, the following facts are brought out:

Thirteenth. In passing from east to west across southern Indiana three prominent topographic features are crossed. These features and the combinations of strata that have caused them are as follows, where crossed by Township 3 north:

(1) The high eastward facing escarpment along the Ohio River caused by a thick series of easily eroded calcareous shales overlain by thick and resisting limestones. (2) The high eastward-facing escarpment with its outliers to the east, known as the "Knobs." This escarpment is the result of a thick series of soft clay and sandy shales, protected by sandstone and resisting limestones. Along the line under discussion this escarpment is 28 miles west of the escarpment along

the Ohio. (3) The high hills of Martin County, which are the result of a series of limestones and sandstones capped by more resisting sandstones and which do not rise as an escarpment from the east, but become gradually higher, owing to the resisting nature of their lowest beds. The distance from the Knobstone escarpment to the highest hills capped with the Mansfield sandstone is about 30 miles. Between these prominent topographic features are broad, flat trough like valleys worn out in the soft beds which lie between the hard and resisting series of strata just mentioned.

Fourteenth. The structure of each of these topographic features where crossed by the section is essentially the same in different stages of development, i. e., that of dissected plateaus sloping gently to the west.

Fifteenth. The top of the eastern plateau where crossed by the section through the center of Township 3 north, is 800 feet above the sea, that of the middle is 820 feet, and that of the western 880 feet above tide, while but a short distance to the north or south the topographic sheets show the elevations of these plateaus to correspond even more closely.

Sixteenth. These closely corresponding elevations suggest that the present topography of southern Indiana may have been developed from an old base level. A former plain of deposition, or a combination of a plain of deposition and a base level of erosion might, however, have given rise to the present topographic features.

Seventeenth. The present drainage systems of southern Indiana owe their general arrangement to the geological structure of the region (with the possible exception of East White River below Rockford); they are very old, and the modifications in them caused by the ice invasion were of minor importance, with the possible exception of East White River.*

*Owing to absence in the field the author was not able to read the proof of this paper.

ON THE PETROLEUM INDUSTRY IN INDIANA IN 1901.

By W. S. Blatchley.

The year 1901 was the most active in the history of the Indiana Petroleum Industry. The number of wells sunk and barrels of oil produced were far in excess of those of any previous year. Notwithstanding these facts, the area of known productive territory was but little increased. No new pools of importance outside of the main field were opened up, and that field had added to it only a few square miles of territory near Marion, Grant County, and small areas in one or two other places, less than a dozen square miles in all. Steady drilling inside the limits of productive territory was the rule during the year. Fewer wild cat bores were sunk, and most of such ventures proved abortive. A good average price was obtained for the oil, better than in any other year except 1900. The fluctuations in price were less than for a number of years, the variation between the minimum and maximum prices being only 15 cents per barrel. The average initial output of producing wells was slightly higher than in 1900, thus showing that the main oil territory of Indiana has not as yet reached the zenith of its output.

There is no doubt but that, as the gas pressure declines and the supply of that valuable volatile fuel ceases, the greater part of the present gas territory will produce oil. Both gas and oil had a common origin, viz., the destructive distillation of the plants and animals of the old Silurian days. Neither is being formed in commercial quantities beneath the surface of Indiana at the present time. The gas is but the volatile portion of the oil which has risen into the higher porous portions of the Trenton limestone, the mother rock, productive of both. When gas ceases to flow, the hydrostatic pressure behind the oil will press the latter into the spaces which formerly held the gas. As a result, many bores formerly sunk for gas, when cleaned out and drilled a little deeper, will produce oil. Many of the first wells sunk for gas were drilled only 20 to 35 feet into Trenton, whereas the experience of recent years has shown that much of the oil is secured between 40 and 70 feet in that formation. But few have found oil below 75 feet in Trenton.

Not all the present gas-producing territory will yield oil, as over much of it the gas doubtless occupies porous portions of the Trenton which lie to one side rather than above the bodies of oil which in the past have yielded the gas. It must always be remembered by persons who seek to develop both gas and oil, that gases and liquids possess some properties which are widely different. Every gas possesses the property of diffusion, which causes it to occupy all the space into which it can find its way. Its particles move freely among one another and the interspaces between these particles vary greatly in size according to the pressure to which the gas is subjected. For example, a gallon of natural gas, poured into an air-tight room will, in a short time, permeate every portion of that room; each cubic foot of space in time holding a like number of molecules of the gas. In like manner natural gas has found its way through very minute pores or spaces of the Trenton limestone into areas of such limestone, perhaps quite distant from the mother pool of oil. The latter, on account of its being a liquid with far less freedom of motion among its molecules, does not possess this power of diffusion and occupies only those porous portions of the Trenton in which it has been collected by gravity or by the hydrostatic pressure of the water behind it. Thus it will be seen that these reservoirs of oil may be immediately below the gas and often with their surface levels reaching in places a slope of an anticline to which bores may be sunk without penetrating the gaseous reservoir in the crest of the anticline; or they may be at some distance to one side of the gaseous reservoir to whose contents they have given origin. Wherever gas is found, a body of oil is likely to be found at no great distance in the same formation. Oil, however, may be struck in a territory and no gas be found; the latter product, if formed, having by its property of diffusion, escaped into the atmosphere, or disseminated in small quantities throughout the neighboring rocks. It may be also that the conditions for the volatilization of any large portion of the oil have been absent; the liquid, by strong and never ceasing pressure, having filled all the space in the pores of the rocks which it occupies. In such a case the quantity of gas would be small or wholly lacking.

SURFACE INDICATIONS.—One other thing I would mention in this connection. *In Indiana there are no surface indications whatever which denote the presence of gas or oil* in the underlying rocks. Scarcely a day passes but I am in receipt of a letter from some portion of the State, in which it is stated that bubbles of gas are continually escaping from some pond, spring or stream, or that a light scum of oil occurs upon the surface of some body of water. The persons writing believe that such bubbles or scum are certain indications of the presence of large quantities of gas or oil in the vicinity. In this they are always mistaken. Gas and oil are found in commercial quantities in Indiana only at depths ranging from 500 to 1,600 feet below the surface.* Between the formations containing the gas and oil, namely the Trenton limestone and the Corniferous sandstone, there are always one or more close-grained shales 50 to 300 feet in thickness. These shales are wholly impervious to both gas and oil; i. e., no particle of either of these fluids can find its way through them. In fact, such a shale is an absolute necessity to the presence of a commercial body of either gas or oil, else both these would have long since found their way upward into the atmosphere. The bubbles of gas, noted as escaping from water, are, in almost every instance, marsh gas, which is formed by decaying organic matter at the bottom of the water, or in some deposit of carbonaceous material near by. The oil has exuded in minute quantities from some shale, clay, limestone or sandstone, as all such rocks contain some oil. But a drop or two is necessary to form many square feet of film or scum over the surface of a spring or pool.

Again, the oil-producing rocks in Indiana follow no definite direction, as in some other States. There is no northwest-southeast, or northeast-southwest axis or trend which the intelligent operator can follow and sink a productive bore 99 times out of a hundred. His operations in Indiana have always an element of chance connected with them. If he keeps well within the bounds of productive territory his chances of failure are much fewer than if wildcatting on the outside of such limits. But on the best area of productive territory an occasional bore will come in dry. In the early history of the Indiana field these dry holes, especially if they were a little to one side, were thought to condemn large tracts. However, some of the best wells of recent years have been sunk on such condemned areas.

Oil Smellers.—A number of letters have been received in recent months asking if there is any instrument by which oil can be located in paying quantities. Some of these letters are from parties who have employed so-called "oil experts." Mr. Charles E. Wyman, of Martinsburg, Washington County, in writing of his experience, said: "The expert whom I employed came from Chicago. He would get out of the buggy about every quarter of a mile and go to the rear in such a position that I could not see what he was doing. He

*The Jasper County field is an exception to this, a heavy form of oil being there found at 100 to 120 feet below the surface. However, a shale impervious to the oil lies between t and the surface.

would only be gone a minute or two, and I could not get a chance to see the instrument which he claimed to have. Both he and his companion assured me that they could locate oil if in paying quantities within six miles of them. Do you know of any instrument or substance that oil will attract or repel, or have I just been duped? It would be a great thing to know where oil lies in paying quantities before the wildcat bore is put down."

With this last statement I fully agree. There would be no wildcat bores if such knowledge were possible. To all such inquiries I reply that there is one instrument, and but one, that can be used in locating oil, and that is the drill. All others are and ever will be humbugs; and all men who claim to be able to locate oil in commercial quantities by instruments, hazel rods or what not, are either harmless innocents or fakirs of high degree. They may by chance locate one or two productive wells, but there is no guarantee but that the next half dozen bores will be as barren of oil as a dried codfish is of water.

FAKE OIL COMPANIES.—The discovery of oil in large quantities in Texas, in the spring of 1901, led to the formation of scores of "get-rich-quick" oil companies in different parts of the United States. These companies have filled the papers with glittering advertisements of shares that could be purchased for five to twenty cents on the dollar, but which, in a few days or weeks, would increase twenty to a hundred-fold in value. Prospectuses have been scattered broadcast, which have told in glowing terms of the immense profits to be made in a year or two. Stock certificates by tens of thousands, representing the finest specimens of the engraver's art, with pictures of derricks on each corner, and tiers of barrels in the background, have been issued to the gullible. The average American citizen likes to be humbugged, and the fake oil company promoter has, during 1901, given such citizen the best opportunity he has had for years.

The available assets of most of these companies consists of little more than a superb allowance of gall, and a hundred or two dollars invested in prospectuses and stock certificates. A number of these companies have bought room enough on the crest of Spindle Top Hill, near Beaumont, Texas, for a derrick to stand upon; have leased or bought a small tract of wholly undeveloped and probably barren territory somewhere within a hundred miles' radius of that noted field, have put down a single productive well on Spindle Top, and then have promulgated the news in all ways possible that they have "brought in a gusher," and that the proceeds from the sale of the

200,000 or more barrels which it is daily producing, and of others which they will soon bore, will make millionaires of all the stockholders in the company. No more palpable fraud was ever devised to separate the citizen from his hard-earned dollar than these mushroom oil companies. Not one person in ten thousand will ever get a cent of dividend on the stock he has purchased. Not one in a thousand will ever again see the principal he has invested. The oil sharper finds it a great deal easier and more profitable to sell the highly engraved certificates of stock than to drill oil wells or develop any actual oil property. The Oil City Derrick, in commenting on the multiplicity of such companies, said: "There are honorable exceptions, and companies are in the field, officered by gentlemen of the highest integrity, with no other purpose than the prosecution of a legitimate business upon business lines. They can be enumerated with ease, identified without difficulty, and indicated by the fingers on one hand. The square companies have no stock for sale. All the rest are fake organizations, or, what amounts to the same thing, organizations on paper, with no assets except the green goods in which they deal—in this instance green-tinted paper called certificates—which might as well be sawdust or paper waste so far as current value is concerned."

If such companies had confined their operations to Texas, but little would be said about them in this connection, but several of them, organized in Chicago and elsewhere, have bought up or leased small holdings in Indiana, and have been selling their worthless stock to the citizens of this and adjoining States. One of these, located in Chicago, leased 326 acres near Wilders, Indiana, and then issued an attractive prospectus, one of the main features of which was a portion of the report on the Jasper County oil fields made by this department in its annual report for 1900. The paper, as prepared and published by me, was, in this prospectus, garbled in every conceivable way to make it conform to the best interests of the Chicago Oil Company. Words and whole sentences were omitted or changed, as the interests of the said company demanded. Their prospectus stated that they had seven producing wells in operation, with an output of 75 barrels daily, and that the net profits from the output of these wells in one year would be $100,000; and from 100 wells, which they expected to sink, $675,000 per year. Mr. C. K. MacFadden, of Geneva, Indiana, the well-known superintendent of the main Jasper County field, visited, without making known his identity, the offices of this company in December, 1901. From his letter to me regarding this visit, I quote as follows: "Never in my life have I seen such a brazen and deliberate steal attempted by people who put up an outward appearance of respectability and honesty. Their statements, almost without exception, were absolutely false, and instead of having a production of 135 barrels daily, my field superintendent informs me that the total production from their wells would, in his judgment, not fill a teacup with oil in twenty-four hours' pumping, and that their oil which is used for exhibition purposes must have been taken from either our tanks or from those of our neighbors."

Another fake oil company, located in New York City, but incorporated under the laws of South Dakota, also sends out an attractive prospectus, stating that they have secured 320 acres of land located in Indiana, 75 miles from Chicago; that they propose to sink four wells to each acre, which wells will average two barrels per day. This product, when sold at $2.00 per barrel, will yield a net profit of $967,000 annually, to be divided among the stockholders. Fifty thousand shares of stock at 20 cents each are offered to a gullible public.

The whole Jasper County field, at the present rate of production, will not yield in 20 years, what a single one of these companies offers to produce in one year. Better it would be for the person who has money to invest, to buy grass seed and scatter it abroad for the sparrows, than to invest in the stock of these or other similar companies. The assurance of some kind of returns from the investment would be infinitely greater.

There are doubtless many legitimate oil companies in Indiana and elsewhere which are operating valuable holdings, and which have stock for sale. The remarks above made apply in no manner to such companies. For the most part they do not advertise their stock by the methods mentioned. If each person who has money to invest would investigate, either personally or through some reliable party who is known to him, the oil property of the company whose stock he is thinking of buying, it would lessen the profits as well as the number of such fake companies as we have mentioned. In investing in oil stock or anything else, it never pays "to buy a pig in a poke."

SHALLOW BORES IN CENTRAL-SOUTHERN AND WESTERN INDIANA.—Investigations carried on during recent years in the central-southern and western portions of Indiana and records of many bores which have been sunk in those regions, have led me to believe that the majority of the drill holes sunk therein in search of gas and oil failed to reach Trenton limestone, the rock formation which produces the most of the gas and oil in this State. This failure to sink the bores deep enough was due to several causes, chief among which is the great difference in the strata overlying the Trenton limestone in these portions of the State from those overlying the same formation in the main gas and oil-producing areas. In the latter areas the Niagara limestone of the Upper Silurian age and the Hudson River limestone and Utica shales of the Lower Silurian, are the only formations to be pierced by the drill between the drift or surface and the oil and gas-bearing Trenton. In the central-southern and western portions, especially the latter, a number of formations which are wholly absent in the main gas and oil field, intervene between the surface and the top of the Niagara limestone. The drillers employed during the gas and oil excitement of 1887 to 1895 to sink the bores in these regions were, for the most part, from the gas fields. Their knowledge of geology was small, and in many instances, after passing through a shale which resembled the Utica, and which they doubtless thought was that formation, they called the underlying rock "Trenton limestone," and soon abandoned the bore as barren. The shales which they had pierced may have been any one of a half dozen carboniferous shales, or, what is more likely, the black Genesee shale, no one of which occurs in the main gas field.

Again, strong flowing veins of salt water were struck in a number of the bores, and the local companies, whose members were paying for the drilling, became alarmed at the extra cost necessary to case off such water, and often abandoned the bore before reaching Trenton. In a number of instances in the southwestern counties, the Corniferous limestone, which in places, as Loogootee, Terre Haute, etc., is oil and gas-bearing, was not even reached, though it lies 900 to 1,200 feet above the Trenton. Wherever a bore was thus abandoned without reaching Trenton, all the money spent was wholly wasted, there being neither negative nor positive results. Moreover, much territory was condemned as nonproductive without being given a fair test.

The foregoing statements are not made because I believe that gas or oil in paying quantities will eventually be found in the Trenton limestone of southern and western Indiana, for I have no reasons for such belief. Neither have I reasons for believing the contrary. If the earlier bores had of a certainty reached Trenton and proven barren, then negative evidence would have been available. The one fact which I do wish to impress upon the citizens of the regions mentioned is that much of their territory has not been properly tested. Another and more important reason for the statement is to induce companies who sink future bores to see to it that nothing stops the drilling before Trenton limestone is reached, or, rather, before that formation has been pierced at least 75 feet. Beyond that depth there is little possibility of finding either gas or oil. A contracting driller of experience can easily and without great expense case off any salt water which may give him trouble. An accurate record of the thickness of each formation passed through, together with a small vial of the drillings of each, will aid much in determining the horizon which the drill is piercing at any depth, and such record and samples should always be kept.

THE MAIN INDIANA OIL FIELD IN 1901.

No great strikes were made in the main Indiana oil field in 1901, and new developments increased the area of that field but little. It extends from the Ohio-Indiana State line westward to Marion, Grant County, and from Warren, Huntington County, south to Hartford City, Blackford County. The greatest length of the field is about 48 miles and its extreme width about 20 miles. There are, however, a large number of sections within the area thus bounded which have, as yet, not been fully tested. A map showing the exact area tested up to January 1, 1901, with details of the new developments from January 1, 1897, to that date, was published in the last (1900) report of this department. The details which follow relate, for the most part, to bores sunk during 1901 on the sections denoted as untested on the map mentioned. The number of barrels of oil produced in the main field in 1901 was 5,307,579, or 92.7 per cent. of the total product of Indiana Trenton limestone oil.

Developments in Adams County in 1901.—In Adams County the year started out with the drilling in of two or three good wells on the Studebaker and Tumbleson leases, Section 31, Blue Creek Township. One of these flowed at the rate of 300 barrels daily for a short time, but dropped to 150 when put to pumping, and to 75 in about two weeks. Several others almost as large were put down during the year in that section, while a number of bores on the same leases struck less porous Trenton, and yielded only 10 to 25 barrels in the beginning. Section 30, adjoining the pool on the north, produced one or two small wells and one fair one during the year.

On Section 36, Monroe Township, just west of the rich pool in Blue Creek, two small producers, and one bore with an initial output of 150 barrels, were completed. Two test bores were sunk about two miles northwest, in the same township, in the hopes of opening up a new field in that direction. One of these, on the Habegger lease, Section 34, was a small producer, starting at four barrels. The other, on the Shug lease, Section 21, was dry. A dry hole had been previously sunk on the Buffenberger farm, Section 25, so that the results were negative, and further drilling was stopped.

In Jefferson Township, Section 6 produced a few light wells. The only other new developments in this township were in Section 30, just north of the New Corydon pool, where a bore on the Collins farm, starting at 150 barrels, was completed in November. A test bore on the Hauser lease, Section 33, came in dry.

In Wabash Township bores on Sections 3, 13, 21, 25 and 26, shown as untested on the map of last year's report, resulted in dry holes; one bore alone, on Section 25, being a small producer. In the same township Section 20 produced some fair wells, while Section 32, previously untested, yielded a number of good ones. The west half of Section 33, adjoining, proved fair territory, as did also a portion of Section 36.

This was the sum total of new developments in Adams County during the year. Altogether 175 bores were sunk in the county, as against 120 in 1900. Of these, 157 were productive, the average initial output being 29.5 barrels, as against 25.6 in the previous year, a very good showing indeed. The percentage of dry holes was slightly increased, being 10.2 in 1901 and 9.8 in 1900.

In December the holdings of the Superior Oil Company, whose headquarters were at Geneva, Adams County, were sold to a New York company. The sale was one of the largest in recent years, consisting of 5,000 acres of leases in Adams, Jay and Wells counties, including the noted Blue Creek pool, northeast of Geneva. On these leases were 152 producing wells, with a total daily output of 400 barrels. The price paid was $300,000.

Developments in Jay County in 1901.—The developments in Jay County during the year were few and far between. It was thought for a time that new territory would be opened up in Pike Township, about five miles south of Portland, as three wells were completed in June on the Ware and Lush leases, Section 9, which started off at 15 barrels each. One or two bores had been previously sunk in this vicinity which showed a fair quantity of oil, but not enough to justify extensive operations. Three dry holes, located on Sections 8, 9 and 17, followed the small producers in October, while a fourth, on the Creamer farm, in Section 30, stopped drilling for the year.

In Wabash Township, near New Corydon, a well whose initial production was 100 barrels, was completed in April on the Martin lease, Section 4. This resulted in a number of bores being sunk on other portions of that section and on the north half of Section 5. Of these, three came in dry and three others were five to ten-barrel producers. This territory adjoins Sections 31 and 32, Jefferson Township, Adams County, where a number of good wells have been completed.

Bores sunk on untested territory in Bear Creek Township produced a dry hole on Section 3 and a five-barrel well on the Hardy lease, Section 19.

In Jackson Township a dry hole and a gas well were completed on Section 25, while Section 26, to the west, yielded three or four fair producing oil wells and two dry holes.

All other bores in the county were on known productive territory, though a number of them came in dry or as small producers. During the year only 70 bores were sunk in Jay County, as against 105 in 1900. Twenty of the 70 were dry. The average initial output of the 50 producers was 17.6 barrels, a decrease of 4.8 barrels from the average initial production of 1900.

Developments in Wells County in 1901.—This county, which, in the past, has been the banner oil-producing county of the State, still led in total output, but in the number of new wells sunk, became second to Grant. But little new territory was opened up within its bounds, but on territory already tested a large number of bores were sunk, the operators believing that they could afford to drill for small wells, owing to the lessened chances of failure. In this they showed a wise and conservative policy and at the same time maintained the production of the county.

In the eastern part of Nottingham Township, the limits of the known productive area was extended half a mile or so northward by the bringing in of a good well on the Berie farm, southwest quarter of Section 8 (13 east). In this region the average record of the bores is about as follows:

	Feet.
Drive pipe	70
Casing	310
Top of Trenton	980

In the same township several good wells were drilled in Section 14, along the eastern boundary of productive territory; also on the Schooly lease, Section 9. The southeast quarter of this section furnished a dry hole, as did also the Risser lease, Section 16, the Burger lease, Section 15, and the Slavey farm, Section 35.

In Chester Township, the limits of productive territory were extended a mile north to the Liberty Township line, a number of fair producing wells having been sunk on Sections 3 and 4. With them, however, were several dry holes, so that the new area is none of the best. Some of the best producers of the year in Wells County were brought in on the Maddox lease in Section 34 and on Section 33, adjoining.

The bores sunk in Jackson Township were numerous, and for the most part quite productive, the best one being on the J. J. Good farm, northwest quarter of Section 20. This township is now a close rival to Nottingham for production, and may even exceed the latter. The only new territory opened up was on the Terral lease, Section 7, and the Logue lease, northwest quarter of Section 6, where fair producers were drilled.

In Liberty Township a few small producers were bored on the Huffman and other leases in Section 30, a half mile or more north of the known limits.

The total number of bores drilled in Wells County during the year was 470, as against 579 in 1900. Of these, 40 were dry, an increase in percentage of 2.1. The average initial production fell from 19 barrels in 1900 to 17.2 barrels in 1901.

Developments in Blackford County in 1901.—The new developments in this county during the year have proven that a large portion of the untested territory shown on last year's map as lying between Hartford City and tested territory in Washington and Harrison townships, is productive.

In Harrison Township, on the west half of Section 31, four fair wells were completed on the Woodward, Walker and Stallsmith farms. The record of the bore on the last named farm, northwest quarter of the southwest quarter of Section 31 (24 N., 11 E.), was as follows:

	Feet.
Drive pipe	197
Casing	321
Top of Trenton	958
Total depth	1,058

In Washington Township, Sections 34, 35 and 36 have become fairly productive, a number of wells starting out at 25 to 60 barrels. One dry hole was bored on the Sipe lease, southwest quarter of Section 34; another on the Bugh farm, northwest quarter of Section 25, and a third on the E. Flower farm, Section 29, which had a tendency to stop further operations in those sections. On the southwest quarter of Section 6, one or two small producing wells were also sunk. The remaining bores in this township were on known productive territory. Sections 8 and 17 yielded the largest number of good producers. One of these, on the J. Byrd lease, in Section 17, created quite an excitement last February by being reported in the newspapers as a 3,000-barrel gusher. It was a large salt water well, and never produced over 225 barrels of oil daily. In ten days the yield was down to 65 barrels. It was but one-half mile from the Dale well, which, in 1898, started at 350 barrels.

Licking Township was the seat of most of the drilling in Blackford County during the year, 114 bores having been drilled in and about the edge of the Hartford City field. Of these, 36, or 31 per cent., were dry holes. The average initial output of the 78 productive wells was 28.4 barrels. One of the best wells finished in the new territory was on the Maddox lease, northeast quarter of Section 14, which started out in September at 250 barrels, and averaged 125 barrels the first week. Four other good wells were drilled in on this quarter section within an area of 60 acres. Four or five dry holes were sunk in the same section on the edges of this small pool. Two or three fair producers were also completed in the north half of Section 12. The south half of Sections 1 and 2 and the west half of Section 3 developed into good territory. On Section 4 dry holes were drilled on the northeast and southwest quarters. Three nonproducers were also finished on Section 9, which had the effect of condemning the entire section. The majority of the bores in this township were sunk on Sections 3, 10 and 16.

During the year 258 bores were drilled in Blackford County, as against 202 in 1900. Of these, 47, or 18.2 per cent., were dry. The average initial output of the productive wells was 20.9 barrels, a little more than double what it was in 1900, when more extensive wildcatting was the rule.

Developments in Huntington County in 1901.—There was much less doing in Huntington County during the year than in 1900, the total number of bores sunk for oil having been but 75, as against 147 the previous year. The only really new territory opened up was Section 36, in Wayne Township, where several fair wells were sunk on the White and Spaulding leases.

All of Section 31, in Jefferson Township, has come within productive limits, a number of good wells having been completed on this area. One of these on the George Scearce farm was an old gas well, which, when cleaned out and put to pumping without being shot, started off at 30 barrels. There are many such wells near the limits of former gas territory which have been abandoned for some time. They were never sunk sufficiently deep into Trenton to properly test the oil-bearing qualities of that rock. If cleaned out, drilled 30 to

50 feet deeper and shot, the most of them would probably yield oil in paying quantities.

Of the 75 bores sunk in Huntington County in 1901, but six, or 8 per cent., were dry holes. The average initial production was 24.7 barrels, as against 30.8 barrels the previous year.

DEVELOPMENTS IN GRANT COUNTY IN 1901.—To Grant County belongs the greater part of the new developments in Indiana territory during the year, as well as the largest number of bores sunk in any county, there being 578 drilled in, of which 80 were dry or gas-producing. While the larger number of wells were sunk in Center and Franklin townships, near Marion, the ones with the best average initial output were in the Van Buren Township field, which has slowly grown into one of the best, if not the best, producing territories in the State.

In this (Van Buren) township much of the territory marked as untested on the map of last year's report has been drilled, and, for the most part, proven productive. The northeast quarter of Section 10 produced several good wells, as did the south half of 19, the southwest quarter of 20 and the east half of 21. These were within known productive limits, but untested. All of Sections 25 to 30, in the next to the southern tier, produced fair to good wells, with the exception of Section 26, on which one dry hole and one 10-barrel well alone were drilled. The Pully lease in the northwest quarter of 29 and the Lugger farm in the south half of 30 were especially promising. On the south line of the township tests were drilled on Sections 32 to 34, 31 being as yet untested, and 36 having several dry holes and gas wells. The Rowland lease, northwest quarter of Section 32, produced one small well. On the Lease farms, west half of 33, four bores were sunk, one of which produced gas, the others, 5, 60 and 75 barrels initial output. A 45-barrel producer was also drilled on the Moriarty farm in the south half of the section. The southeast quarter Section 34 did better, as a test on the T. B. Doyle farm yielded a 100-barrel well.

In April, F. M. Johnson, one of the leading operators in the Van Buren field, sold his holdings, consisting of 1,000 acres of leases and 53 producing wells, for $65,000. The leases were on some of the best prospective lands in the township.

Monroe Township, just south of Van Buren, is, as yet, largely gas-producing. Previous to 1901 only the northwest quarters of Sections 15 and 18 and the south half of 25 had yielded oil, and that only in small quantities. During the year 20 additional bores were sunk in the township. Some of the most productive of these were on the Joshua Strange farm, northeast quarter of Section 15, one of which started at 100 barrels. Twelve bores were drilled on this lease of 160 acres, but one of which was dry. An average section of these was about as follows:

	Feet.
Drive pipe	238
Casing	390
Top of Trenton	993
Total depth	1,060

The two pay streaks were found at 1,021 and 1,035 to 1,050 feet. Some of the wells yield quite a quantity of gas. This is used for fuel on the lease and also supplies in part the citizens of Arcana, a nearby town.

The Hultz lease, on the southeast quarter of Section 15, had also two good wells sunk upon it. Several additional bores put down on different parts of Section 18 were light producers, while one on the Carter lease, southeast quarter, was dry. A test bore on the northeast quarter of Section 10 yielded gas and salt water. Another on the northwest quarter of 11 was a small producer, as was also one on the southwest quarter of Section 20. There is little doubt but that most of this township will become productive of oil as soon as the gas supply is sufficiently exhausted.

In Washington Township, west of Van Buren, almost all of Section 1 became good productive territory during the year. The Creviston lease, in the northeast quarter, had a half dozen or more good producers to its credit, and fair wells were drilled on each of the other quarter sections. The east half of Section 12, to the south, had two bores finished, which started at 90 and 120 barrels.

On the northwest quarter of Section 27 a bore on the Turner farm came in as a big salt water well, but, after pumping about six weeks, began to yield oil in paying quantities. Just north of Marion, in the west half of Section 31, two light producers were finished on the Vandermeter farms. The limits in the remaining portion of the township remained about the same as shown on last year's map.

The Marion field proper includes developments in Center, Franklin and Mill Creek townships. It was here that the most extensive work was done in Indiana in 1901, and the largest area of new territory opened up. At the beginning of the year there were developments only in four sections southwest of Marion in Center and Mill Creek townships. About 20 wells, with a total output of 200 barrels daily, were in operation. During the year 177 bores were sunk in Center Township, 78 in Franklin and 32 in Mill Creek. Of these, 41 in Center, 9 in Franklin and 13 in Mill Creek were dry or yielded gas only. The remaining 224 produced oil in paying quantities. At the close of the year the Marion field proper contained about 230 productive wells, the total output of which was close to 2,000 barrels daily.

Taking up Center Township in detail, by sections, we find that the Hays lease, southwest quarter of Section 2, produced a number of fair wells. The best of these was No. 7, a record of its bore being as follows:

	Feet.
Drive pipe	180
Casing	425
Top of Trenton	960
Total depth	1,061

Three pay streaks were found, the first one at 25 feet producing gas, the second at 40 feet oil, and the third at 60 feet oil. The well made 2,100 barrels the first 30 days. The southeast of Section 3 also developed two or three light wells, the initial output being 12 to 25 barrels each. A bore with similar results was also sunk on the Brinker lease, on Section 4.

In the next tier of sections, south, No. 7, lying just east of Marion and partially within the city limits had a large number of bores sunk upon it, most of which were on town lots or small tracts. Three of the best producers were on the northwest quarter on the Barley and Spencer tract of eight acres. Their No. 1 well, finished in June, made 200 barrels the first 24 hours, and 2,200 the first 30 days. By December 1st the product had fallen to 30 barrels daily. The record of this bore was as follows:

	Feet.
Drive pipe	190
Casing	410
Top of Trenton	910
Total depth	1000

Gas was struck in the first pay streak at 935 feet, and gas and oil in the second at 965 feet, the thickness of this pay being 35 feet. About 1,200 barrels of salt water are pumped each day with the oil. Wells Nos. 2 and 3 were lighter, making about 20 barrels each at the end of 30 days. On Section 8, one gas well and several light oil wells were completed. Section 9 produced gas alone, as did the northwest quarter of 10. The southeast quarter of 10 and all of 11 came in as light producing territory. Section 12 remained untested.

Section 13 produced two or three light oil wells, one gas well and one dry hole. On the northwest quarter of Section 14 several good bores were sunk, one of which flowed 50 barrels natural for several days. The remainder of the section was poor, yielding two gas wells and a dry hole. No. 1, on the Voris lease, near the center of 15, three miles east of Marion, started at 85 barrels and produced 1,600 barrels in 30 days. The record of its bore was:

	Feet.
Drive pipe	190
Casing	410
Top of Trenton	910
Total depth	1,000

The first oil was found 35 feet in and the second at 60 feet. Two other bores on the southwest quarter of the same section were light producers. On Section 16 one good well, a number of light ones, and one dry hole were drilled north and west of last year's productive area. Seventeen and 18 are mostly divided into town lots and small tracts. On these a number of productive wells, starting at 15 to 50 barrels, were drilled, and a few better ones at 75 or thereabouts.

Section 19, south of Marion, produced a dry hole on the Knight lease, northwest quarter, and two good wells on the Miller farm. On the Marion Brick Company's land, Section 20, four producers starting at 20 to 90 barrels and one dry hole were bored. Another dry hole was finished on the Henderson lease, and two or three light producers on the Kiger land. East of 21, which was developed in 1900, Section 22 yielded a water well; 23, two big gas wells, while 24 had a mixture of gas wells, light oil wells and water wells. These last three sections will doubtless produce a quantity of oil after the gas pressure has been sufficiently reduced.

In Mill Creek Township 40 per cent. of the bores sunk during the year were either dry holes or gas wells. The Ayres and Hiatt leases, on the north halves of Sections 28 and 29, produced a number of fair wells and two dry holes. A good well was bored on the D. E. Harris farm, Section 5, west of Jonesboro, and a small one on the Overman lease, same section. Bores in Sections 4 and 26 yielded gas only.

The operations in Franklin Township, west and southwest of Marion, were wholly new. They were started by the Marion Fruit Jar Company, which, about April 1st, cleaned out, drilled deeper and shot an old gas well on the Sohn farm, in Section 13, a mile and more west of any producing territory. It started off at 70 barrels, and, as a result, a number of rigs were immediately erected on that and adjoining leases. The No. 2 Sohn, finished about May 1st, showed a large pressure of gas, and pumped 100 barrels of oil. By June 1st five wells were completed, which yielded an average of 40 barrels each, besides several others which produced only gas or salt water. Bores on Sections 24 and 26, to the south and southwest of 13, came in dry and stopped development in that direction. The greater part of Sections 1, 2, 11 and 12, north and northwest, proved productive, the best well bored in the township being on the Isaac Smithson lease, Section 13. A record of it showed:

	Feet.
Drive pipe	140
Casing	390
Top of Trenton	920
Total depth	1,035

The first pay streak was found 40 feet in. This and most other wells in this township were bored 100 to 130 feet into Trenton. The well yielded 200 barrels the first day and 2,300 barrels the first 15 days. It was finished July 4th, and on December 1st was still producing 40 barrels daily. Besides the bores on the sections named, a few light producing wells were sunk on Section 14 and one or two on Sections 3 and 4.

In Pleasant Township, farther north, two bores were sunk in Section 36, one of which, on the Vandermeter lease, started at 15 barrels daily; the other, on the Faukbonner farm, was dry. One on the Matter farm, Section 23, yielded gas only. Another on the Campbell farm, Section 4, eight miles northwest of Marion, produced salt water and a light showing of oil, while still another, in Section 34, came in dry. This showed that this township is practically outside the limits of productive territory. It may in places yield a few good wells, but they will be in isolated pools rather than in the field proper.

Of the total number of bores sunk in Grant County in 1901, 14.1 per cent. were classed as dry holes or gas producers. This was quite an increase over the previous year, when but 5.4 per cent. were dry. The average initial output of the producing wells fell off but little, being 21.6 barrels, as against 22.5 in 1900.

ISOLATED AREAS OUTSIDE THE MAIN FIELD.

Developments in the Alexandria Field in 1901.—While the number of bores in the Alexandria field during the year were nearly double what they were in 1900, the results were far less satisfactory. The average initial output decreased from 39 to 21.7 barrels. Most of the wells were light producers, but few starting in at over 50 barrels. In the latter part of the year so many dry holes and small wells were completed that the operators lost hope, and the number of bores decreased greatly. However, one or two good strikes will start up brisk operations again.

In Richland Township, south of Alexandria, 10 bores were sunk, only four of which yielded oil. One of these, on the Meisner lease, Section 6, near the operations of last year, started at 75 barrels. A second bore, same lease, yielded water only.

The best well in the township was on the Fuller farm, same section. This had an initial output of 100 barrels. A dry hole was bored on the Jones farm, in Section 7.

In Monroe Township 94 bores were sunk, 39 of which were dry. Two of these, on Section 3, resulted in a 40-barrel well and a dry hole. One, in Section 4, produced salt water only. In Section 7 one bore on the D. Bowers lease started at 100 barrels, while several others on this and adjoining leases were small producers. A third bore, sunk by J. E. Lippencott, on the Heritage lease, near his big producer of the year before, produced gas alone, while two on the Edwards tract were dry holes. The Painter lease, on Section 8, produced two of the best wells of the year, their initial output being 75 and 150 barrels. The Kelly lease, same section, produced two dry holes and one light well, while on the Moreland farm a dry hole was bored. This shows the spotted nature of the territory.

On Section 9 a bore on the Wisehart farm started at only 10 barrels. The J. M. Hughes farm, on 10, had one well which yielded 150 barrels the first day, and another which started at 90 barrels. Most of the bores on Section 17 were light; one on the N. Carver farm, where, in 1897, the first big strike in the Alexandria field was made, producing salt water only. The Bowers and Watson leases on Section 19 produced some good wells; the Gilchrist farm some light ones; while a test on the Boyd farm came in dry. On Section 20, east of Alexandria, the S. H. Buck farm, on which a good test bore was sunk late in 1900, yielded two dry holes and two light wells. Several other bores on the same section were light or dry. Two dry holes were bored on the Innis and Nicson farms, in Section 23, while the Baxter farm, in Section 29, had a dry hole and two or three fair wells to its credit.

It will thus be seen that little, if any, new territory was opened up, the one section in Richland and 10 in Monroe at present producing all the oil in the Alexandria field. The total production of the field in barrels by months is given in the annexed table:

PRODUCTION OF THE ALEXANDRIA, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1901.

January	6,909
February	5,994
March	5,459
April	11,643
May	16,510
June	21,929
July	24,811
August	23,321
September	19,759
October	21,086
November	17,825
December	14,230
Total	189,476

THE PERU FIELD IN 1901.—No new territory was opened up, either in Peru, or in Erie Township, three miles east of the old field. In the former field but two bores, one starting at 40 barrels and the other at five, were drilled, while many of the old wells were abandoned. In the Erie Township field five bores were sunk, three of which were dry, the others being small producers. A lack of fuel for operating was one of the main reasons why the developments fell off so greatly from the year before, when 49 bores were sunk in the two pools. At the Kellar's Station or Rich Valley pool, in the edge of Wabash County, a few miles east of the Erie Township field, but three bores were drilled in 1901. Two of these were very light wells, the other dry.

The output in barrels of the Peru and Rich Valley pools by months for the year was as follows:

PRODUCTION OF THE PERU AND RICH VALLEY OIL POOLS BY MONTHS FOR THE YEAR 1901.

January	13,526
February	14,928
March	18,004
April	16,423
May	18,619
June	14,362
July	13,419
August	12,850
September	9,892
October	11,811
November	9,636
December	9,518
Total	162,988

This was a decrease of 74,300 barrels, or 31.3 per cent., from the production of 1900.

Developments in Wabash County in 1901.—Besides the three bores sunk in the Rich Valley pool, Noble Township, Wabash County, mentioned above in connection with the Peru field, two bores were sunk near Lafontaine, Liberty Township, about 12 miles north of Marion, Grant County, and one near Treaty, in the same township, four miles farther north. The latter developed a large flow of salt water and a good showing of oil.

One of the Lafontaine wells, on the Sparks farm, Section 25, made a fair showing of oil and a large amount of gas. The other, on the Green farm, same section, started at five barrels of oil and a large output of salt water. A well on the Logan farm, Section 35, Liberty Township, was also gas-producing. While some oil doubtless exists beneath the southern third of Wabash County, the chances are that it is in isolated pools and will be hard to locate.

Developments in the Parker-Selma Field in 1901.—The pools near Parker, Randolph County, and Selma, Delaware County, which may be treated as one, inasmuch as they are but three miles apart, were the seat of quite an amount of drilling during the past year. The first well of the year was opened up inside of the town limits of Selma, a mile or so from the nearest producing wells, and started at 10 barrels. An old gas well, also located near the town, which was cleaned out and shot, yielded 150 barrels of oil the first day. On the J. Meeks farm, east of Parker, several good wells were drilled, the largest of which had an initial output of 225 barrels, and at the end of 10 days was still producing 100 barrels.

In Section 36, Liberty Township, an old gas well on the Thorp farm, when cleaned out, drilled deeper and shot, produced 50 barrels the first day. A test bore on the Williams farm, Section 16, also showed up well, starting at 75 barrels.

In Section 1, Center Township, about three miles northwest of Selma, three light producing wells were drilled on the McGalliard and adjoining farms. They started at five to fifteen barrels each.

In Section 11, Delaware Township, a good strike was made on the Krohn farm, a mile southwest of the town of Albany. Trenton rock was struck at 925 feet and penetrated 50 feet. The bore yielded 60 barrels of oil and a large amount of salt water the first day it was pumped. Two other bores in the same vicinity proved dry.

By the close of the year 35 producing wells had been bored in the Parker-Selma field, while in locating them 22 dry holes and gas wells had been drilled. The average initial output of the producing wells was 30.1 barrels. In June a pipe line was laid by the Indiana Pipe Line Company from this field to their main station at Montpelier. The total number of barrels piped from the Parker-Selma field by months during the remainder of the year was as follows:

NUMBER OF BARRELS OF OIL PIPED FROM THE PARKER-SELMA OIL FIELD BY MONTHS FOR THE YEAR 1901.

June	5,055
July	6,035
August	6,985
September	7,188
October	7,672
November	7,743
December	7,715
Total	48,393

DEVELOPMENTS NEAR DELPHI, CARROLL COUNTY IN 1901.—In May a test bore put down one mile southeast of Delphi resulted in a small producing well, and for a time created much excitement, both among the residents of that city and among operators in different parts of the Indiana field. Major Laban Sparks, of Lafayette, had noted for years the escape of gas and oil in small quantities from a well on the banks of Deer Creek, within the limits of Delphi. This well was bored in 1890 for gas or oil to a depth of 912 feet. It developed a strong vein of sulphur water, which is still flowing, and a small quantity of gas, which, when lighted, will yet burn with a steady blaze a foot or so in length. Major Sparks organized a company, leased a large acreage of land and located his first well on the Stansel farm near the Carroll County fair grounds. A record of the bore, when finished, was as follows:

	Feet.
Drive pipe	30
Casing	650
Top of Trenton	954
Total depth	960

The casing extended through the Niagara and Hudson River limestones to the top of Utica shale. The Trenton limestone was pierced but six feet, on account of indications of a strong flow of salt water. Oil arose in the well to a depth of 800 feet. When put to pumping, it yielded 50 barrels for a day or two, but soon dropped to 10 barrels. The oil was a dark-colored, ill-smelling lubricating fluid. A sample of it was submitted to Prof. H. A. Huston, State Chemist, who reported on it as follows:

Lafayette, Indiana, May 31, 1901.

Indiana Oil and Asphaltum Company, Lafayette, Indiana:

Gentlemen—The sample of oil from Delphi, Indiana, submitted by you has been examined and found to have a density of 0.9045, equal to 25.5° Beaume; flash point closed test 252° F.; flash point, open test 270° F.; fire test, 290° F. Distillation test; 2.2 per cent. by volume is removed below 302° F.; between 302° F. and 572° F. 12.9 per cent. by volume is removed. This is what is considered the illuminating oil fraction, but so little of it comes over before the temperature reaches nearly the upper limit that it is probable that the oil would not be found satisfactory for illuminating purposes, and the quantity of it is hardly great enough to justify the distillation of this oil for producing illuminating oil.

When cool, the oil still flows at 5° F., and comes very near to the specifications made by the C., B. & I. R. R. for the oil called "Black Engine" oil, zero grade, which is used for lubricating car and engine axles during cold weather. The flash point of the oil is too low for the grade of Black Engine oil which they use in warm weather.

Very respectfully,
H. A. HUSTON,
State Chemist.

The well was shut down after a tank or two of oil had been pumped, on account of a lack of shipping facilities. As a result of this strike, six other bores were sunk, two in the immediate vicinity of the first, both of which produced about the same amount of oil. The three are being pumped by one power, and the product stored in tanks. No record of their exact output by months is available. The other four were half a mile or more distant, in different directions, and were dry. The pool struck by the three producing wells is probably of small area and wholly isolated from the main field.

THE BROAD RIPPLE FIELD IN 1901.—Not a bore was sunk in this field during the year. Several of the old wells have not been pumped for some time, while others are pumped only at intervals. The total production fell off nearly one-half from 1900, when it was 30,194 barrels. The amount produced by months in 1901 was as follows:

PRODUCTION OF THE BROAD RIPPLE, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1901.

January	1,648
February	1,077
March	1,447
April	1,861
May	2,432

June	1,176
July	1,227
August	1,900
September	1,159
October	1,790
November	473
December	848
Total	17,038

CORNIFEROUS ROCK PETROLEUM.

As noted in last year's report, oil is found in the Corniferous rocks of Indiana in three widely separated localities, namely, Terre Haute, Vigo County; Loogootee, Martin County, and near Medarysville, Jasper County. A detailed account of the developments in each of these fields up to January 1, 1901, was given in the report mentioned.

THE TERRE HAUTE POOL IN 1901.—No bores were sunk at Terre Haute during the year. The A. B. McWhinney well, drilled in the fall of 1900, and which showed but little oil when completed, began to yield in May, 1901, and, during the remainder of the year, produced 2,723 barrels, an average of about 12 barrels a day. A second well, sunk in 1899, about 40 rods northeast of the Phœnix well, was closed down most of the year.

The Phœnix well still remains by all odds the best oil well in the State. Finished in 1889, it has since averaged more than 1,000 barrels per month, and the yield seems to increase, the output in 1901 being 15,174 barrels, as against 12,090 in 1900. The total output of the Terre Haute wells by months during the year 1901 was as follows:

PRODUCTION OF CORNIFEROUS ROCK OIL AT TERRE HAUTE, INDIANA, BY MONTHS FOR THE YEAR 1901.

January	1,599
February	1,581
March	1,778
April	1,481
May	1,920
June	1,458
July	1,585
August	1,080
September	1,803
October	1,242
November	1,540
December	1,330
Total	18,397

THE LOOGOOTEE FIELD IN 1901.—Eight bores were sunk in the vicinity of Loogootee during the year. Six of these were in Sections 2, 3, 5, 34 and 35, Barr Township, Daviess County, and yielded gas only. Two in Martin County, on leases already developed, had a total initial output of 15 barrels. The number of barrels shipped from the Loogootee field by months, during the year, was as follows:

SHIPMENTS FROM LOOGOOTEE, INDIANA, OIL FIELD BY MONTHS DURING THE YEAR 1901.

January	755
February	606
March	449
April	563
May	586
June	554
July	...
August	569
September	549
October	572
November	...
December	701
Total	5,904

STATISTICS OF THE INDIANA PETROLEUM INDUSTRY FOR 1901.

As already mentioned, the output of petroleum from the Trenton Limestone fields of Indiana was greater in 1901 than in any previous year. This was due largely to the small fluctuation in value, and the fair average price received throughout the year. New wells were constantly coming in and all old ones were pumped to their full capacity. When the price of oil falls below 70 cents the operator often becomes disheartened, and stops drilling. Producing wells are also often disconnected. When the price ranges from 70 to 90 cents the operator is making a good profit, and the amount of production, provided the field has not reached its limit, is always advanced.

At the beginning of the year the price of Indiana oil was 82 cents. It continued to advance slowly until March 16th, when it reached a maximum of 89 cents. This price it held until April 1st, when it began slowly to decline, and by the middle of May had dropped to the minimum price of 74 cents. On July 17th it began to rise again, and September 28th reached the maximum of 89 cents once more. This was maintained until December 12th, when another decline began, the price at the close of the year being 80 cents. The average price for the year was 83.4 cents, as against 96.5 in 1900.

The total production of Trenton rock oil in Indiana in 1901 was 5,725,474 barrels, which, at the average price of 83.4 cents, amounted to $4,775,045. Compared with 1900, this was an increase in production of 812,798 barrels or 16.5 per cent. Owing, however, to the lower average price, the amount received by the producer was but $34,314, or .72 of one per cent. more than in 1900.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the eleven years beginning January 1, 1891, and ending December 31, 1901. This does not include the amount used in the field for fuel and other purposes. The second table shows the annual production, the average yearly price, and the total value by years for the same period:

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1902, BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
January	6,171	15,841	111,824	259,000	300,568	365,582	290,746	317,014	297,291	353,451	425,140
February	5,981	18,946	96,025	232,107	230,559	241,743	309,922	272,780	220,440	302,493	384,735
March	5,159	24,794	134,549	282,376	310,303	386,586	341,961	325,301	290,257	364,590	432,922
April	4,973	26,184	146,493	287,330	352,077	395,032	328,779	310,034	325,774	381,804	447,261
May	5,757	31,033	186,939	321,502	397,001	417,963	340,023	311,208	344,831	426,363	482,118
June	8,136	40,888	209,616	333,479	403,569	434,167	369,803	320,477	334,282	446,492	481,807
July	10,809	49,203	221,666	327,349	434,376	422,968	375,249	314,861	329,086	437,087	506,065
August	11,603	56,109	248,353	345,031	420,132	407,238	371,921	332,777	347,621	466,127	523,106
September	16,500	66,034	245,615	319,588	409,169	415,675	362,528	326,264	332,283	418,716	519,087
October	19,029	95,699	252,568	339,424	393,153	394,283	408,179	319,490	326,781	467,521	532,960
November	20,801	129,270	245,607	304,030	373,789	337,331	430,958	200,644	326,802	406,684	510,788
December	21,715	144,067	236,038	337,450	361,436	362,164	423,069	300,457	332,266	441,347	479,485
Total	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714*	4,912,675	5,725,474

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1902, WITH VALUE.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
Total production (barrels of 42 gallons)	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474
Total value at wells of all oils produced, excluding pipeage	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411	$1,871,849	$2,228,276	$3,331,750	$4,740,731	$4,775,045
Value per barrel	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63	$0 43	$0 59⅜	$0 87½	$0 96½	$0 83⅜

*This sum in the table on page 12, Report of this Department for 1899, was 11,000 barrels greater, that being the amount of Corniferous rock petroleum produced at Terre Haute in that year and included in the monthly production of Trenton rock oil.

From the above tables it will be seen that the largest production of Trenton limestone oil in any one month was in October, 1901, when 532,960 barrels were produced. The production of the Indiana Trenton rock fields for the eleven years reached the enormous total of 38,475,833 barrels, for which was received $25,849,735, or an average of $2,349,976 per year.

By adding to the foregoing table the output of the Corniferous rock oil at Terre Haute and Loogootee, viz., 24,301 barrels, we have a grand total of 5,749,975 barrels of petroleum produced in the State during the year, the total value of which was $4,795,312.

In the following table there is shown the number of wells put down in the different fields of Indiana for petroleum in each month since June, 1891:

NUMBER OF WELLS COMPLETED IN THE INDIANA OIL FIELDS FROM 1891 TO 1902, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	......	......	......	......	......	......	6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897	41	35	40	47	49	52	60	45	55	89	119	54	686
1898	41	23	29	43	38	55	53	80	72	82	92	86	694
1899	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900	113	67	98	148	165	163	158	155	135	152	118	108	1,580
1901	111	72	81	121	167	171	167	169	184	207	220	132	1,802
Total	.....	......	......	......	......	......	......	......	......	......	......	......	10,357*

*This does not include the wells in the Jasper County field, but includes those at Terre Haute and near Loogootee.

This table shows that 222 more bores were sunk for oil in Indiana in 1901 than in any preceding year. Of the 1,802 bores put down, 1,794 were in the Trenton limestone fields and eight in the Corniferous limestone field in Daviess and Martin counties. The fair average price received for the product throughout the year; the reduction in the cost of iron pipe and other supplies, and the fact that the majority of the bores were put down by old established companies in territory already known to be productive, were the principal causes for this increase of activity in drilling.

From the table it will be learned that up to January 1, 1902, 10,357 bores had been sunk in Indiana for oil. On that date, there were 6,765 producing wells in the State as against 5,492 on January 1, 1901, a gain of 1,273 for the year. By subtracting it will also be learned that since oil was first found in the State, 3,592 bores have proven dry or have been abandoned as nonproductive. The number abandoned in 1901 was 238, or 41 more than in 1900, while the number of dry holes drilled during the year was 291, or 76 more than in 1900. Of the total number of bores drilled in 1901, 16.1 per cent., or 1.1 per cent. more than in 1900, were dry.

The following table gives the

TOTAL NUMBER OF DRY HOLES DRILLED IN THE INDIANA OIL FIELDS FROM 1891 TO 1902, BY MONTHS.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	......	......	......	......	......	......	......	2	5	4	3	1	15
1892	2	6	6	2	3	4	2	3	3	18	6	21	76
1893	7	10	10	6	14	6	11	9	5	14	10	9	111
1894	19	14	24	14	13	13	9	21	15	14	8	17	181
1895	7	4	13	16	22	20	15	23	12	12	9	13	166
1896	10	13	6	28	26	20	14	19	4	4	6	8	158
1897	8	9	7	12	5	16	11	9	16	11	18	8	130
1898	14	4	2	13	9	6	7	10	12	8	13	16	114
1899	5	9	14	5	5	7	12	9	12	13	8	4	103
1900	11	6	16	20	27	20	32	26	15	21	26	17	237
1901	16	10	20	14	32	24	22	27	26	36	44	20	291

In the following table there is shown the

NUMBER OF PRODUCING WELLS, NUMBER OF DRY HOLES, TOTAL BORES AND AVERAGE INITIAL PRODUCTION OF WELLS DRILLED IN EACH OF THE OIL-PRODUCING COUNTIES OF INDIANA IN 1900 AND 1901.

COUNTY.	Producing Wells, 1900.	Producing Wells, 1901.	Dry Holes, 1900.*	Dry Holes, 1901.*	Total Bores, 1900.*	Total Bores, 1901.*	Percentage of Dry Holes, 1900.*	Percentage of Dry Holes, 1901.*	Average Initial Production of Productive Wells, 1900.	Average Initial Production of Productive Wells, 1901.
Adams	120	157	13	18	133	175	9.8	10.2	25.6	29.5
Blackford ...	166	211	36	47	202	258	17.8	18.2	10.4	20.9
Delaware	9	23	4	19	13	42	31.	45.2	18.6	16
Grant	227	488	13	80	240	568	5.4	14.1	22.5	21.6
Hamilton	3	1	7	......	10	1	70.	....	40.	40.
Huntington..	134	69	13	6	147	75	8.8	8.	30.8	24.7
Jay	64	50	41	20	105	70	39.	28.5	22.4	17.6
Madison	18	59	38	45	56	104	68.	43.2	39.	21.7
Marion	6	....	3	......	9	....	33.3	....	15.8	....
Miami	45	4	4	3	49	7	8.2	43.	15.4	13.7
Randolph ...	5	13	3	5	8	18	37.5	27.7	8.	44.2
Wabash	2	4	3	2	5	6	60.	33.3	12.5	5.
Wells	542	430	37	40	579	470	6.4	.5	19.	17.2
Daviess	....	....	10	6	10	6	100.	100.	....	....
Martin	3	2	13	......	16	2	81.2	....	20.	7.5
Total	1,344	1,511	238	291	1,582	1,802	†*a*15.	*a*16.1	*a*21.4	*a*21.5

*These columns include bores sunk for oil which yielded gas.

† *a* = average.

REPORT OF STATE INSPECTOR OF MINES.

Office of Inspector of Mines,
Indianapolis, Ind., February 10, 1902.

Prof. W. S. Blatchley, State Geologist:

Dear Sir—I have the honor to submit to you herewith my third annual report as Inspector of Mines, covering the calendar year of 1901, and being the twenty-second annual report of this department and the eleventh made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

TABLE OF CONTENTS.

REPORT.

While following the same general lines as in former reports, it has been our purpose to improve on the different subjects reported herein and the arrangement thereof, thus making the report more comprehensive, reliable and of greater interest to the general public.

The production of bituminous and block coal is given separately and each of the products is divided so as to show the entire product hand mined and machined mined, the same being subdivided into screened, slack and nut and mine run coal and the general distribution thereof.

The table of employes shows accurately the number of persons engaged in mining, being subdivided so as to show the number of persons employed at each class of work. The table of wages is also more complete, inasmuch as it shows the aggregate wages paid to each class of labor. We also give an average wage table, showing the gross earnings of miners, inside day men and outside day men, the average earnings per person employed in each capacity for the year. A comparative table is also given showing the increased gains in the number of tons and wages and per cent. of each over that of 1900.

There has been included in this report a table of lost time, showing the aggregate number of days lost at mines and the various causes thereof. Mine accidents have been handled more completely, either by table of by descriptive work.

The Legislature of 1901 gave to this office an additional assistant inspector and a clerk. This increase has enabled us to make inspections more frequently, to investigate accidents more thoroughly, etc., and has been of much value to the general work of this office. Andrew Dodds, of Oakland City, was appointed on March 11, 1901, as such additional assistant. His work in inspections and reports has been eminently satisfactory.

TABLE

Showing the Production of Coal in Tons of 2,000 Pounds in Indiana During the Year 1901 at Mines Employing More Than Ten Men, by Months and by Counties.

County.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Totals.
Clay	111,502	103,017	110,176	75,940	47,894	57,459	73,623	104,681	99,811	132,139	117,464	119,532	1,153,238
Daviess	24,620	22,000	15,870	21,539	17,362	10,191	14,133	18,856	20,512	24,119	20,006	21,012	232,287
Greene	117,118	108,081	109,890	80,262	65,973	50,586	70,796	90,733	94,925	117,994	128,109	136,003	1,170,470
Knox	7,223	6,587	6,519	2,579	2,770	3,093	1,594	4,554	6,825	5,229	4,727	8,482	60,162
Martin	680	815	763	918	396	426	....	....	....	....	....	....	3,998
Parke	70,056	76,611	58,527	46,195	42,354	41,093	40,396	48,528	54,824	56,577	66,205	71,639	673,005
Perry	2,763	2,148	1,748	1,783	1,437	1,287	1,192	1,228	970	1,351	732	1,040	17,679
Pike	27,427	24,461	25,942	20,455	15,599	10,766	14,904	12,297	18,478	29,258	33,519	35,802	268,908
Sullivan	105,161	93,180	85,131	79,521	82,074	54,696	57,756	59,702	75,839	96,718	84,439	96,097	970,314
Vanderburgh	20,485	21,362	18,325	12,720	6,738	7,548	9,739	14,066	15,595	19,765	18,224	18,328	182,895
Vermillion	74,185	67,034	68,551	58,626	54,555	46,115	54,566	51,618	56,107	60,122	71,220	75,824	738,523
Vigo	107,125	98,871	97,691	92,657	83,933	85,274	82,494	82,567	89,700	101,987	127,455	142,566	1,192,320
Warrick	23,151	21,225	20,796	19,463	15,083	16,747	12,781	13,273	16,447	21,376	19,300	18,283	217,925
Fountain	4,233	3,043	3,684	4,519	3,161	2,153	2,712	2,416	1,895	2,435	2,508	2,274	35,033
Gibson	7,939	7,499	8,120	2,581	5,322	6,090	8,555	8,608	9,562	12,046	12,944	13,180	102,446
Grand total	....	....	....	....	....	....	....	....	....	....	....	....	7,019,203

TABLE

Showing the Wages Paid to Employes in Indiana, During the Year 1901, at Mines Employing More Than Ten Men, by Months and by Counties.

County.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Clay	$109,269 85	$109,283 51	$108,660 38	$78,456 86	$62,592 00	$62,131 70	$90,284 51	$106,922 52	$103,482 15	$126,798 12	$114,651 81	$123,972 62	$1,196,506 03
Daviess	24,981 98	23,626 04	17,426 30	19,411 18	17,422 42	14,593 57	13,949 29	2,127 01	20,111 78	27,342 34	20,520 45	25,411 65	226,924 01
Fountain	3,988 60	3,145 95	3,640 13	5,369 50	3,259 95	2,811 90	2,723 45	2,688 45	2,211 15	2,803 95	2,773 56	2,434 37	37,850 96
Gibson	5,929 61	5,549 79	6,153 98	2,517 45	2,516 22	4,613 71	6,495 40	6,673 15	7,425 77	8,959 67	9,264 90	9,268 94	75,368 59
Greene	83,441 86	74,435 78	76,063 87	61,132 60	56,416 03	41,128 59	50,149 03	61,702 37	61,185 72	82,344 35	86,361 94	89,736 16	824,108 30
Knox	7,996 61	5,323 52	5,113 48	2,409 14	2,495 32	3,164 65	1,467 27	3,834 46	5,325 75	4,117 29	3,037 78	6,811 35	51,096 62
Martin	642 00	632 10	694 07	725 61	451 19	464 60	....	....	....	....	....	....	3,609 47
Parke	85,150 48	91,986 77	47,807 02	37,657 46	31,742 52	36,418 90	39,967 35	47,858 42	49,937 43	57,483 17	63,040 08	67,607 08	656,556 62
Perry	2,133 09	1,871 56	1,149 91	1,310 15	1,155 26	1,040 19	925 05	971 10	754 58	1,096 93	836 44	937 57	14,181 83
Pike	22,867 33	20,482 65	19,428 97	16,268 28	13,734 36	9,417 55	12,320 56	11,406 77	14,830 72	20,636 37	26,447 03	26,393 97	214,234 56
Sullivan	67,206 26	57,990 33	63,275 72	45,859 72	39,588 22	40,670 48	43,465 68	49,316 26	58,338 53	52,790 80	49,685 26	67,345 06	635,587 20
Vanderburgh	18,207 91	23,363 77	15,991 86	12,141 68	5,158 50	6,484 14	9,490 39	11,516 79	12,585 46	6,826 21	27,429 89	18,691 73	167,888 33
Vermillion	53,631 28	48,175 84	47,758 44	44,288 13	36,389 35	37,506 94	22,925 95	24,584 75	34,042 23	82,903 40	50,254 37	55,854 80	536,316 48
Vigo	83,379 99	59,195 83	81,077 69	71,917 54	71,362 24	74,812 39	72,934 60	73,999 08	73,390 34	84,079 74	92,859 44	98,639 69	901,650 17
Warrick	12,836 70	12,907 54	15,565 08	12,359 20	9,507 22	13,973 64	8,918 42	8,246 40	11,301 60	14,749 04	13,484 38	12,105 99	138,660 69
Grand total	....	....	....	....	....	....	....	....	....	....	....	....	$5,680,539 86

REVIEW OF COAL TRADE AND MINING CONDITIONS.

The coal business in Indiana for the year 1901, in all its various branches, has been unparalleled. The total production, which reached 7,019,203 gross tons, shows an increase of $736,140 tons, or 11.09 per cent., over 1900. This large increase may be attributed to several causes, the most important of which are, an increasing demand for Indiana coal in adjoining states, the absence of strikes of any consequence, the failure of the gas supply in many localities, necessitating the use of coal for fuel, the enlargement of mining facilities in the way of mining machines, mechanical haulage, etc., in some of our older mines, and the large increase in the number of new mines opened within the past two years (very probably the most important factor).

Yet, as large as was the increase in production, it would have been perceptibly greater had it not been for the shortage of railroad cars, which became a serious drawback, particularly during the months of October, November and December. However, in justice to the different railroad companies, it should be stated that the increased demand for cars was brought about by the unusual increase in the number of new mines opened in 1900 and 1901, there having been thirty-two in the former and sixteen in the latter year, an increase of about thirty-nine per cent. over any year prior to 1900. The greater number of the new mines referred to have become large producers, thus requiring an unusually large supply of cars at the mines, as well as between the mines and the various markets.

The market price of coal during the past year has been good, though varying considerably. In some instances, usually large contracts, the price paid at the mine was as low as eighty-three cents per ton mine run; while again it was sold as high as one dollar and twenty-five cents per ton.

The aggregate wages paid in 1901 amounted to $5,680,539.56, an increase over 1900 of $837,196.60, or eleven and nine-hundredths (11.9) per cent., while the total number of mine employes was 12,096, an increase of 3,208, or thirty-two and four-tenths (32.4) per cent. over that of 1900. Notwithstanding this large increase in employes, the average wage table given in this report shows the average earnings to be $436.29 per miner, $544.47 per inside day man. Considering the aggregate number of days lost from various causes, as shown by the table of lost time in this report, the above figures speak well for the earning capacity of persons engaged in mining and in other capacities at Indiana mines.

A careful review and examination of the tables and general descriptions in the following report will show beyond doubt that the year has been the best in the history of the Indiana coal business, and that the prospects for 1902 are equally promising.

IMPROVEMENTS AND CHANGES IN OWNERSHIP OF MINING PROPERTY.

Clay County.

The Collins Coal Company installed electric chain machines in its Gifford No. 1 Mine in October. Three machines are in use at the present time. This number will be increased as soon as there is sufficient room. Their No. 2 Mine is equipped with the same kind of machines; power will be furnished from No. 1.

The Brazil Block Coal Company has added to the equipment of its No. 8 Mine a Smith-Vail Electric Pump, it being used to pump out an old abandoned mine whose works are adjacent to No. 8. The pump has a seven-inch suction and a six-inch discharge, and is situated some 2,000 feet from the power plant at No. 8. The only attention required to keep it in operation is oiling once in twenty-four hours. This company has also installed a third-rail motor haulage in the main west entry of their No. 1 Mine.

The Jackson Coal and Mining Company has put in a revolving small coal screen at its Cornwell mine. The screen is forty inches in diameter and twelve feet in length, having one-fourth and one-inch mesh, and is driven by a twenty-four horse-power engine.

The Rob Roy Mine changed hands in May, and is now owned and operated by the Andrew Coal and Mining Company.

Daviess County.

The Daviess County Coal Company has built a new head-frame and tipple at its Montgomery No. 2 Mine.

Greene County.

The L. T. Dickason Coal Company equipped their Wild Cat Mine with electric machines in June. At the present time they have in use four Morgan-Gardner and two Sullivan machines of the chain type.

The Black Creek Coal Company has sunk and equipped with a stairway a second outlet, or manway, at its Black Creek Mine.

The Island Coal Company has put in the Mitchell dump at its No. 2 Mine, which has increased the capacity of the mine considerably, as well as assisting materially in cleaning the coal. The company has replaced the twelve-foot fan at No. 2 with one sixteen feet in diameter.

Knox County.

The Prospect Hill Mine changed hands August 8th, and is now operated by Freeman, Buntin, Wetzel & Company.

Pike County.

The Hartwell Mine, formerly owned by Cabel & Company, was bought by the S. H. Wulfman Coal Company, of Huntingburg, and is now being operated by the latter company. This company has made a new opening, and is also cleaning up and reclaiming some of the old workings.

The J. Woolley Coal Company has equipped its Petersburg mine with rope haulage, which will greatly increase the capacity of the mine.

The Alden Mine, located near Winslow on the Southern Railroad, formerly owned by the Alden Mercantile Coal Company, changed hands last spring, and is now owned and operated by the St. Louis Gas Company, of St. Louis, Missouri. The coal from this mine was formerly hauled by mules over a tram-road a distance of one and one-half miles to the tipple, which was located on a siding of the Southern Railroad within the corporate limits of Winslow. This mode of hauling the output of the mine was both slow and expensive, and the present company has recently constructed a railroad switch to the mine, erected a new tipple and equipped the mine with a view to securing a large output.

The Aberdeen Coal Company has provided a second outlet, or man-way, in compliance with the law, at the Aberdeen mine.

Perry County.

Bergenroth Brothers have replaced the furnace with fan ventilation at their Troy Mine. The change has greatly improved the sanitary condition of the mine.

Parke County.

Cox No. 3 Mine, formerly owned by the Brazil Block Coal Company, is reported as having been sold to the Bruiletts Creek Coal Company, the change occurring December 1st.

The Otter Creek Coal Company has sunk the Mary Mine to the lower block seam, i. e., Coal III, and is now mining from both seams. The second outlet was completed and equipped with a stairway during the summer.

Sullivan County.

The Indiana-Chicago Coal Company has added to the equipment of its Dugger Mine an electric fan, which has greatly benefited the ventilation of the mine. It has also replaced the third rail motor haulage system with a 10-ton Morgan-Gardner traction motor. This is the largest haulage motor now in use in Indiana mines.

The Bunker Hill Mine, formerly owned by Sexton, Crowder & Company, changed hands last spring, and is now owned by the Washington Fuel Company. The present company has bought three hundred acres of excellent coal land adjoining this property.

The Green Hill Coal Company has sunk and equipped the second outlet at its Green Hill Mine. The work of sinking the shaft and building the stairway was completed about September 15th.

The Hymera Coal Company, at the Hymera Mine, has sunk a shaft to the old workings in the top vein, which were abandoned about two years ago. The purpose of the shaft is to hoist out the water accumulated in the old workings, which have a very heavy dip away from the shaft, the water being considered dangerous to lives of workmen in the lower seam.

The Shelburn Mine suspended operation in April by reason of miners striking for pay. It remained idle until October, when it was leased by twenty of the former employes. They cleaned up the mine and commenced shipping coal November 1st. At last report, twenty-three persons were employed.

Vanderburgh County.

The Crescent Coal Company has sunk and equipped a second outlet at the Unity Mine (now Crescent Mine). They have also erected coal bins for the purpose of coaling railroad engines, and have made other extensive repairs on the surface plant, to the amount of something over five thousand dollars.

The machines at the Sunny Side Mine, owned by the Sunny Side Coal and Coke Company, have been taken out. The mine is now being worked solely as a hand or pick mine.

Vigo County.

The Bruiletts Creek Coal Company has made some very extensive improvements at their Klondyke Mine, located near Ehrmandale, having built a new tipple and lengthened the slope, thereby reducing the very steep grade. They have also bought a new hoisting engine.

The Seeleyville Coal and Mining Company has lately completed the manways at their Rose Bud and Royal mines.

TABLE

Showing Amount of Money Expended on Improvements of Various Kinds of Mine Property, by Counties.

Clay	$6,098 00
Daviess	3,120 00
Gibson	319 50
Greene	16,000 00
Knox	700 00
Parke	4,631 07
Pike	2,127 71
Sullivan	19,788 23
Vanderburgh	5,327 00
Vermillion	21,799 00
Warrick	300 00
Total	$60,210 51

STRIKES.

The year just ended has been productive of many local strikes, each of which, however, occurred at individual mines, and with but seven exceptions were of so short duration that no special mention of them will be made.

The exceptions referred to were strikes that occurred at the following named mines, i. e., Knox and Prospect Hill, in Knox County; Cannelton, in Perry County; Shelburn, in Sullivan County; Cayuga, in Vermillion County, and the Star No. 1 Mine, in Warrick County. Following is a brief statement of the causes and adjustment of each strike as near as could be learned, also the number of persons affected and the length of time lost:

On April 1st a strike was inaugurated at the Knox and Bicknel mines, brought on by a difference between operators and miners as to the price to be paid for lifting bottom. The former mine, employing a total working force of twenty-four persons, was idle through April, May and until about June 20th, at which time an adjustment of the trouble was brought about by concessions on the part of each of the interested parties. The Bicknell Mine, employing forty-seven persons, remained idle until some time in September, when, after repeated efforts on the part of the officials of both the miners and operators' organizations, a settlement was effected. We have been unable to learn the exact terms under which the miners resumed work, but are informed that each of the contending parties claims a victory. This being true, the settlement, no doubt, was satisfactory to all concerned.

The Prospect Hill Mine furnishes employment to a force of twenty-four persons. A strike occurred at this mine in October, originating from the discharge of two miners, but ultimately developing into a strike as to whether or not the mine should be operated with organized labor. The operators claimed that owing to certain conditions existing in the mine, they were unable to pay the same prices for day labor, etc., as paid at mines where organized labor was employed. An attempt to operate the mine with non-union labor was made, which precipitated a riot, in which William Scott, the mine boss, and four other persons were roughly handled. As an outgrowth of this trouble, several persons were arrested, two of whom were fined, each of the others proving an alibi. After twenty-one days' idleness, the mine resumed operation with a force of twenty persons, but on what terms, we have been unable to learn.

A strike at the Shelburn Mine was declared May 11th, by reason of the company's failing to pay the preceding half month's wages. The seventy-one persons employed in and about the mine quit work, and the mine remained idle until November 1st, at which time it was leased by twenty of the former employes, who cleaned it up and commenced shipping coal the latter part of that month. It is reported that all claims were settled by the company in September.

The Cayuga strike, in which twenty-two persons went out, was precipitated on July 8th by the company's refusing to pay a miner for a set of tools lost by reason of his room's caving in during a week of idleness of the mine. The real object of the strike, however, developed later on, when the miners refused to resume work until the mine superintendent should be discharged. They were ordered back to work by both the State and National Presidents of the United Mine Workers. Upon their refusal to resume work, the charter of the Cayuga Local was revoked and a letter written to the mine management authorizing them to employ other union miners. This the company was unable to do, and matters remained thus until August 20th, when the Cayuga Mine Local was reinstated and the matter brought to arbitration, resulting in the mine superintendent's being suspended from the management of the mine for a period of thirty days, and an amicable adjustment of all other existing grievances.

The strike at the Star No. 1 Mine, in which sixty-five persons were thrown idle for thirty days, originated over some trouble at the Star No. 2 Mine, a small mine employing less than ten men and operated by the same company. The exact cause of the strike was not learned, but from information received at this office, the settlement made was satisfactory to all concerned.

The causes of the strike at the Cannelton Mine, in which twenty-four persons were engaged, were much the same as those at the Prospect Hill Mine, the company claiming that the distance the coal had to be hauled (nearly four miles), and other existing conditions, that it was unable to pay organization prices. As a consequence, the mine has been idle since March 1st. It is reported that it has been abandoned, which is not improbable, since it is a very old mine and is nearly worked out. Little was being done at the time of the strike except drawing pillars.

Following are copies of agreements entered into by and between the Bituminous Miners of District No. 11 and the Block Coal Miners of District No. 8 and the operators of the respective districts, each district being a separate branch of the United Mine Workers of America:

TERRE HAUTE AGREEMENT.

April 1, 1901, to April 1, 1902.

Pursuant to an agreement made between the Coal Operators and United Mine Workers of America, of Illinois, Indiana, Ohio and Pennsylvania, made at Columbus, Ohio, February 9, 1900, the price of mining for bituminous coal in the State of Indiana shall be 80 cents per ton of 2,000 pounds for screened lump coal, made over a standard screen, and 49 cents per ton of 2,000 pounds for run-of-mine. That further details in scale of prices for pick and machine mining in the State of Indiana for one year, beginning April 1, 1901, shall be as follows:

Pick Mining.

(Yardage.)

In entries 7 to 9 ft. wide, $1.66.

In entries 12 ft. wide the price shall be five-eighths of regular price, or $1.03½.

Entries shall not exceed 12 ft., it being understood that this applies to entry work only.

BREAK THROUGHS.

Break throughs between entries shall be paid for at entry prices. Break throughs between rooms, when sheared or blocked, shall be paid for at entry prices, but no break throughs shall be driven without the consent of the operators. Nothing herein shall interfere with the law governing break throughs.

ROOM TURNING.

Room turning, $4.00.

Room necks to be driven 12 ft. in and widened at an angle of 45 degrees when so desired by the operator. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 ft. wide, the price shall be five-eighths of regular price, or $2.50.

MACHINE MINING.

In entries 7 to 9 ft. wide, $1.19.

In entries 12 ft. wide, five-eighths of price for narrow entries, or 74 cents.

Narrow work after punching machines shall be sheared when demanded by the operator. Narrow work after the chain machine must be done in a workmanlike manner.

BREAK THROUGHS.

Break throughs between entries, same as entry prices. Break throughs between rooms shall be paid for at same price when similarly driven.

ROOM TURNING.

Room, turning, $3.00.

Room necks to be driven 12 ft. in and widened at an angle of 45 degrees when so desired by operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 ft. When room necks are driven 12 ft. wide, price shall be five-eighths of regular price, or $1.87.

DAY WORK FOR PUNCHING MACHINES.

Machine work, when paid for by the day, shall be for:

Machine runner	$2 82
Helper	2 25

Day Work, Chain or Cutter Bar Machine.

When paid for by the day shall be for:

Machine runner $2 67½
Helper 2 67½

Day work by machines shall apply only to opening new mines and defective work, such as horse backs, etc.

Price Per Ton for Machine Mining.

FOR PUNCHING MACHINE.

Screened Lump—Runner, 9c; Helper, 8c; Loading, Shooting and Timbering, 45c; Total, 62c.

Run of Mine—Runner, 5¾c; Helper, 5¼c; Loading, Shooting and Timbering, 28c; Total, 39c.

FOR CHAIN MACHINE.

Screened Lump—Runner, 5¼c; Helper 5¼c; Loading, Shooting and Timbering, 48c; Total, 58½c.

Run-of-Mine—Runner, 3¼c; Helper, 3¼c; Loading, Shooting and Timbering, 30c; Total, 36½c.

Machine shovels shall be furnished by the operators, but when replaced the old shovels must be returned, and, in case of careless breaking or destruction, the helper shall pay for the shovel so destroyed.

Blacksmithing.

Price of blacksmithing shall be 1¼c on the dollar. Sharpening shall be done in a workmanlike manner, and men shall not have to wait for their tools.

Day Labor.

Inside day labor shall not be less than $2.25 per day of eight hours, when men are employed, and track men and timber men shall receive $2.30 per day of eight hours, and all outside day laborers working at the mines, excepting weighmasters, flat trimmer and dumper, who shall be regarded strictly as company men, shall be recognized as members of the United Mine Workers of America, provided that the present scale of prices now paid for outside day labor shall prevail during the existence of this contract, together with present conditions and hours of labor; and provided, further, that, in emergencies or in the absence of any regular employe the right of the operator to employ men not members of the United Mine Workers for outside day labor shall not be questioned.

GENERAL.

1. When the coal is paid for mine run, it shall be mined in as good condition as when paid for on a screened lump basis, and, when loaded on the miner's car, it shall, as nearly as possible, be free from slate, bone coal, or other impurities, and, if it can be shown that any miner persistently violates the letter or spirit of this clause, he shall be discharged. Nor shall he load out an undue proportion of fine coal in any one car, but shall see that the fine coal is mixed with the large coal in such a way as to make a fair quality of mine run coal. This provision for cleaning coal and penalty for failure also applies to screened lump coal.

2. The semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme Court of Indiana and of the United States.

3. The time of beginning work in the morning and the length of intermission at noon shall be considered a local question.

4. That the above scale is based upon an eight-hour work day; that it is definitely understood that this shall mean eight hours' work at the face, exclusive of the noon time; six days in the week, or 48 hours in the week, and that no local ruling shall in any way deviate from this agreement, or impose conditions affecting the same, but any class of day labor may be paid at the option of the operator for the number of hours and fraction thereof actually worked at the hour rate, based on one-eighth of the scale rate per day; provided, that when men go into the mine in the morning, they shall be entitled to two hours' pay, whether the mine works or not; providing, further, that overtime of day labor shall be paid for at the same rate per hour.

5. Inside day work may be done upon idle days, and in case of emergency, on overtime.

6. It is agreed that if any difference arises between the operators and the miners at any time, a settlement shall be arrived at without stopping the work. If the parties immediately affected can not reach an agreement themselves, the question shall be referred without delay to a Board of Arbitration, consisting of two operators, selected by the operator interested, and two miners, selected by the local union of the United Mine Workers of America involved. In the event of these four being unable to reach a decision, they shall select a fifth man, and the decision of the Board so constituted shall be final, but no miner or operator interested in the difference shall be a member of such board.

7. The duties of the Mine Committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines, except as hereinafter set forth in Article No. 16. In case they fail to agree, they shall proceed to adjust the trouble by the selection of an arbitration board, as provided in Article 6 of this agreement. The Mine Committee shall have no other authority, nor exercise any other control, nor in any way interfere with the operation of the mine, and, for violation of this agreement, the committee, or any member thereof, or mine boss or superintendent, shall be discharged.

8. That under no circumstances will the operators recognize or treat with a Mine Committee or any representative of the United Mine Workers of America during the suspension of work, contrary to this agreement.

9. The operator shall have the privilege of working a night shift for cutting coal with machines. All men so employed shall be paid 25 cents extra for each eight hours' work at night, in addition to the scale price per ton.

10. Work on driving entries and drawing pillars may be by double shift, at the option of the operator.

11. This contract shall in no case be set aside because of any rules of any local union of the United Mine Workers of America, nor shall there be any rules made controlling or interfering with the operations of the mines except by the consent of the operators and miners.

12. Coal may be dumped as slowly as the operator may find necessary to thoroughly screen it, even if the car is brought to a stop, but it shall not be dumped in such a way as to throw the coal over the car door or unnecessarily break it.

13. Any miner, knowing his place to be unsafe, shall protect same without delay and shall go into the mine for that purpose outside of regular hours and on idle days.

14. No restrictions shall be placed on the amount of coal which machines may mine, nor on the number of cars that any miner may load in any specified time.

15. The price of powder per keg shall be $1.75. The miners agree to purchase the powder from their operators, provided it is furnished of standard grade and quality, that to be determined by the operators and expert miners jointly where there is a difference.

16. It is agreed that any hoisting engineer shall not be subjected to the interference or dictates of the Mine Committee or the local unions, but all differences between the engineer and his employer shall be adjusted by the officers of the United Mine Workers of America and the employer.

17. It is further agreed that the operators shall offer no objection to the check-off for the check-weighmen and for dues for the Federation, provided that no check-off shall be made against any person until he shall have first given his consent in writing to his employer. This applies to all day work as well as miners.

INDIANA BITUMINOUS COAL OPERATORS' ASSOCIATION,
By J. SMITH TALLEY, President.
P. H. PENNA, Secretary.

W. D. VAN HORN,
President District No. 11, U. M. W. of A.
J. H. KENNEDY,
Secretary-Treasurer District No. 11, U. M. W. of A.

CONTRACT.

PICK MINING SCALE FOR 1901.

CONTRACT BETWEEN THE OPERATORS, MINERS AND DAY LABORERS OF THE BRAZIL BLOCK COAL DISTRICT FROM APRIL 1, 1901, TO APRIL 1, 1902.

1. Entered into this 16th day of April, 1901, between the Operators' Scale Committee of the Block Coal District and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the United Mine Workers of America, of Illinois, Indiana, Ohio and Pennsylvania, made at Columbus, February 9, 1901.

3. The price for mining screened block coal in the Block Coal District of Indiana shall be 90 cents per ton of 2,000 lbs. It being understood also that the price for digging unscreened coal shall be an equivalent of the price paid for screened coal.

4. That further details in scale of prices for pick mining in the Block Coal District shall be as follows:

5. The payment for low coal shall be upon the following scale:

6. For all coal two feet ten inches and under three feet one inch, ninety-five (95) cents.

7. For all coal under two feet ten inches, one dollar ($1.00).

8. The price of yardage shall remain the same, according to the agreement entered into at Columbus. Work on driving entries may be double shift, at the option of the operator; and 25 cents extra per yard shall be paid for all double yardage, and 12½ cents per yard for single yardage where same is worked double shift.

9. Inside day scale:

	April 1st to October 1st.	*October 1st to April 1st.*
Track Layers	$2 28	$2 30
Track Layers' Helpers	2 10	2 25
Trappers	1 00	1 00
Bottom Cagers	2 10	2 25
Drivers	2 10	2 25
Trip Riders	2 10	2 25
Water Haulers	2 10	2 25
Timber Men, where such are employed	2 28	2 30
Pipe Men, for compressed air plants	2 22	2 25
All other inside day labor	2 10	2 25

10. The price of Blacksmithing shall be 1½ cents on the dollar.

11. Semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme Courts of Indiana and of the United States.

12. Inside day work may be done upon idle days, and, in case of emergency, on overtime; but 48 hours shall constitute a week's work.

13. That the hour to begin work in the morning shall be seven (7) a. m., with thirty minutes' stop for dinner, and begin shooting at 3:30 o'clock

p. m., from April 1, 1901, to October 1, 1901, and from October 1, 1901, to April 1, 1902, the mines shall start at 7:30 a. m., with thirty minutes' stop for dinner, and begin shooting at 4:00 p. m., and that no shooting shall be done at the mine except by mutual consent between the bank boss and Bank Committee, and in the event that the mine is to work half a day it shall be the duty of the mine boss to notify the Bank Committee of the fact.

14. That eight hours a day means eight hours' work in the mine at the usual working places for all classes of inside workmen. This shall be exclusive of the time required in reaching said working places in the morning and departing from the same at night.

15. The miners hereby agree to do all the propping in their rooms, except setting of props required to break the bottom in shooting the same, and if any props are loosened or displaced, thereby endangering the safety of the workmen, the miners agree to reset the same.

16. It is also agreed on the part of the operators not to require the miners to put down their own road.

17. Also, to give each miner, as near as possible, an equal turn of cars, and not to allow any day hands to load coal on idle days.

18. No miner shall be discharged or discriminated against because of his refusal to do work by the day when called upon by the pit boss.

19. It is also agreed not to require the miners to load or clean falls unless they are caused by some fault of the miner not properly timbering his working place, or his having shot or otherwise caused his timbers to become insecure, and in which case it will be the duty of the miner to put his place in good order again.

20. It is further agreed that if any differences arise between the operator and miner at any pit, settlement shall be arrived at without stopping of work. If the parties immediately affected can not reach an adjustment between themselves, the question shall be referred to the Executive Board of the United Mine Workers of America, representing District No. 8, and an equal number of operators, whose action shall be final, but no miner or operator interested in the differences shall be a member of said committee.

21. Regarding Drivers: They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the parting at which they receive the empty cars, but in no case shall the driver's time be docked while he is waiting for said cars at the point named, but when the men go into the mine in the morning they shall be entitled to two hours' pay, whether or not the mine works the full two hours, but after the first two hours the men shall be paid for every hour thereafter by the hour, or for each hour's work, or fractional part thereof.

22. If for any reason the regular routine of the work can not be furnished inside labor for a portion of the first two hours, the operators may furnish other than the regular labor for the unexpired time.

23. The Block Coal District of Indiana may continue the use of the Diamond Bar Screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

24. This contract is entered into in good faith by both parties, and there is to be no deviation from it by the operators, miners or day laborers.

Committee on behalf of operators for the Executive Committee, District No. 8, United Mine Block Coal District Workers of America, for Block Coal Miners:

WILLIAM WILSON, President.
JOHN E. SWAIN, Vice-President.
HARRY WRIGHT, Secretary-Treasurer.
R. S. PEEL, Board Member.
ROBERT HOUSTON, Board Member.
W. H. ZIMMERMAN.
M. H. JOHNSON.
C. A. EASTMAN.
W. W. RISHER.
J. H. McCLELLAND.

CONTRACT.

MACHINE MINING SCALE FOR 1901.

CONTRACT BETWEEN THE MACHINE OPERATORS OF THE BLOCK COAL DISTRICT AND THE EXECUTIVE BOARD DISTRICT NO. 8 UNITED MINE WORKERS OF AMERICA, GOVERNING PRICES AND CONDITIONS OF MINING IN MACHINE MINES BLOCK COAL DISTRICT.

1. Entered into this 16th day of April, 1901, between the Operators' Machine Mines of the Block Coal District and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the United Mine Workers of America, of Illinois, Indiana, Ohio and Pennsylvania, made at Columbus, February 9, 1901.

3. The price for loading, shooting, timbering, taking care of all draw slate that is four (4) inches and under, in rooms and entries, shall be 46 cents per ton.

Price for entry driving, 6 to 9 ft. wide, 46 cents per yard.

Price for entry driving, 9 to 12 ft. wide, 29 cents per yard.

The loader agrees to keep the bug dust and draw slate back 14 ft. from the working face.

All entries more than 12 ft. in width shall be paid same as rooms.

Machine Runners and Helpers to be paid 22½ cents per ton, and, when working by the day, Machine Runner to be paid $2.70 per day; Helpers, $2.40 per day.

Entry driving, 6 to 9 ft. wide, Machine Runner to be paid 22½ cents per yard.

Entry driving, 9 to 12 ft. wide, Machine Runner to be paid 14 cents per yard.

It is further agreed that where there is not sufficient room to gob the bug dust and draw slate, the loader will load it in bank cars and the company will unload it.

It is understood that there shall be nothing paid for room turning or low coal, and there shall be nothing charged for blacksmithing. There shall be no discrimination against any employe.

The Block Coal District of Indiana may continue the use of the Diamond Bar Screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

This agreement to become a part of the agreement entered into on the 16th day of April, 1901, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

On behalf of the Machine Operators of the Block Coal District:

W. H. ZIMMERMAN.
J. H. McCLELLAND.

On behalf of the Executive Board, District No. 8, United Mine Workers of America:

WILLIAM WILSON, President.
JOHN E. SWAIN, Vice-President..
HARRY WRIGHT, Secretary-Treasurer.
R. S. PEEL, Board Member.
ROBERT HOUSTON, Board Member.

TABLE

Showing by Counties the Name of Mine, Number of Tons Screened, Slack and Nut and Mine Run Coal, Total Tons of All Grades of Coal Produced, and the Distribution Thereof; the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand-Mined Coal.

BLOCK COAL MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	MACHINE MINED.				PICK MINED.				DISTRIBUTION.		WAGES PAID.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 1	61,924	12,035	27	73,986	....	....	....	....	12,157	61,829	$44,237 28	$28,050 51	$11,407 39	$83,695 18
Brazil Block No. 8	55,424	10,961	....	66,385	19,386	3,760	4,034	27,180	12,461	81,104	58,432 54	28,703 98	10,462 39	97,598 91
Gart No. 10	11,659	2 320	....	13,979	2,869	571	....	3,440	1,950	15,469	13,103 25	6,528 84	3,436 50	23,068 59
Brazil Block No. 11	34,442	6,347	....	40,789	11,338	2,019	....	13,357	6,247	47,899	35,316 89	17,352 58	6,712 24	59,381 71
Diamond No. 3	16,913	3,327	23	20,263	11,616	2,022	4	13,642	541	33,364	23,139 49	10,150 65	7,825 03	41,115 17
Diamond No. 5	24,420	4,457	....	28,877	14,569	2,433	....	17,002	653	45,226	33,395 35	11,157 72	7,894 01	52,447 08
Briar Hill	16,013	2,480	1,524	20,017	....	....	....	....	13,817	6,200	10,720 47	5,625 74	6,115 17	22,461 38
Total	220,795	41,927	1,574	264,296	59,778	10,805	4,038	74,621	47,826	291,091	$218,345 27	$107,570 02	$53,852 73	$379,768 02

PARKE COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 12	41,797	8,295	256	50,348	4,116	850	26	4,982	4,621	50,719	$35,245 24	$19,830 11	$8,194 17	$63,269 52
Totals in Block Coal Machine Mines	262,592	50,222	1,830	314,644	63,894	11,655	4,064	79,613	52,447	341,810	$253,590 51	$127,400 13	$62,046 90	$443,037 54

BLOCK COAL—HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Distribution. Indiana.	Distribution. Other States.	Wages Paid. To Miners.	Wages Paid. To Inside Day Men.	Wages Paid. To Outside Day Men.	Wages Paid. Total Wages Paid.
Columbia No. 4	3,912	850	....	4,762	2,269	2,493	$3,686 13	$835 67	$623 76	$5,145 56
Columbia No. 5	29,808	7,125	2,162	39,095	30,405	8,690	29,732 87	5,851 94	4,080 93	39,665 74
Cornwell	18,758	3,831	....	22,589	15,922	6,667	19,662 85	4,422 95	2,357 77	26,443 57
Crawford No. 2	23,364	8,195	1,345	32,904	14,699	18,205	26,401 52	5,267 99	3,770 14	35,439 65
Crawford No. 3	39,136	9,411	....	48,547	32,063	16,484	36,632 59	6,466 01	4,713 89	47,812 49
Crawford No. 4	13,225	3,050	....	16,275	8,610	7,665	12,214 38	2,813 93	1,812 60	16,840 91
Crawford No. 5	28,584	9,170	3,144	40,898	18,049	22,849	28,940 25	5,733 27	4,117 14	38,790 66
Crawford No. 7	1,966	340	....	2,306	572	1,734	2,197 30	1,949 81	1,438 68	5,585 79
Dewey	12,000	2,215	....	14,215	10,524	3,691	11,673 62	2,816 88	1,665 91	16,156 41
Eureka No. 2	23,567	3,803	106	27,476	11,042	16,434	23,174 75	6,844 65	3,626 45	33,645 85
Eureka No. 3	17,796	3,346	1,206	22,348	8,541	13,807	20,024 45	5,104 50	2,696 35	27,825 30
Eureka No. 4	17,054	4,013	585	21,652	7,978	13,674	17,800 60	3,914 95	2,226 15	23,941 70
Eureka No. 5—(New mine; no report)	....	....	....	....	....	....	....	....	....	....
Gart No. 3	11,054	2,140	192	13,386	6,435	6,951	11,389 59	3,303 18	3,285 62	17,975 37
Gart No. 5	39,220	7,770	578	47,568	30,513	17,055	41,706 19	11,603 48	6,066 82	59,376 49
Gart No. 7	....	....	171	171	....	171	237 97	....	23 75	261 72
Gladstone	14,545	3,395	3,935	21,875	....	21,875	17,102 49	6,966 02	5,845 43	29,913 94
Harrison No. 2	2,630	580	....	3,210	1,888	1,322	2,413 05	701 40	383 20	3,497 65
Harrison No. 3	4,019	1,210	....	5,229	2,953	2,276	3,749 30	850 45	947 30	5,547 05
Lawrence No. 6	15,851	3,650	....	19,501	16,492	3,009	16,377 94	2,014 28	1,828 70	20,220 92
Markland	3,390	1,143	....	4,533	4,533	....	3,117 40	833 50	657 50	4,608 40
Monarch	....	....	8,338	8,338	8,338	....	9,719 20	2,485 31	922 19	13,126 70
Pratt	24,716	2,562	855	28,133	27,860	273	23,644 00	6,625 00	4,366 00	34,635 00
Rob Roy	15,068	2,782	26	17,876	7,961	9,915	14,774 12	2,671 44	2,485 25	19,930 81
Totals for Clay County	359,663	80,581	22,643	462,887	267,647	195,240	$376,372 56	$90,076 61	$59,938 51	$526,387 68

PARKE COUNTY.

Brazil Block No. 9	155	30	....	185	....	185	$109 50	$50 00	$25 00	$184 50
Crawford No. 1	3,377	651	....	4,028	1,606	2,422	3,071 56	700 53	398 51	4,170 60
Mary	32,438	6,056	....	38,494	2,032	36,462	35,429 01	8,077 55	4,536 96	48,043 52
McIntosh No. 3	22,234	5,605	8,696	36,535	4,019	32,516	32,483 91	8,277 50	3,811 78	44,573 19
Otter Creek	3,147	621	869	4,637	2,330	2,307	3,797 24	572 92	794 62	5,164 78
Standard	22,466	4,850	256	27,572	18,739	8,833	20,585 00	4,724 00	2,799 00	28,108 00
Superior No. 1	44,827	10,890	1,418	57,135	16,607	40,528	44,661 84	7,739 45	4,292 55	56,693 84
Superior No. 2	51,880	10,695	2,217	64,792	22,845	41,947	52,156 09	13,023 59	6,929 39	72,009 07
Totals for Parke County	180,524	39,398	13,456	233,378	68,178	165,200	$192,294 15	$43,165 54	$23,487 81	$258,947 50

TOTALS IN BLOCK COAL HAND MINES.

Clay County	359,663	80,581	22,643	462,887	267,647	195,240	$376,372 56	$90,076 61	$59,938 51	$526,387 68
Parke County	180,524	39,398	13,456	233,378	68,178	165,200	192,294 15	43,165 54	23,487 81	258,947 50
Totals in Block Coal Hand Mines	540,187	119,979	36,099	696,265	335,825	360,440	$568,666 71	$133,242 15	$83,426 32	$785,335 18

BITUMINOUS MACHINE MINES.

DAVIESS COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Cable No. 9	1,535	468	9,557	11,560	2,917	935	22,876	26,728	38,288	....	$19,611 61	$14,180 46	$3,610 04	$37,402 11
Total	1,535	468	9,557	11,560	2,917	935	22,876	26,728	38,288	....	$19,611 61	$14,180 46	$3,610 04	$37,402 11

GREENE COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Black Creek	44,517	28,231	34,814	107,562	495	309	622	1,426	81,873	27,115	$47,905 98	$14,561 64	$5,001 18	$67,468 80
Gilmour	....	....	3,411	3,411	....	....	....	....	3,411	....	3,585 58	653 35	977 41	5,216 34
Glenburn	13,391	10,337	17,267	40,995	30,427	23,318	33,042	86,787	116,908	10,874	78,054 22	13,517 83	8,303 67	99,875 72
Hoosier	....	....	10,360	10,360	....	....	6,679	6,679	17,039	....	8,045 64	6,737 23	3,218 52	18,001 39
Island No. 1	....	....	90,213	90,213	....	....	10,321	10,321	82,005	18,529	43,094 30	15,867 50	6,898 31	65,860 11
Island No. 2	60,831	48,135	15,911	124,877	11,565	5,590	1,756	18,911	95,130	48,658	66,802 94	18,736 55	13,279 13	98,818 62
Midland	4,992	5,402	673	11,067	....	....	....	....	9,436	1,631	5,093 71	3,172 17	1,586 05	9,851 93
Summit No. 2	60,815	18,907	63,958	143,680	1,185	440	....	1,625	30,555	114,750	55,944 89	18,443 70	9,216 82	83,605 41
Total	184,546	111,012	236,607	532,165	43,672	29,657	52,420	125,749	436,357	221,557	$308,527 26	$91,689 97	$48,481 09	$148,698 32

PARKE COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 12	41,797	8,295	256	50,348	4,116	850	26	4,992	4,621	50,719	$35,245 24	$19,830 11	$8,194 17	$63,269 52
Cox No. 3	....	....	63,997	63,997	....	....	14,685	14,685	17,979	60,703	35,242 24	16,921 52	13,026 25	65,190 01
Parke No. 8	14,339	11,634	39,395	65,368	3,873	....	10,191	14,064	50,918	28,514	36,994 25	14,601 62	7,084 30	58,680 17
Total	56,136	19,929	103,648	179,713	7,989	850	24,902	33,741	73,518	139,936	$107,481 73	$51,353 25	$28,304 72	$187,139 70

SULLIVAN COUNTY.

Bunker Hill	36,012	13,101	....	49,113	1,706	640	....	2,346	....	51,459	$23,449 52	$13,092 30	$6,402 85	$42,944 67
Dugger	65,714	33,131	688	99,533	....	....	....	....	58,837	40,696	41,676 58	17,491 64	8,421 81	67,590 03
Green Hill	15,280	7,391	391	23,062	573	288	....	861	6,126	17,797	12,807 47	4,483 90	3,255 54	20,546 91
Hymera	40,118	55,214	43,447	138,779	....	....	....	....	65,315	73,464	51,804 59	18,106 53	9,392 16	79,303 28
Ingleside	1,216	621	487	2,324	8,060	3,854	2,637	14,551	13,232	3,643	8,729 29	2,445 96	1,574 50	12,749 75
Jackson Hill No. 1	14,827	8,262	9,120	32,209	2,196	1,288	1,757	5,241	22,561	14,889	17,154 76	6,736 58	2,976 46	26,867 80
Jackson Hill No. 2	79,394	60,813	51,463	191,670	4,208	3,105	....	7,313	124,643	74,340	70,475 45	21,244 85	7,848 73	99,569 03
Jackson Hill No. 3	329	347	164	840	....	....	....	....	415	425	....	1,040 45	940 83	1,981 28
Phœnix No. 1	....	....	143,757	143,757	....	....	11,930	11,930	78,303	77,384	69,211 62	27,601 45	15,077 26	111,890 33
Phœnix No. 3	(Repor	ted wit	h No. 1)	....	....	....	....	....	....	....	....	....	....	....
Phœnix No. 5	(Repor	ted wit	h No. 1)	....	....	....	....	....	....	....	....	....	....	....
Shelburn	2,492	1,719	353	4,564	3,072	1,776	509	5,357	4,085	5,836	5,983 31	3,341 74	2,903 62	12,228 67
Star City	82,456	41,220	1,423	125,099	....	....	....	....	48,233	76,866	52,072 54	27,043 94	11,976 00	91,092 48
Total	337,838	221,819	251,293	810,950	19,815	10,951	16,833	47,599	421,750	436,799	$353,365 13	$142,629 34	$70,769 76	$566,764 23

VANDERBURGH COUNTY.

Sunnyside	17,640	11,219	5,628	34,487	9,794	4,447	1,855	16,096	41,793	8,790	$21,715 65	$7,818 55	$6,878 30	$36,412 50
Total	17,640	11,219	5,628	34,487	9,794	4,447	1,855	16,096	41,793	8,790	$21,715 65	$7,818 55	$6,878 30	$36,412 50

VIGO COUNTY.

Glen Oak	9,617	4,755	44,492	58,864	....	....	15,339	15,339	....	74,203	$29,072 07	$13,478 66	$11,795 84	$54,346 57
Lawton	8,207	4,320	....	12,527	15,691	8,430	....	24,121	10,251	26,397	22,381 00	6,473 00	3,716 00	32,570 00
Parke No. 10	29,519	25,824	65,587	120,930	....	....	....	....	100,011	20,919	51,330 87	18,867 45	8,623 51	78,821 83
Ray	6,888	5,051	5,661	17,600	24,600	16,490	8,949	50,039	43,252	24,387	29,009 43	10,493 31	5,268 42	44,771 16
Total	54,231	39,950	115,740	209,921	40,291	24,920	24,288	89,499	153,514	145,906	$131,793 37	$49,312 42	$29,403 77	$210,509 56

WARRICK COUNTY.

Big Vein No. 1	....	....	56,656	56,656	....	....	614	614	57,270	....	$22,920 30	$6,334 80	$3,637 65	$32,892 75
Big Vein No. 2	(New	mine;	tonnag	e not rep	orted)	....	....	....	....		....	....	....	....
Total	....	....	56,656	56,656	....	....	614	614	57,270	....	$22,920 30	$6,334 80	$3,637 65	$32,892 75
Totals in Bituminous Machine Mines	651,926	404,397	779,129	1,835,452	124,478	71,760	143,788	340,026	1,222,490	952,988	$965,415 05	$363,318 79	$191,085 33	$1,519,819 17

BITUMINOUS HAND MINES.

CLAY COUNTY.

NAME OF MINE.	PRODUCTION. Tons of Screened Coal.	PRODUCTION. Tons of Slack and Nut Coal.	PRODUCTION. Tons of Mine Run Coal.	PRODUCTION. Total Tons of all Kinds of Coal Produced.	DISTRIBUTION. Indiana.	DISTRIBUTION. Other States.	WAGES PAID. To Miners.	WAGES PAID. To Inside Day Men.	WAGES PAID. To Outside Day Men.	WAGES PAID. Total Wages.
Cloverland	43,119	16,700	17,580	77,399	58,537	18,862	$46,754 29	$7,821 34	$6,703 37	$61,279 00
Fortner	6,326	2,264	78	9,068	8,119	949	6,740 41	1,876 05	1,571 57	10,188 03
Gifford No. 1	78,611	24,534	....	103,145	....	103,145	67,440 61	12,464 83	8,975 57	88,881 01
Glen	16,729	5,185	....	21,914	540	21,374	16,769 00	2,742 00	2,041 00	21,552 00
Klondyke	22,449	15,973	3,205	41,627	35,752	5,875	21,444 48	7,202 91	4,414 16	33,061 55
Pearl	27,845	12,733	184	40,762	37,119	3,643	21,174 29	4,083 99	4,175 51	29,433 79
Silverwood No. 3	36,312	21,207	....	57,519	35,724	21,795	31,418 20	8,883 45	5,653 30	45,954 95
Total	231,391	98,996	21,047	351,434	175,791	175,643	$211,741 28	$45,074 57	$33,534 48	$290,350 33

DAVIESS COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Black Diamond	1,701	111	1,811	3,623	3,623	....	$2,352 15	$342 25	$463 00	$3,157 40
Cabel No. 4	11,874	3,642	....	15,516	15,516	....	10,188 18	2,981 48	2,823 59	15,993 25
Hawkins	....	....	2,495	2,495	2,495	....	1,222 55	480 50	747 50	2,450 55
Hoosier	785	....	1,933	2,718	2,718	....	1,584 95	494 00	426 15	2,505 10
Logan Grove	....	....	2,858	2,858	2,858	....	1,407 62	496 75	326 25	2,230 62
Montgomery No. 2	7,792	636	44,594	53,022	41,636	11,386	39,188 75	12,235 38	5,078 15	56,502 88
Montgomery No. 3	17,512	1,869	66,011	85,392	66,984	18,408	59,368 35	15,656 10	7,375 50	82,399 95
Mutual	14,978	1,800	6,732	23,510	8,730	14,780	14,897 10	3,191 65	2,724 25	20,813 00
Union	....	....	4,865	4,865	4,865	....	2,597 10	492 80	379 25	3,469 15
Total	54,642	8,058	131,299	193,999	149,425	44,574	$132,806 75	$36,370 91	$20,344 24	$189,521 90

FOUNTAIN COUNTY.

Silverwood	23,958	11,075	....	35,033	26,915	8,118	$24,170 80	$9,577 69	$4,202 47	$37,850 96
Total	23,958	11,075	....	35,033	26,915	8,118	$24,170 80	$9,577 69	$4,202 47	$37,850 96

GIBSON COUNTY.

Oswald	19,275	28,656	54,515	102,446	95,015	7,431	$53,198 78	$12,830 79	$9,339 02	$75,368 59
Total	19,275	28,656	54,515	102,446	95,015	7,431	$53,198 78	$12,830 79	$9,339 02	$75,368 59

GREENE COUNTY.

Fluhart	32,070	18,578	11,576	62,224	50,069	12,155	$35,541 96	$10,972 35	$5,212 43	$51,726 74
Island Valley No. 1	10,893	6,600	20,271	37,764	26,357	11,407	19,676 63	6,518 69	4,024 61	30,219 93
Island Valley No. 2	20,647	11,933	103	32,683	19,538	13,145	19,241 25	4,315 21	3,103 90	26,660 36
Island Valley No. 3	43,103	26,909	55,612	125,624	86,150	39,474	69,003 56	11,605 34	6,201 95	86,810 85
South Linton	53,685	34,898	31,602	120,185	77,478	42,707	64,581 81	14,277 39	4,781 42	83,640 62
Summit No. 1	(Reported with No. 2)			....	....	....	....	....	....	....
Templeton	17,018	8,800	104,639	130,457	122,231	8,226	69,659 00	13,030 00	8,414 00	91,103 00
Victoria	1,727	595	1,297	3,619	....	3,619	3,177 17	959 37	1,111 94	5,248 48
Total	179,143	108,313	225,100	512,556	381,823	130,733	$280,881 38	$61,678 35	$32,850 25	$375,409 98

KNOX COUNTY.

Bicknell	7,222	5,465	2,541	15,228	13,588	1,640	$7,576 22	$1,814 21	$1,582 79	$10,973 22
Edwardsport	6,398	5,451	9,527	21,376	21,376	....	12,219 95	4,749 89	3,419 07	20,388 91
Knox	5,400	3,796	4,331	13,527	13,527	....	5,902 95	1,697 00	1,812 00	9,411 95
Prospect Hill	4,327	1,983	3,701	10,011	10,011	....	5,931 14	2,575 59	1,815 81	10,332 54
Total	23,347	16,695	20,100	60,142	58,502	1,640	$31,630 26	$10,836 69	$8,629 67	$51,096 62

BITUMINOUS HAND MINES—Continued.

MARTIN COUNTY.

NAME OF MINE.	Production. Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Distribution. Indiana.	Other States.	Wages Paid. To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Tunnel	408	289	3,301	3,998	3,998	....	$2,590 83	$609 24	$409 40	$3,609 47
Total	408	289	3,301	3,998	3,998	....	$2,590 83	$609 24	$409 40	$3,609 47

PARKE COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Lucia	20,349	10,780	51,540	82,669	54,054	28,615	$46,930 78	$12,088 57	$8,849 40	$67,868 75
Lyford No. 1	....	....	1,368	1,368	....	1,368	670 32	212 29	286 09	1,168 70
Lyford No. 2	8,092	5,148	47,388	60,628	7,753	52,875	29,596 67	14,211 52	7,321 45	51,129 64
Mecca	16,088	6,776	3,314	26,178	17,550	8,628	16,000 05	6,981 95	4,050 81	27,032 81
Total	44,259	22,704	103,610	170,843	79,357	91,486	$93,197 82	$33,494 33	$20,507 75	$147,199 90

PERRY COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Cannelton	92	....	2,915	3,007	3,007	....	$1,511 29	$549 00	$461 98	$2,522 27
Troy	....	....	14,672	14,672	14,672	....	8,364 94	2,098 10	1,196 52	11,659 56
Total	92	....	17,587	17,679	17,679	....	$9,876 23	$2,647 10	$1,658 50	$14,181 83

PIKE COUNTY.

Aberdeen	6,808	4,923	7,529	19,260	7,978	11,282	$11,555 63	$2,627 70	$2,971 48	$17,154 81
Alden—(Idle; no report)	....	....	....	....	....	....	....	....	....	....
Ayrshire No. 2	....	....	2,527	2,527	2,392	135	1,566 79	97 75	50 00	1,714 54
Ayrshire No. 3	39,608	21,370	17,008	77,986	37,747	40,239	38,372 21	15,808 44	11,694 68	65,875 33
Ayrshire No. 4	....	....	27,435	27,435	22,689	4,746	15,772 04	2,655 37	1,279 61	19,707 02
Ayrshire No. 5	250	219	13,068	13,537	10,689	2,848	8,980 56	1,891 54	1,279 65	12,151 75
Blackburn	1,362	1,287	6,179	8,828	7,610	1,218	4,890 93	1,687 90	314 34	6,893 17
Carbon	....	....	6,371	6,371	6,371	....	3,380 56	1,221 00	891 25	5,492 81
Hartwell	53	30	3,725	3,808	1,510	2,298	2,010 93	931 99	738 55	3,681 47
Littles	22,335	26,473	21,855	70,663	66,558	4,105	36,312 65	9,315 60	5,535 31	51,163 56
Petersburg	....	....	18,940	18,940	18,940	....	10,120 75	2,948 85	1,801 81	14,871 41
Rogers	....	....	19,553	19,553	19,553	....	10,209 76	4,135 39	1,183 54	15,528 69
Total	70,416	54,302	144,190	268,908	202,037	66,871	$143,172 81	$43,321 53	$27,740 22	$214,234 56

SULLIVAN COUNTY.

Briar Hill	1,547	975	1,819	4,341	....	4,341	$2,427 10	$735 26	$284 24	$3,446 60
Caledonia	28,236	31,224	30,829	90,289	16,718	73,571	33,757 47	11,122 49	6,915 45	51,795 41
White Ash	8,513	4,797	3,825	17,135	17,135	....	10,018 98	1,993 98	1,568 00	13,580 96
Total	38,296	36,996	36,473	111,765	33,853	77,912	$46,203 55	$13,851 73	$8,767 69	$68,822 97

VANDERBURGH COUNTY.

Diamond	8,749	4,645	1,977	15,371	15,371	....	$10,005 72	$2,060 03	$2,456 19	$14,521 94
First Avenue	6,766	7,141	28,363	42,270	36,844	5,426	31,220 18	6,868 20	4,430 45	42,518 83
Ingleside	10,813	....	28,710	39,523	39,523	....	27,085 11	5,873 05	5,077 10	38,035 26
Union	6,623	3,324	6,619	16,566	16,566	....	12,979 70	1,486 70	3,245 50	17,711 90
Unity	....	....	18,582	18,582	17,115	1,467	14,299 65	2,374 75	2,013 50	18,687 90
Total	32,951	15,110	84,251	132,312	125,419	6,893	$95,590 36	$18,662 73	$17,222 74	$131,475 83

BITUMINOUS HAND MINES—Continued.

VERMILLION COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Crown Hill	380	140	225	745	745	....	$372 50	$200 00	$100 00	$672 50
Bruilett's No 3	1,474	1,985	32,347	35,806	3,356	32,450	17,725 05	3,277 60	1,803 70	22,806 35
Bruilett's No. 4	11,415	5,970	145,756	163,141	19,408	143,733	81,144 80	16,104 55	5,735 40	102,984 75
Bruilett's No. 5	44,392	27,549	28,037	99,978	16,740	83,238	48,190 40	7,406 50	3,625 53	59,222 43
Buckeye	41,098	18,915	11,547	71,560	....	71,560	41,181 54	14,779 06	8,519 51	64,480 11
Cayuga	....	....	7,404	7,404	7,404	....	4,476 15	1,659 55	1,638 70	7,774 40
Oak Hill	24,107	14,346	42,581	81,034	2,333	78,701	45,057 18	7,647 55	6,355 24	59,059 97
Prince	....	....	170,935	170,935	....	170,935	95,925 31	25,680 09	9,363 86	130,969 26
Torrey No. 4	....	....	96,725	96,725	17,428	79,297	50,713 28	17,953 30	10,335 18	79,001 76
Willow Grove	777	685	9,733	11,195	432	10,763	7,166 25	917 61	1,261 09	9,344 95
Total	123,643	69,590	545,290	738,523	67,846	670,677	$391,952 46	$95,625 81	$48,738 21	$536,316 48

VIGO COUNTY.

Brick Works	....	....	14,625	14,625	14,625	....	$8,430 11	$2,684 70	$1,171 65	$12,286 46
Broadhurst	6,097	2,135	5,619	13,851	13,159	692	5,688 86	1,323 60	771 50	7,783 96
Chicago No. 6	5,096	7,331	16,587	29,014	....	29,014	9,245 14	2,993 52	1,479 90	13,718 56
Diamond	66,067	30,451	19,587	116,105	83,408	32,697	70,692 00	20,671 00	9,379 00	100,742 00
Ehrlich	31,772	23,827	....	55,599	17,478	38,121	26,742 57	8,194 41	2,946 85	37,883 83
Grant No. 1	441	335	1,021	1,797	1,228	569	2,136 33	764 96	1,393 67	4,294 96
Grant No. 2	5,376	32,845	118,226	156,447	94,373	62,074	88,589 98	12,849 41	8,410 08	109,849 47
Hector	24,525	19,579	3,070	47,174	45,378	1,796	23,590 28	6,675 20	5,361 54	35,627 02
Rose Bud	44,863	26,228	4,353	75,444	71,464	3,980	43,459 53	7,740 66	5,791 83	56,992 02
Klondyke	8,371	6,380	2,250	17,001	2,964	14,037	7,804 05	2,733 80	1,641 50	12,179 35
Koch	....	....	1,120	1,120	1,120	....	561 90	230 00	155 00	946 90
Miami	3,572	1,708	476	5,756	....	5,756	4,147 36	1,331 30	453 31	5,931 97
Nickelplate	17,638	5,020	42,449	65,107	....	65,107	39,333 92	15,561 84	12,162 56	67,058 32
Peerless	39,618	23,450	16,360	79,428	18,967	60,461	45,715 00	12,916 00	5,943 00	64,574 00
Red Bird	973	688	6,318	7,979	7,979	....	4,810 47	843 76	591 86	6,246 09
Royal	21,596	10,590	25,784	57,970	57,644	326	31,836 62	4,569 70	4,286 25	40,692 57
Larimer	....	....	3,299	3,299	3,299	....	1,913 42	245 60	449 00	2,608 02
Union	84,089	47,070	2,616	133,775	93,360	40,415	75,203 00	18,345 00	9,714 00	103,262 00
Vigo	....	....	8,212	8,212	....	8,212	3,971 03	815 35	1,122 43	5,908 81
Woodland Valley	644	258	2,295	3,197	2,897	300	1,893 75	366 75	293 80	2,554 30
Total	360,738	237,895	294,267	892,900	529,343	363,557	$495,765 32	$121,756 56	$73,518 73	$691,140 61

WARRICK COUNTY.

Air Line	3,670	2,501	4,716	10,887	10,887	....	$5,785 56	$679 70	$861 61	$7,326 87
Big Four	2,213	883	55,881	58,977	53,051	5,926	27,830 15	4,231 51	4,235 44	36,297 10
Caledonia	1,650	1,350	33,792	36,792	29,053	7,739	19,113 44	3,699 14	3,057 08	25,869 66
Chandler	5,080	2,599	2,513	10,192	7,910	2,282	5,865 87	1,002 19	814 47	7,682 53
DeForrest	1,718	859	8,865	11,442	11,442	....	5,632 56	1,067 83	782 99	7,483 38
Star No. 1	....	....	32,375	32,375	32,375	....	14,697 38	4,060 81	2,350 21	21,108 40
Total	14,331	8,192	138,142	160,665	144,718	15,947	$78,924 96	$14,741 18	$12,101 80	$105,767 94
Totals in Bituminous Hand Mines	1,217,160	716,871	1,819,172	3,753,203	2,091,721	1,661,482	$2,091,703 59	$521,079 21	$319,565 17	$2,932,347 97

TABLE

Showing Total Production and Wages at Indiana Mines for 1901.

	Machine Mined.				Pick Mined.				Distribution.		Wages.			
	Screened.	Slack and Nut.	Mine Run.	Total.	Screened.	Slack and Nut.	Mine Run.	Total.	Indiana.	Other States.	Miners.	Inside Day and Monthly Men.	Outside Day and Monthly Men.	Total.
Total Block Machine Mines.....	262,592	50,222	1,830	314,644	63,894	11,655	4,064	79,613	52,447	341,810	$253,590 51	$127,400 13	$62,046 90	$443,037 54
Total Block Pick Mines	....	....	....	....	540,187	119,979	36,099	696,265	335,825	360,440	568,666 71	133,242 15	83,426 32	785,335 18
Total Block....	262,592	50,222	1,830	314,644	604,081	131,634	40,163	775,878	388,272	702,250	$822,257 22	$260,642 28	$145,473 22	$1,228,372 72
Total Bituminous Machine Mines.	651,926	404,397	779,129	1,835,452	124,478	71,760	143,788	340,026	1,222,490	952,988	$965,415 05	$363,318 79	$191,085 33	$1,519,819 17
Total Bituminous Pick Mines......	....	....	....	....	1,217,160	716,871	1,819,172	3,753,203	2,091,721	1,661,482	2,091,703 59	521,079 21	319,565 17	2,932,347 97
Total Bituminous	651,926	404,397	779,129	1,835,452	1,341,638	788,631	1,962,960	4,093,229	3,314,211	2,614,470	$3,057,118 64	$884,398 00	$510,650 50	$4,452,167 14
Total Machine Mined...........	914,518	454,619	780,959	2,150,096	....	....	....	....	....	....	....	....	....	....
Total Pick Mined.	1,945,719	920,265	2,003,123	4,869,107	....	....	....	....	....	....	....	....	....	....
Grand total...	2,860,237	1,374,884	2,784,082	7,019,203	....	....	....	....	3,702,483	3,316,720	$3,879,375 86	$1,145,040 20	$656,123 72	$5,680,539 86

NOTE.—Miners,' Machine Runners' and Helpers' and Loaders' Wages are reported together under "Miners."

TABLE

Showing Per Cent. Gain in Gross Tons Produced, Gross Wages Paid and Total Number Persons Employed at Indiana Mines for Year 1901, Over that of 1900.

	1901.	1900.	Tons Gained.	Per Cent.
Total tons produced	7,019,203	6,283,063	736,140	11.7+
Total wages paid	$56,800,539 86	$4,843,343 26	$837,196 60	11.09+
Total number employes	12,096	9,888	3,208	32.4+

TABLE

Of Idle Time, Showing Number of Days Lost and the Various Causes Therefor.

Cause.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
No cars	166	67	67	114	6	56	138	329	247	368	704	593	2,765
No orders	964	667	866	538	1,344	1,030	814	859	612	497	208	155	8,554
Strikes	51	101	75	126	182	167	146	128	89	73	26	38	1,202
Suspended indefinitely	....	48	151	184	266	505	486	270	81	85	52	26	2,154
Making repairs	28	43	79	77	41	6	30	69	40	39	9	12	473
Floods in mines	....	....	15	19	....	....	....	....	5	....	....	....	39
Mine squeezes	....	....	....	26	27	....	....	....	....	....	....	....	53
Pending settlement	....	....	....	499	....	....	....	....	....	....	....	....	499
Funerals	14	2	6	....	2	....	....	....	....	7	26	2	59
Mine fires	....	....	....	26	16	....	....	75	75	....	....	14	206
Improvements	....	....	....	....	19	53	39	27	....	6	....	....	144
Miscellaneous	20	1	....	4	17	6	2	....	16	12	....	10	88
Total	1,243	929	1,259	1,613	1,920	1,823	1,655	1,667	1,165	1,087	1,025	850	16,236

NEW MINES.

The following new mines have been opened and equipped within the past year:

CLAY COUNTY.

GIFFORD NO. 2 MINE.

A most valuable addition to the Collins Coal Company's mining interests is its new No. 2 Mine, located one mile northwest of its No. 1 Mine, on an extension of the railroad switch to the last named mine. The seam mined is the same as that at No. 1, i. e., Coal III, and is opened by a shaft eight by fifteen feet in size and seventy-five feet deep. The first coal was shipped about December 1st. Mining is done by electric chain machines. The equipment of the entire plant is modern in every detail, the company having installed first motion hoisting machines, self dumping cages, shaker screens, automatic scales and all other conveniences incident to handling a large ouptut and preparing several grades of coal suitable to the various market demands, as well as curtailing the expense of production. When fully developed, the mine will rank among the largest producers in Clay County.

CRAWFORD NO. 6 MINE.

This mine is owned and operated by the Crawford Coal Company, and is located near Center Point on a coal switch from the Center Point Branch of the Vandalia Railroad. The sinking of the shaft, which is eight by twenty feet in size, 116 feet deep, was completed in July. The machinery, cars, etc., from the No. 4 Mine, which was abandoned in May, were used in equipping it. The seam sunk to is Coal III, which was here found to be two and one-half feet thick, although drillings made in the near vicinity show the seam to be much thicker. For this reason but little has been done toward developing the mine, except driving entry and prospecting for thicker coal.

CRAWFORD NO. 7 MINE.

This is also a new addition to the Crawford Coal Company's block coal properties. It is located one-half mile north of the old Crawford No. 4 on a switch off of the Center Point Branch of the Vandalia Railroad. The seam mined is Coal III, averaging three and one-half feet in thickness, opened by a shaft eight by sixteen feet in size, eighty-four feet deep. The sinking and equipment of the shaft was completed and coal shipped about October 1st.

Coal IV, known as the top block seam, is here found in workable thickness. A tunnel which will be about fifty feet in length is now being driven up to it from the bottom seam; both seams will be mined and hoisted from the same opening.

An inspection of this mine was made in November. But little was being done at that time except driving the double partings, timbering the shaft, bottom, etc. There was a total working force of fourteen persons, working double shifts.

LAWRENCE NO. 6 MINE.

This is a block coal hand or pick mine, owned and operated by Zeller, McClellan & Company, of Brazil. It is located one mile north of Brazil on an extension of the Sheridan Brickworks railroad switch, one-half mile in length. The seam mined here is Coal III of the lower block seam and is found under exceptionally good conditions, having an average of four feet five inches in thickness, excellent roof and bottom. Unfortunately, however, the area of coal field to be mined from this opening is limited to about sixty acres.

The mine is operated by a shaft eight by twenty feet in size, forty-one feet deep, the sinking of which was commenced July 4th and completed in sixteen days. The shaft was equipped and the first shipment of coal made September 13th.

An inspection of this mine was made October 20th, by Assistant Inspector Long, who reported it in good condition and as employing ninety persons.

NEW EUREKA MINE.

This mine is located at the Logan Grove, near Washington; it is owned and operated by Wilson Brothers, supplying local trade in the city of Washington and surrounding country.

The seam mined is Coal V, averaging three and one-half feet in thickness, opened by a slope seventy-five feet long. Coal is hoisted by a gin operated by horse power.

An inspection of this mine was made October 25th, when it was found in good condition and employing thirteen miners. This force will be increased as the mine is opened out, and when finished will furnish employment to about twenty-five miners and five or six day men.

Greene County.

MIDLAND MINE.

This mine is owned and operated by the Midland Coal Company. It is located seven miles northwest of Linton on the Southern Railway. The seam mined here is Coal III, averaging seven feet in thickness, and is opened by a shaft eight by eighteen feet in size, 245 feet in depth.

The opening of this mine, with one exception, i. e., the Jackson Hill No. 3, is probably of more importance to the coal interests of Indiana than any other development made within the past year, or in fact for a number of years. It taps a new field, or, at least, one which has heretofore been considered of no value as mining property for the reason that seams IV, V and VI have been either thrown out or thinned so that they were unprofitable to mine. These three seams were considered the only workable seams in this part of the State. Prior to the opening of the Midland Mine, with the exception of a few local mines along the eastern horizon or outcrop of the coal field extending north from the Ohio River through Perry, Dubois, Spencer, Martin and Owen counties, Coal III was mined only in Clay and Parke counties, where it is known as the lower block seam, Coal IV being the lowest known workable coal in any other part of the State.

The seam tapped by the Midland Mine is workable over an area of several thousand acres, extending north, south and east from that point. It splits, however, going southwest and west, and is divided into two benches by a slate or dirt band, ranging from two to three and one-half feet in thickness. This condition is found at the Hoosier Mine located four miles southwest of Midland, a description of which was given in the report for 1900. It is also characteristic of this coal field that while the seam is much thicker than that found in the block field (the drillings at some points show as much as eight feet of coal), but it contains many more impurities; and though a good coal for steam and domestic use, the quality is inferior to that of the block coal.

The company operating this mine has spared no expense in equipping the mine, having installed an electric machine plant, double first-motion 125 horse-power hoisting engines, self-dumping cages and all other modern appliances required to handle a large output of coal. Mr. H. W. Sexton, the superintendent, makes the assertion that the capacity of the mine will reach 1,600 tons per day during the present year.

An inspection of the mine was made October 28th, when it was found to be in excellent condition. At that time, two Morgan-Gardner chain machines were in use, with a total working force of about forty-five persons. This force will be increased as rapidly as room is made to put on men, and when fully developed, six machines will be used, giving employment to about 175 persons.

GILMOUR MINE.

The Gilmour Mine is owned and operated by the Indiana Southern Coal Company, situated about three miles southwest of Jasonville on the Sullivan Branch of the Southern Indiana Railway. The seam mined here is Coal IV, reached by a shaft eight and one-half by eighteen and one-half feet in size, 152 feet deep. The quality of the coal is the same as that of other Greene County mines where this seam is mined, descriptions of which have been given in former reports.

The mine is situated on a tract of land of 525 acres in area, owned by this company. The land was drilled and tested thoroughly before locating and commencing to sink the shaft. The shaft was sunk during the past summer, and the switch and equipment of the mine were completed ready to hoist coal about November 1st.

Mining is done by electric machines. The sinking and equipment of the mine was done under the management of John P. Gilmour, who is also superintendent of the New Pittsburg Coal and Coke Company. Mr. Gilmour has had wide experience in such matters. In this instance, he has spared no expense in the construction of mine buildings, arrangement of tracks and equipping it as a modern mine, convenience and durability being the only points considered. The engine and boiler rooms, shop and all other mine buildings, except the tipple, have been constructed of brick and stone, with concrete floors and tiled roof, which renders them fire proof (a matter that can not receive too serious consideration in the construction of mine buildings). The mine will also be developed on the latest improved mining methods, which, with the use of modern appliances for handling coal, will insure not only a large output but also reduce the cost of production to the lowest point consistent with good mining.

VICTORIA MINE.

This mine is owned and operated by the Victoria Coal and Mining Company. The company was organized in the spring of 1900, and commenced operations about four miles north of Linton on the

Southern Indiana Railway. After sinking a shaft, however, the coal seam sunk to was found in such poor condition that it was considered as unprofitable to mine, and the property was abandoned, little having been done in the way of development.

Some changes in the organization of the company were made later in the year and a tract of land two and one-half miles west of Linton on the Illinois Central Railway was leased. After drilling this tract of land, 180 acres in area, a shaft eight by fourteen feet in size, 122 feet deep, was sunk. The shaft was completed and the mine partially equipped in January, 1901. For some reason, the mine switch from the Illinois Central was not put in until September following, at which time the equipment of the mine was complete and the shipping of coal was commenced.

This is a hand or pick mine, the surface arrangement of which is very complete. First-motion hoisting engines, self-dumping cages and the latest improved shaker screens (which are said to be very effective in cleaning coal) are in use there.

An inspection was made November 15th, at which time the first cross-entries were being turned on each side of the shaft. About thirty persons were employed, working double shift. The seam mined is Coal IV, averaging five feet ten inches thick.

Parke County.

NEW CENTURY MINE.

This mine is owned by the New Century Coal and Mining Company and is located on a switch one and one-fourth mile long connected with the Otter Creek Coal Company's switch from the Chicago & Eastern Illinois Railroad. The sinking of the shaft, which is eight and one-half by sixteen feet in size and 175 feet deep, was finished early in the spring, but the first shipment of coal reported was in November.

The seam mined is Coal III, the same as that mined at the Lucia Mine, owned by the same company, which has an average of five feet in thickness.

Pike County.

AYRSHIRE NO. 6 MINE.

This mine is owned and operated by The David Ingle Coal Company and is located one-fourth mile north of Ayrshire No. 4 on a switch from the Southern Railway about one-half mile in length. The seam mined is the same as that at Ayrshire No. 3 and No. 4, i. e., Coal V, averaging five feet thick, and is opened by a drift. The quality of coal, roof, bottom and other conditions are about the same as found at the other Ayrshire mines.

An inspection was made in October, when the working force was less than ten persons. It is intended to increase this number until the mine has a capacity of three hundred tons per day.

MASSEY MINE.

This mine is owned and operated by the Massey Coal and Mining Company and is located two and one-half miles northeast of Oakland City on a coal switch from the Evansville and Indianapolis Railway. It is operated by a shaft eight by sixteen feet in size and fifty feet deep, the sinking and equipment of which was completed ready to ship coal about November 1st.

The seam mined is Coal V. Where the shaft is sunk, the coal is but four and one-half feet thick, though the entries which are being driven north, east and west show a thickness of six and one-half feet. The quality of the coal is said to be excellent for steam purposes. The principal market for the product is found in Indianapolis, Evansville and intermediate points.

SULLIVAN COUNTY.

JACKSON HILL NO. 3 MINE.

This addition to the mining interests of the Jackson Hill Coal and Mining Company is located on the Farmersburg Branch of the Evansville and Terre Haute Railroad, three-fourths of a mile west of the old abandoned No. 1 Mine.

The seam mined has an average thickness of six feet nine inches, and though containing many impurities, it is said to be an excellent steam coal. The roof immediately overlying the coal is a very dark shale from two to six feet thick, which seems inclined to cut or shell off, especially in the entries and narrow places.

There seems to be much difference of opinion as to the geological number of this seam, some claiming that it is Coal II, while a majority of persons who are acquainted with our different coal seams claim that it is Coal III, or the same as that found at the Midland Mine. Considering the different strata sunk through and the characteristics of coal and roof, the latter opinion is more probably correct. Be that as it may, this is a new find in this part of the State and one which will add greatly to the value of Indiana mining interests. Mining at this mine will be done by compressed air punching machines, the company having installed the compressed air plant formerly used at its No. 1 Mine. The balance of the equipment is modern in every detail, and when fully developed the mine will be one of the largest producers in Sullivan County.

Sinking was commenced late in the spring, completed and mine equipped and the first car of coal shipped on November 1st. An inspection was made by Assistant Inspector Dodds on January 10th; he reported it in good condition with the exception of a few minor defects in the way of equipment, which are to be expected at new mines. These the company are remedying as rapidly as possible.

VERMILLION COUNTY.

CROWN HILL MINE.

This is a bituminous hand or pick mine owned and operated by the Clinton Coal Company, of Terre Haute. It is located two miles southwest of Clinton on a coal switch from the C. & E. I. R. R. The seam mined is Coal VII, averaging five feet six inches in thickness, being about eight inches thicker than that found at the Bruiletts Creek, Oak Hill and other mines in the vicinity, where the same seam is mined. It is operated by a shaft eight by fifteen feet in size, 164 feet deep, the sinking of which was commenced August 8th. Coal was reached about October 20th. Little has been done since that time, however, except the driving of the double partings, completing the equipment and shaping matters up preparatory to shipping coal the first of the present year.

VIGO COUNTY.

MIAMI MINE.

This is a bituminous hand or pick mine, owned and operated by the Miami Coal Company, of Brazil. It is located two miles south of Ehrmandale on an extension of the C. & I. C. R. R. mine switch to the Nickelplate Mine. The mine is operated by a shaft eight by eighteen feet in size, thirty-two feet deep, which was sunk in May. The railroad switch was not laid nor the equipment of the mine completed until October 5th, when the first shipment of coal was made. The equipment of the mine is very complete in all details, more especially so with reference to screening machinery, which, together with the railroad tracks, is so arranged that four different grades of coal may be separated and loaded on cars at the same time. The seam mined is Coal VI, averaging from six to seven feet thick, the quality and other conditions of which is practically the same as found at the Nickelplate, Cloverland and other mines where this seam is mined.

ROSE BUD MINE.

The Rose Bud is a bituminous hand or pick mine, owned and operated by the Seeleyville Coal and Mining Company, located west of Seeleyville on a switch from the Vandalia Railroad. It is operated by a shaft nine by eighteen feet in size, 110 feet deep, which was sunk in November, 1900. The tipple and other equipment was not completed until the latter part of January following and the first car of coal was shipped February 1, 1901.

The seam mined is Coal VI, varying from six and one-half to seven and one-half feet in thickness. The roof is very poor, requiring a great deal of timbering. The quality of coal and other conditions are about the same as found at the Hector, Ehrlich, Seeleyville and other mines in the immediate vicinity, where this seam is mined. The mine is exceedingly well equipped, having the Parker self-dump cages, and first-class machinery of all kinds.

The company has lately completed a second outlet or manway in the shape of a slope 175 feet long, which will also be used as a timber chute, for sending timber into the mine.

WARRICK COUNTY.

BIG VEIN NO. 3 MINE.

This mine, owned and operated by the J. Woolley Coal Company, is situated one mile east of Boonville on a switch three-fourths of a mile long from the Southern Railway.

The seam mined here is Coal V, varying from seven to nine feet thick, and is of excellent quality for steam and domestic uses. It is opened by a shaft thirty-seven feet deep by eleven by eighteen feet in size, which is by far the largest hoisting shaft in Indiana. The equipment is modern in every respect. It was made on special order by Prox & Brinkman, of Terre Haute. The haulage roads in the mine are made of forty-pound steel rails fish-plated together and laid on four by eight-inch cross ties; three ton mine cars are used. The hoisting engines, self-dumping cages, screening machinery, steam plant and all other parts of the equipment have been constructed in accord with this large sized mine car.

An inspection of the mine made in November showed it to be in excellent condition. At that time but four men were employed and the mining was being done by hand. Since that time, however, the company has installed two Norwalk air compressors of 125-horsepower each, and mining is now being done by compressed air punching machines. When fully developed, this mine should be the largest producer in the State.

ABANDONED MINES.

Table Showing Names of Mines, Owners, Location and Date of Abandonment.

Name of Mine.	Owner.	County.	Location.	Date.
Crawford No. 1	Crawford Coal Co	Clay	2 miles N. E. of Carbon	March 1.
Crawford No. 2	Crawford Coal Co	Clay	Near Centerpoint	July 16.
Harrison No. 2	Chicago-Indiana Coal Co	Clay	2½ miles E. Clay City	March 1.
Harrison No. 3	Chicago-Indiana Coal Co	Clay	2½ miles E. Clay City	September 21.
Gart No. 3	Brazil Block Coal Co	Clay	Near Brazil	June 1.
Hawkins	Washington Coal Co	Daviess	Near Washington	July 1.
Summitt No. 1	Summitt Coal Co	Greene	2 miles W. Linton	December 1.*
Tunnel	F. M. Wampler	Martin	Tunnel Switch	July 1.†
Otter Creek	Brazil Block Coal Co	Parke	2 miles N. E. Carbon	March 1.
Ayrshire No. 2	David Ingle Coal Co	Pike	Ayrshire	September 1.
Jackson Hill No. 1	Jackson Hill C. and M. Co	Sullivan	Farmersburg Branch E. & T. H. Ry	June 1.
Grant No. 1	Grant Coal Min. Co	Vigo	Grant	November 1.
Koch	George Koch	Vigo	Coal Bluff	February 28.

* This mine was opened in 1887 and has been one of the largest producers in Greene County. In January, 1901, the working force was reduced; since that time it has been operated on a very small scale.

† This mine has been running on a small scale since July 1.

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, and Persons Employed Outside; Total Number of Employes at Each Mine; Number of Days Worked and Number of Mules Used; Totals by Counties.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside	Total.	Days Worked.	Mules.
Brazil Block No. 1	....	20	54	47	12	133	249	9
Brazil Block No. 8	30	18	51	50	15	164	232	14
Brazil Block No. 11	18	14	33	30	8	103	220	16
Briar Hill	7	12	24	10	8	61	187	7
Cloverland	124	......	....	14	10	148	148	8
Columbia No. 4	30	......	....	8	2	40	77	5
Columbia No. 5	54	......	....	10	5	69	207	8
Cornwell	57	......	....	8	5	70	137	3
Crawford No. 2	60	......	....	9	4	73	227	3
Crawford No. 3	95	......	....	11	7	113	205	6
Crawford No. 4	46	......	....	10	5	61	115	4
Crawford No. 5	85	......	....	12	6	103	158	8
Dewey	44	......	....	4	3	51	133	4
Diamond No. 3	11	10	26	19	10	76	210	7
Diamond No. 5	16	10	29	19	10	84	209	8
Eureka No. 2	60	......	....	16	6	82	186	10
Eureka No. 3	61	......	....	12	6	79	172	7
Eureka No. 4	53	......	....	9	6	67	134	5
Fortner	26	......	....	5	4	35	99	6
Gart No. 3	55	......	....	11	8	74	82	4
Gart No. 5	93	......	....	19	8	120	199	10
Gart No. 10	53	10	15	14	5	97	128	7
Gifford	106	8	32	19	12	177	250	10
Gladstone	38	......	....	14	5	57	162	10
Harrison No. 2	27	......	....	5	4	36	38	3
Harrison No. 3	22	......	....	4	3	29	76	3
Klondyke	85	......	....	19	8	112	99	10
Markland	20	......	....	5	4	29	80	1
Monarch	15	......	....	3	2	20	268	2
Pearl	61	......	....	7	6	74	114	6
Pratt	60	......	....	14	6	80	178	8
Rob Roy	30	......	....	5	4	39	218	4
Silverwood No. 3	61	......	....	11	10	82	245	5
Glen	31	......	....	3	4	38	178	6
Crawford No. 7	23	......	....	8	5	36	63	1
Lawrence No. 6	71	......	....	6	....	77	88	5
Total	1,728	102	264	470	226	2,790	5,771	233

DAVIESS COUNTY.

Cabel No. 4	43	......	....	7	6	56	154	5
Cabel No. 9	46	6	12	39	8	111	143	10
Hawkins	7	......	....	3	2	12	102	2
Hoosier	7	......	....	2	2	11	91	......
Montgomery No. 2	66	......	....	23	9	98	197	5
Montgomery No. 3	117	......	....	26	12	155	242	7
Mutual	40	......	....	8	6	54	218	5
Black Diamond	8	......	....	1	2	11	172	2
Union	12	......	....	3	1	16	160	......
Logan Grove	14	......	....	2	3	19	78	1
Total	360	6	12	114	51	543	1,557	37

FOUNTAIN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Silverwood No. 4	49	......	....	12	6	67	279	6
Total	49	......	....	12	6	67	279	6

GIBSON COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Oswald	85	......	....	25	16	126	205	9
Total	85	......	....	25	16	126	205	9

GREENE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Black Creek	10	8	44	14	9	85	213	7
Fluhart	89	......	....	25	11	125	162	12
Gilmour	....	12	45	10	6	73	42	2
Hoosier	28	6	17	9	4	64	175	2
Island No. 1	22	20	42	30	12	126	167	10
Island No. 2	59	30	69	36	19	213	183	14
Island Valley No. 1	37	......	....	12	6	55	168	6
Island Valley No. 3	117	......	....	20	9	146	198	8
Island Valley No. 2	51	......	....	6	7	64	153	4
South Linton	130	......	....	21	11	162	158	10
Summitt No. 2	12	14	78	29	9	142	177	14
Templeton	110	......	....	20	11	141	252	12
Wild Cat	90	10	20	29	10	159	213	8
Midland	....	6	25	7	8	46	45	2
Victoria	19	......	....	4	5	28	62	2
Total	774	106	340	272	137	1,629	2,368	113

KNOX COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Bicknell	32	......	....	7	5	44	116	3
Edwardsport	47	......	....	11	7	65	199	6
Knox	23	......	....	4	4	31	138	3
Prospect Hill	13	......	....	5	[illegible]	21	231	3
Lynn	6	......	....	1	3	10	26	1
Total	121	......	....	28	22	171	710	16

MARTIN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Tunnel	23	......	....	3	2	28	87	2
Total	23	......	....	3	2	28	87	2

PARKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Anthony	13	......	....	3	3	19	20	......
Brazil Block No. 12	6	16	55	30	12	119	201	12
Cox No. 3	20	26	40	16	23	125	172	15
Crawford No. 1	36	......	....	6	4	46	40	2
Lucia	73	.....	....	19	6	98	237	7
Lyford No. 1	8	......	....	2	2	12	34	2
Lyford No. 2	73	......	....	32	10	115	170	14
Mary	67	......	....	11	7	85	255	4
Mecca	34	......	....	13	6	53	191	7
McIntosh No. 3	74	......	....	11	5	90	174	4
Otter Creek	26	......	....	4	3	33	52	2
Parke No. 8	17	30	27	33	11	118	183	10
Standard	42	......	....	6	4	52	189	7
Superior No. 1	70	......	....	11	4	85	133	8
Superior No. 2	132	......	....	25	8	165	182	10
New Century	24	......	....	2	4	30	23	2
Total	715	72	122	224	112	1,245	2,046	106

PERRY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Cannelton	33	......	....	6	5	44	42	5
Troy	20	......	....	3	3	26	237	2
Total	53	......	....	9	8	70	279	7

PIKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Aberdeen	37	......	....	6	6	49	148	3
Ayrshire No. 3	99	......	....	30	20	149	209	16
Ayrshire No. 4	26	......	....	5	4	35	216	3
Ayrshire No. 5	16	......	....	3	3	22	217	5
Blackburn	17	......	....	3	3	23	77	7
Carbon	18	......	....	5	4	27	240	3
Hartwell	10	......	....	3	2	15	62	2
Littles	87	......	....	20	11	118	173	12
Petersburg	26	......	....	7	4	37	117	5
Rogers	23	......	....	4	3	30	165	2
Ayrshire No. 6	....	(Reported with No. 3.)				......	....	2
Total	359	......	....	86	60	505	1,624	60

SULLIVAN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Bunker Hill	4	8	48	21	9	90	195	8
Briar Hill	33	......	....	6	4	43	25	4
Caledonia	71	......	....	17	9	97	238	8
Dugger	....	12	74	36	15	137	161	12
Green Hill	....	4	30	9	8	51	198	6
Hymera	....	16	92	29	16	153	202	11
Ingleside	40	......	....	10	8	58	128	4
Jackson Hill No. 1	17	32	55	33	17	154	63	7
Jackson Hill No. 2	....	14	97	35	13	159	182	12
Phoenix No. 1	14	18	60	37	14	113	148	18
Phoenix No. 3	31	2	6	4	4	47	170	5
Phoenix No. 5	4	10	30	5	5	54	124	7
Star City	....	16	93	60	20	189	181	26
Shelburn	20	8	17	10	9	64	90	6
White Ash	38	......	....	5	5	48	118	3
Jackson Hill No. 3	....	......	....	6	5	11	48	2
Total	272	140	602	333	161	1,508	2,271	139

VANDERBURGH COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Persons Employed Outside.	Total.	Days Worked.	Mules.
Diamond	20	....	....	4	4	28	191	4
First Avenue	43	......	....	10	11	64	259	6
Sunnyside	23	16	15	17	9	80	178	12
Ingleside	46	......	....	8	8	62	222	6
Union	21	......	....	5	6	32	184	4
Unity	22	......	....	4	4	30	237	3
Total	175	16	15	48	42	296	1,271	35
VERMILLION COUNTY.								
Bruiletts No. 3	23	......	....	14	6	43	54	8
Bruiletts No. 4	102	......	....	25	7	134	254	11
Bruiletts No. 5	96	......	....	16	7	119	195	6
Buckeye	62	......	....	14	8	84	170	11
Cayuga	12	......	....	3	2	17	170	2
Crown Hill	10	......	....	3	2	15	24	1
Oak Hill	117	....	....	14	8	139	166	9
Prince	140	....	....	34	11	185	228	16
Torrey	97	......	....	32	11	140	228	12
Willow Grove	14	......	....	2	2	18	98	4
Total	673	......	....	157	64	894	1,587	80
VIGO COUNTY.								
Chicago No. 6	64	......	....	15	5	84	21	3
Brick Works	13	......	....	3	2	18	296	2
Broadhurst	12	......	....	2	2	16	96	2
Diamond	144	......	....	27	10	177	206	17
Ehrlich	61	......	....	12	6	79	213	7
Grant No. 1	7	......	....	3	3	13	156	3
Grant No. 2	151	......	....	21	10	182	211	8
Glen Oak	7	8	35	12	12	74	258	10
Hector	53	......	....	12	7	72	160	6
Klondyke	60	......	....	16	9	85	80	4
Koch	12	......	....	2	2	16	34	2
Miami	44	......	....	5	6	55	24	5
Nickelplate	74	......	....	15	9	98	204	6
Peerless	95	......	....	21	10	126	206	15
Parke No. 10	3	36	70	34	16	159	165	11
Red Bird	13	......	....	2	2	17	159	2
Ray	108	12	12	20	11	163	116	11
Rose Bud	79	......	....	14	9	102	169	7
Royal	50	......	....	7	6	63	261	4
Union	141	......	....	31	14	186	220	14
Vigo	19	......	....	3	3	25	108	3
Larimer	10	......	....	2	3	15	138	2
Lawton	25	16	23	5	5	74	167	6
Total	1,245	72	140	284	162	1,903	3,678	150
WARRICK COUNTY.								
Air Line	16	......	....	2	2	20	155	3
Big Four	61	......	....	8	9	78	240	6
Big Vein	7	12	30	8	6	63	270	6
Caledonia	50	......	....	7	9	66	231	5
Chandler	16	......	....	2	2	20	155	3
DeForrest	13	......	....	2	2	17	150	2
Star No. 1, No. 2	41	......	....	9	7	57	137	6
Total	204	12	30	38	37	321	1,338	31
Grand total	6,836	526	1,525	2,103	1,106	12,096	25,071	1,024

TABLE

Showing Number of Miners, Total Wages of Miners and Average Wages Per Miner; Number of Inside Day and Monthly Men, Total Wages of Same, and Average Wages Per Man; Number of Outside Day and Monthly Men, Total Wages of Same, and Average Wages Per Man, by Counties.

COUNTY.	Number of Miners.	Total Wages of Miners.	Average Earning per Miner.	Number of Inside Day and Monthly Men.	Total Wages of Inside Day and Monthly Men.	Average Earning per Inside Day and Monthly Man.	Number of Persons Outside.	Total Wages of Persons Outside.	Average Earning per Outside Man.
Clay	2,094	$806,459 11	$432 88	470	$242,721 20	$516 42	226	$147,325 72	$651 88
Daviess	378	152,418 36	403 38	114	50,551 37	443 52	51	23,954 28	465 77
Fountain	49	24,170 80	452 46	12	9,577 69	798 14	6	4,202 47	700 41
Gibson	85	53,198 78	625 84	25	12,830 79	513 23	16	9,339 02	583 68
Greene	1,220	589,408 64	483 12	272	153,368 32	553 67	137	81,331 34	593 65
Knox	121	31,630 26	261 48	28	10,836 6[illegible]	387 02	22	8,629 67	392 25
Martin	23	2,590 83	112 64	3	609 24	203 08	2	409 40	204 70
Parke	909	428,219 04	471 08	224	147,843 23	660 01	112	80,494 45	718 70
Perry	53	9,876 23	186 34	9	2,647 18	294 11	8	1,658 50	207 31
Pike	359	143,172 81	398 81	86	43,321 53	503 73	60	27,740 22	479 00
Sullivan	1,014	399 568 68	394 05	333	156,481 07	462 91	161	79,537 45	494 02
Vanderburgh	206	117,306 01	583 49	48	26,481 28	551 69	42	24,101 04	573 89
Vermillion	673	391,952 46	582 39	157	95,625 81	609 08	64	48,738 21	761 53
Vigo	1,457	627,558 69	430 78	284	171,068 98	602 39	162	102,922 50	635 26
Warrick	246	101,845 26	414 00	38	21,075 98	554 63	37	15,739 45	425 39
Total	8,887	$3,879,375 86	$436 29	2,103	$1,145,040 20	$544 47	1,106	$656,123 72	$593 24

FATALITIES AND INJURIES.

The monthly reports of mine bosses made to this office for the year 1901 show an aggregate of two hundred and eighteen (218) accidents to mine employes, classified as follows: Fatal, twenty-four (24); serious, seventy-seven (77); and minor, one hundred and eighteen (118), as shown by the annexed table:

TABLE.

Cause.	Fatal.	Serious.	Minor.	Total.
Falling slate	10	19	33	63
Falling coal	2	5	22	29
Mine shaft	4	2	..	6
Mine cage	1	..	2	3
Mine cars	3	19	26	47
Machines	..	1	6	7
Blown out shots	..	7	6	13
Delayed shots	1	2	1	4
Premature shots	1	2	2	5
Tamping shots	2	..	..	2
Powder explosion	..	5	1	6
Smoke explosion	..	5	..	5
Fire damp	..	2	2	4
Kicked by mule	..	5	3	8
Miscellaneous	..	3	13	16
Total	24	77	117	218

Each of the fatalities above noted has been thoroughly investigated either by myself or by one of my assistants, and except where persons have lived for some time after being injured, the investigation was made in conjunction with the coroner of the county in which the accident occurred.

The list of fatalities represents not only those who were killed outright, but also those who received injuries which ultimately resulted in death, some of whom lived for several months. Heretofore, as a rule, only persons killed outright and on whom inquests were held were reported in the list of fatalities. This fact makes it appear on the face of this report that this year has been productive of more fatal *accidents, proportionately, than most former years.*

A brief review of the facts as to the causes that give rise to the many accidents in coal mines may not be amiss here.

It may be said that fifty per cent. of accidents in mines can be attributed either directly or indirectly to the use of powder, causing windy shots, smoke explosions, props to be knocked down by flying coal, thus causing slate falls, etc.

It is no uncommon sight on going through the working places of a mine early in the morning to find from two to fourteen props, and frequently a greater number, which have been knocked out by shots fired at quitting time on the evening before. In many instances of this kind, the miner will put off resetting his props until after he has loaded a car or so of coal, and straightened things out for his day's work; or, in other words, until he has nothing else to do. As a consequence, it may be days before some of the props are reset, with the result naturally to be expected, i. e., a fall of slate and the imperilment of human life.

The complaint of not being able to get props is frequently made; and while this may be true in some instances, yet considering the fact that in addition to the safety of the workmen, it is also the purpose of props to hold up the roof in their working places and make it possible to mine coal in advance of them, and that the mine owner does not care to lose a block of coal by reason of rooms falling in, is evidence of his willingness to furnish props. The mine boss who fails to furnish props not only neglects the safety of workmen, but also the interests of his employer.

I have given this matter particular attention in past years and have instructed my assistants to do the same. The fact that working places are advanced day by day, and that inspections can not be made more frequently than from three to five months apart, much must necessarily depend upon the miner himself for the care of his working face.

It will be noticed that of the twenty-four fatal accidents occurring within the year 1901, ten, or 43⅔ per cent. of them were caused by falling slate. Six of those fatalities, as is shown in the description of accidents, would have been averted had the most ordinary precautions incumbent upon a miner been taken by the decedents for their own safety. In fact, three of these unfortunates met death while working in direct violation of orders given by the mine bosses and against the advice of fellow-workmen.

The following table shows that three drivers were killed. Of this number at least one (Wint Marvel) would have been spared had he obeyed the express order of the mine boss not to ride on the front end of his trip while coming down a very steep grade. One other (McBurney) might have been spared had there been a flagman stationed at the entry parting to prevent collisions of mine cars. Two miners were killed by shots and two while tamping shots. Of the former two but few circumstances were learned other than that one had gone back on a shot which was supposed to have squibbed (a very dangerous thing to do, as will be conceded by any experienced miner). As to the latter two (Jacks and son), the accident could have been averted by a compliance with the law requiring tamping tools which will not strike fire on coming in contact with sulphur. Of the two persons killed by falling coal while mining off loose shots, little can be said, except that such work is fraught with much danger and should receive extra precautions on the part of miners. Of the four persons killed in mine shafts, and the one by mine cage, a full description of the facts and circumstances attending each case is given in another part of this report.

The names of persons, occupation, dates and cause of each death, the name of the mine and county wherein the fatalities occurred, are given in the following table:

FATAL ACCIDENTS REPORTED AT INDIANA MINES, 1901.

NAME.	DATE.	OCCUPATION.	CAUSE OF ACCIDENT.	NAME OF MINE.	COUNTY.
Wint Marvel	January 4	Driver	Crushed between cars and cross-bar	Phœnix No. 1	Sullivan.
David Jones	January 5	Miner	Falling cage in shaft	Brazil Block No. 10	*Clay.
George Hayes	January 5	Miner	Falling cage in shaft	Brazil Block No. 10	*Clay.
Charles Low	January 7	Miner	Falling off of cage	Bruilett's No. 3	Vermillion
Fred Sampson	January 29	Miner	Went back on shot	Bruilett's No. 3	Vermillion
Rollo Watts	February 3	Timberman	Caught by cage	Torrey No. 4	Vermillion
Robert Lee	March 11	Miner	Falling coal	Island No. 2	Greene.
James Usrey	March 11	Miner	Fell down shaft	Island Valley No. 3	Greene.
George Gibson	March 17	Miner	Falling slate	First Avenue	Vanderburgh.
Robert Bradley	March 21	Miner	Falling draw-slate	Templeton	Greene.
Elija Braken	April 15	Machine Runner	Falling slate	Big Vein	Warrick.
Geo. Dianish	April 18	Miner	Falling coal and slate	Buckeye	Vermillion.
Jas. McBurney	April 19	Driver	Collision of mine cars	Parke No. 10	Vigo.
Elmore Terry	June 23	Driver	Run down by mine car	Big Vein	Warrick.
Wm. Unverferth	June 27	Miner	Falling slate	Glenburn	Greene.
George Kapalo	July 26	Miner	Mine blast	Buckeye	Vermillion.
Jas. Jacks and Son	August 6	Miners	Explosion while charging shot	Bruilett's No. 5	†Vermillion.
John Libertine	August 6	Miner	Falling slate	Brazil Block No. 12	Parke.
Frank Barberline	August 9	Miner	Falling slate	Standard	Parke.
Reese Powell	August 29	Timberman	Falling slate	Grant No. 2	Vigo.
Walter Murphy	October 10	Timberman	Falling slate	Mecca No. 1	Parke.
William Smith	October 19	Miner	Falling slate	Montgomery No. 2	Daviess.
Floryan Kolontay	November 23	Miner	Falling slate	Brazil Block No. 11	Clay.

*Jones and Hayes killed at same time.

†Jas. Jacks was instantly killed; his son died some time later at hospital in Terre Haute.

FATAL ACCIDENTS.

We submit herewith the facts and circumstances relating to each of the above accidents, as established by coroners' inquests, together with comments on same.

The first death to occur in the mines of this State during the year 1901, by reason of accident, was that of Wint Marvel, driver, who, on the morning of January 4th, was caught and crushed between the top of a loaded car and a cross-bar, in Phoenix No. 1 Mine, Sullivan County, operated by the New Pittsburg Coal and Coke Company.

The entry in which the accident occurred rises toward the face with a grade so heavy as to require two sprags in each car when coming out of it. Evidence given at the inquest shows that Marvel, on the morning above mentioned, had gone to the face of the entry after a loaded car; that while going up the entry, he was whipping his mule; that after being hooked to the car, on account of its having been so whipped, the mule became excited and fretful and started down the entry more rapidly than usual. Marvel, in direct violation of the order of the mine boss, was riding on the front end of the car, standing in a stooping position with one foot on the draw-bar of the car and the other on the tail chain. About forty-five feet from the face of the entry, an air pipe lay across the roadway near the roof, extending into a room-neck. Attached to the end of this pipe was a rubber hose used to conduct air into a mining machine, which was in operation at the time. Just as the mule and car were passing under this pipe, the hose connection, in some manner, came off, allowing the air to escape in full force. The noise of the escaping air frightened the mule, which, at the time, was going too rapidly for the safety of the driver, into a run. The supposition is, that when it started to run, Marvel was jerked backward over the edge of the car and was caught between it and a cross-bar, crushing his breast and shoulders, and so injuring him that he died on the following morning.

Marvel was very careless and reckless in attempting to ride on the front end of the car down the heavy grade above referred to, it having at least a seven or eight per cent. fall. Also, he should have known that it would be doubly hazardous to ride in such a position after whipping the mule, which, it is a reasonable presumption, becoming fretful and excited, would naturally travel faster than usual, probably attempt to run away. In either event, his chances to get off of the car without being seriously injured were very meager. A compliance with the order of the mine boss not to ride on the front end of the car would have averted this accident.

The second fatal accident in this State, and one of the most deplorable of the year, occurred January 5th, at the Brazil Block Coal Company's No. 10 Mine, in Clay County.

At a few minutes before seven o'clock on the morning of the above date, David Jones and George Hayes, miners, employed at this mine, entered the cage and signaled the engineer to lower them down the shaft. The engineer for some reason, presumably absent-mindedness, started the cage up instead of down, and did not notice his mistake until he had hoisted it into the sheave wheel, thereby breaking the rope and safety catches and precipitating the cage with the miners on it to the bottom of the shaft, a distance of one hundred and eighty feet, killing both men instantly.

The engineer in charge of the engine was an old and experienced man and bore a reputation as a careful and competent engineer. His absent-mindedness is the only plausible reason which can be ascribed as the cause of the accident. It could have been prevented, however, had there been a top signal bell connected with the engine room with some person in charge of it while the miners were being lowered into the shaft.

On January 7th, Charles Low, miner, employed at the Bruiletts Creek Coal Company's No. 3 Mine, Vermillion County, was instantly killed by falling from an ascending cage.

The evidence adduced at the investigation of this case discloses that Low had two shots in readiness to fire at firing time on the above date, one of which exploded, the other failing to do so. There were also several other shots fired in the near vicinity of Low's working place which, together with the one he had fired, made a large amount of smoke. While trying to fire his missed shot, Low worked some time in this powder smoke, which was very dense and hot.

The usual effect of powder smoke on a person who has worked in it for any length of time is to produce dizziness when he reaches fresh air. The supposition is, that this was true in Low's case, since after so working in the smoke he started up the shaft, and upon reaching the cooler air fell off the cage. It is but a reasonable presumption that he became dizzy, which, together with the motion of the cage, caused him to fall therefrom. However, this is but an opinion, since no one saw him fall. There were two other persons on the cage at the time, but they were standing with their backs to Low, and did not miss him until they reached the top of the shaft.

The cage from which Low fell was one of the Prox-Brinkman self-dump make which on the sides had no guards or supports of any kind by which persons might steady themselves while going up or down the shaft. Although no guards or supports are required by our statute, they are nevertheless greatly needed. Had they been provided in this instance, it is very probable that Charles Low would not have come to his death as he did.

On January 9th, a second death occurred at the last above named company's No. 3 Mine. On that date, Fred Sampson, miner, was killed by a shot fired by himself. No one was present at the time, and but little could be learned as to the real cause.

From evidence given at the inquest, it was learned that Sampson had two shots ready to fire in a room-neck at firing time; that he had fired one of them and had gone back to fire the other, but for some cause failed to get out of reach of the flying coal after lighting the shot. When found, he was lying on some of the loose coal which had been thrown out by the explosion of the shot.

It is the general opinion of those acquainted with the circumstances surrounding this case, that Sampson became confused and lost his way in the smoke made by his first shot. The room-neck being but a very short distance from the entry, and there having been a strong current of air passing that point, it seems that such opinion has no good foundation.

The third death in Vermillion County was that of Rollo Watts, who was killed on February 30th, at the foot of the Torrey Coal Company's No. 4 hoisting shaft.

Watts and two other miners were employed on the night shift to timber and clean up slate-falls. On the evening of the accident, after getting ready for work, they found the regular engineer absent from his post. Wilson Vantreaves, being present, volunteered to lower them down the shaft.

At the investigation of the accident, it was learned that Vantreaves, though not a regular and licensed engineer, in the absence of the regular engineer had frequently lowered persons into and hoisted them out of the mine. It may also be stated here that the engines at this mine are of the first motion pattern and run at a high rate of speed. This being true, none but a thoroughly competent engineer should have been allowed to handle them. On this occasion, Vantreaves lost control of the engines and allowed them to travel under a full head of steam until the cage was within a few feet from the shaft bottom, when, instead of shutting off the steam and setting the brake, he reversed the engine. The speed at which the cage was traveling at the time he so reversed the engine carried it to the bottom of the shaft, where it struck with such force as to throw Watts and his companions off their feet, Watts falling partially over the edge of the cage, probably being stunned by the fall. The engine being reversed and the steam not shut off, the cage began to ascend before the unfortunate man could regain his feet, catching his head and shoulders against the bottom of the shaft curbing and crushing him to death.

Vantreaves was arrested and charged with manslaughter. Though bearing an excellent reputation in every particular and deploring the accident as much, or even more, than any one else, an example should be made of his case which would tend to prevent mine bosses and other persons not fully qualified and competent attempting to run hoisting engines, a thing which only the most competent engineers should be allowed to perform.

The miners, in this instance, should also be censured, inasmuch as they knew Vantreaves was not a competent engineer, and that by placing themselves under his care were thereby contributing to their own danger. Had they waited but a few minutes, the regular engineer would have been at his post, and it is fair to presume the accident would not have happened.

On March 11th, Robert Lee, loader, employed by the Island Coal Company at its No. 2 Mine, Greene County, while working off a standing shot, was injured by falling coal, from the effects of which he died four days later.

On March 11th, at about eight o'clock in the evening, James Usrey, miner, was instantly killed by falling down the Island Valley Coal Company's No. 3 shaft.

Upon investigation of this accident, it was learned that Usrey had been in the habit of going back into the mine after working hours to examine his shots, and for this purpose, on the evening he met his death, he had started to go down the shaft with the night watchman, who stopped on the way for the purpose of oiling the fan, which stood but a few feet from the hoisting shaft. While waiting for him, Usrey opened the shaft gate, and without making any examination whatever to learn whether or not the cage was at the proper landing, stepped into the shaft, falling to the bottom, a distance of forty-seven feet, instant death resulting.

On March 17th, George Gibson, miner (colored), was injured by falling slate in the First Avenue Mine, Vanderburgh County, operated by the Sunny Side Coal and Coke Company, from the effects of which he died the following day.

Gross negligence on the part of the decedent was wholly responsible for this accident. On examining the room in which he was injured, I found the distance between the face of the coal and the first props to be twenty-one feet, also a good supply of timber at hand ready for use.

It appeared in evidence at the inquest, that the mine boss on the day preceding the accident had examined and found the roof over this place to be loose, and thereupon so advised Gibson and ordered him to properly timber it up. Miners working in adjoining rooms also advised Gibson to timber the place. His answer in each instance was to the effect that he had "not mined coal for twenty-one years for nothing, and that he guessed he knew his own business." He continued working in the place without setting the props, with the result most likely to be expected.

The mine boss, in this instance, I think, was also somewhat remiss in performing his duty. After examining the place and learning of its dangerous condition, he should have compelled Gibson either to set the timbers or to quit the room.

On March 21st, at about 11:30 o'clock a. m., in the Templeton Mine, Greene County, owned and operated by the Western Indiana Coal Company, Robert Bradley received injuries from which he died about three months afterward. The piece of draw-slate which fell upon and injured him was nine feet in length, six feet wide and two inches in thickness.

Upon investigation, the following facts and circumstances were established: That Bradley was mining off a loose shot; that he knew that the draw-slate was loose, as his attention had been called to that fact by a miner working in an adjoining working place; that at that time, Bradley pulled a part of the slate down, but failed to set props or in any way to secure the remaining portion. He being an old and experienced miner knew that his safety depended upon this slate's being secured, especially so after he had worked off a part of the loose shot. He made the statement that he had worked off about three cars of coal from the shot, and that he had taken down a part of the draw-slate; but that he thought the remainder of the slate was solid. Yet, I think his examination of it could not have been very thorough, as I am satisfied that the loose shot referred to, which was four feet ten inches thick, measured at right angles from the drill hole, and seven feet in length, which had been fired on the solid, would necessarily have loosened this draw-slate from the drill hole to the outside edge of the fall; and his having mined off three cars of coal would give the slate a chance to draw or sag.

On April 15th, Elija Bracken (colored), machine runner, at the J. Woolley Coal Company's Big Vein Mine, Warrick County, was struck by a piece of falling slate, receiving injuries from which he died three days later.

This accident was investigated by Assistant Inspector Dodds and the Coroner of Warrick County, who returned a joint verdict of accidental death. A suit for damages was instituted by the widow of the decedent at the September term of court of that county. The case was postponed until the December term following, and up to the present time no disposition has been made of it.

On April 18th, George Dianish, miner, while working off a standing shot, was killed by falling coal and slate at the McClellan, Sons and Company's Buckeye Mine, Vermillion County. No one was present at the time and but little was learned at the investigation as to the exact cause of the accident.

On April 19th, James McBurney, driver, was killed in a collision of mine cars at the Parke County Coal Company's Heckland Mine, Vigo County.

The cross-entry in which McBurney was driving rises with a tolerably steep grade from the parting at the main entry, which also rises past the same point, the grade of each entry being so steep as to require several sprags to stop a trip.

On the evening of the accident, McBurney was coming out of the cross-entry with a loaded trip, riding on the front end of the car. He reached the parting at the same time as did another driver, who was coming down the main entry. When McBurney saw the cars were bound to collide, he tried to jump and was caught between the side of the car and the rib of the entry, killing him instantly.

The accident might have been prevented had there been a flagman stationed at this point who could have stopped one of the drivers in time to have avoided a collision. There should be a law enacted requiring coal companies to station flagmen at such places.

On June 3d, Elmer Terry, driver, employed at the J. Woolley Coal Company's Big Vein Mine, Warrick County, was run down by a mine car. He died on the 22d day of June. No further facts regarding this accident were reported to this office.

On June 27th, William Unverferth, loader, was instantly killed by falling slate at the L. T. Dickason Coal Company's Mine, in Greene County.

An investigation of this accident developed some features not usually found in connection with mine accidents. As my report filed with the Clerk of the Greene Circuit Court sets forth all the facts and circumstances ascertained in my investigation as to the cause of this accident, I give it here in full (omitting the formal parts), as follows:

"I, James Epperson, Inspector of Mines, having made investigation as to the cause of the death of one William Unverferth, depose and say as follows:

On June 28, 1901, at about 6 o'clock a. m., I was notified by the mine superintendent of the L. T. Dickason Coal Mine, located near Linton, Ind., that a miner by the name of William Unverferth had been killed in said mine by falling slate at about 9:30 p. m. the day prior.

On receiving the above notice, I immediately went to the mine, and in company with the mine superintendent, mine boss and others, went into it and saw the place where the accident had occurred.

I found that it occurred on a siding which was being made on the main west entry between the second and third north cross entries, at a point about 70 feet outside of the third north entry.

I saw the piece of slate which had fallen on deceased and caused his death. In dimensions, the piece of slate, which was said to have lain directly on him, measured three feet two inches in width, nine feet long and was 15 inches thick. This piece of slate, however, was only a part of the slate fall proper, which extended the full length of the siding, a distance of 70 or 75 feet, varying in width from two to four and one-half feet. After examining the place where the accident had occurred, I then notified the assistant coroner of the accident, and requested that he come as soon as convenient to assist in making investigation.

The assistant coroner reached Linton late in the evening of the 28th, and I assisted him to examine the following witnesses, to wit: Geo. S. Payton, loader; John H. Hornbrook, boss driver; Chas. E. Daniels, road-layer, and Thomas J. Thomas, mine boss. From the evidence given by the above named witnesses and my examination of the premises, we established the facts hereinafter set forth, i. e.:

That the management of the L. T. Dickason Coal Mine had commenced to construct a siding or double parting on the west side of the mine. That the siding was being made between the second and third north entries; that in order to secure width for the siding, there had to be a slab or breast of coal about four feet wide taken off of the south side of the entry.

That the company had caused this breast of coal to be mined with mining machines for a distance of about 70 or 75 feet along the side of the entry at the point above named.

That in order to secure heighth for the haulage road, the company had shot the slate or roof down to a height or thickness of about 15 inches along the main west entry between the second and third north cross-entries.

That this slate had been shot down some days prior to the date on which the slab of coal had been mined to make the siding.

That the mine boss ordered this breast of coal after being mined, to be drilled and shot down by his road-layer, which was done.

That after the coal was mined and shot down, there was left a ledge of slate 15 inches thick the full width and length of the breast of coal above described.

That on the 24th day of June, the mine boss ordered his drivers to load out this coal; also ordered that they load along the edge of the coal next to the roadway so that there could be props set under this ledge of slate.

That it was quitting time on the evening of the 24th when sufficient coal had been loaded to make room for props to be set.

That the mine hoisted coal two hours on the morning of the 25th, and lay idle from that time until the morning of the 27th, by reason of a drivers' strike, no one being allowed to work in the mine.

That during this idle time, the Mine Committee notified the mine boss not to allow any more of this coal to be loaded by his drivers or day men, claiming that the coal should be loaded by loaders.

That on the 27th, the mine boss requested the Mine Committee to select some one to load out the coal.

That the Mine Committee selected William Unverferth and George S. Payton to come back into the mine on the evening of the 27th to load out this coal.

That said two men went back into the mine and started to work at about 6 o'clock p. m., and had loaded two cars of coal, drilled and fired a small shot at one end of the siding and were loading the third car, having it bedded or level full. Payton was working near the car leveling it off, while Unverferth was working back under the ledge of slate, it being at this time about 9:30 o'clock, when the slate fell and killed Unverferth.

That there were no props set under this ledge of slate although there was plenty of room to have set them.

That there was evidence tending to show that there were no props on hand to be set, and equally as much evidence tending to show that there were props on hand.

That William Unverferth was a coal miner, and had mined coal at various times during the past twelve or fourteen years.

That this siding was not William Unverferth's regular place of work, he and Payton having two rooms in another part of the mine in which they were employed as loaders.

The facts as above stated are, I believe, the true facts in this case. But from surrounding circumstances, I am unable to determine who was in fault, the men who were loading the coal, or the mine management."

On July 26th, George Kapalo, miner, was killed by coming in contact with a shot fired by himself in the Buckeye Mine, Vermillion County, owned by McClellan, Sons and Company. Owing to the fact that no one was present at the time of the accident, very little was learned as to its cause, upon investigation.

Kapalo, after lighting his shot and waiting for quite a while, thought it had missed fire, and started back to try it again. When within a very few feet from it, the shot exploded, several pieces of coal striking him and inflicting injuries from which he died while being taken home from the mine.

On August 6th, two lives were lost by reason of a premature blast, in the Bruiletts Creek Coal Company's Mine, Vermillion County. James Jacks was instantly killed, and his son, ——— Jacks, was so badly burned and otherwise injured that he died some weeks later at the hospital in Terre Haute.

No one excepting the father and son was present at the time of the accident. From the testimony of the latter, it was learned that they had charged a hole with several pounds of loose powder, and that the father was either settling the powder back with a tamping bar, or had begun to tamp it, when the powder exploded.

The only plausible theory to account for the explosion is, that while starting to tamp, a piece of sulphur was struck by the iron tamper, causing a spark which ignited the powder. A compliance with the statute requiring copper tamping-tools would have prevented this accident.

On the night of August 6th, John Libertine, employed by the Brazil Block Coal Company for lifting bottom at their No. 2 mine, Parke County, was struck by a piece of falling slate weighing about two tons, receiving injuries from which he died two hours later. No other person being present, the facts and circumstances surrounding this accident are unknown.

On August 9th, Frank Barberline was killed in the Standard Block Coal Company's Standard Mine, Parke County, he being struck by falling rock.

Barberline was engaged in drawing a pillar at the time he met his death. An examination of his working place showed it to be very poorly timbered, although there was plenty of timber at hand with which it could have been made safe.

Negligence in this case should be charged to both the decedent and the mine boss, the former on account of his not providing for his own safety by timbering, and the latter for not either compelling him to timber or to quit the place.

On August 29th, Reese Powell, timberman, was killed by falling slate in the Grant Coal Company's No. 2 Mine, Vigo County. On investigation, the evidence showed that Powell had tried for some time to take down the piece of slate, but for some reason failed to do so. He then went directly beneath it for the purpose of doing some other work, and while so engaged, the slate gave way, falling upon and killing him instantly.

On October 10th, Walter Murphy was instantly killed by falling slate in the Otter Creek Coal Company's Mecca No. 1 Mine, Parke County.

Murphy was employed at this mine as timberman, and had worked in that capacity about three years. At the time of the accident, he had gone into an old air course to level down some slate falls. No one was with him at the time, so very little could be learned as to the exact cause of the accident.

On October 15th, William Smith, miner, was killed by falling slate at the face of his working place in the Daviess County Coal Company's Montgomery No. 2 Mine, Daviess County.

This accident was investigated by Assistant Inspector Dodds and the Coroner of Daviess County. The following extract from the testimony of James McKenna, mine boss at said mine, is a fair statement of the facts and circumstances surrounding the accident.

"Mr. Smith had been working for the Daviess County Coal Company for about three months, I think. He had been working at the place where he was killed all the time excepting about two weeks, as I remember. I was in his room about 12:15 o'clock on October 15, 1901, and examined it thoroughly. I told him it was in a dangerous condition, that the bottom was heaving and that the top had begun to cut on the gob rib. I also advised him to leave the room immediately or he would be killed. He answered that it was a good room and for that reason disliked to leave it; that he had a breakthrough near the face through which he could escape in case of accident. I told him no, that it might come all at once. I told the driver to leave no car there over night. I have not seen the room since the accident."

Had the mine boss performed his duty in this instance, he would have ordered Smith to leave the room. Also, he should have given orders to the driver that no more coal should be hauled out of the room.

On the evening of November 23d, Floryan Kolontay, miner, was instantly killed by falling rock in the Brazil Block Coal Company's No. 11 Mine, Clay County.

At the time of the accident, the company was driving the main east entry and air course on double turn. Kolontay worked on the night turn in the air course. On leaving his work at 3:30 p. m., which is firing time, the miner who preceded Kolontay on the day shift fired a shot which knocked down several props. Kolontay's first duty on commencing work should have been to replace these props. This he failed to do. As a consequence, he had worked but a short time when tons upon tons of rock fell upon him. The accident occurred at about 4:45 o'clock p. m., and four hours hard work by several men were required to remove the rock in order to recover the body.

TABLE

Showing Number of Tons of Coal Produced in Each Year since January 1, 1879; also the Number of Deaths of Mine Employes by Reason of Accident and the Tonnage to each Death for each Year.

Year.	Tons Produced.	No. of Employes.	Deaths.	Tons Per Death.
1879	1,196,490	3,459	..	....
1880	1,550,375	.....	..	....
1881	1,771,536	4,567	10	177,153
1882	1,900,000	.....	..	....
1883	2,560,000	5,403	11	232,727
1884	2,260,000	5,716	9	228,888
1885	2,375,000	6,502	7	339,285
1886	3,000,000	6,406	7	428,571
1887	3,217,711	.....	..	....
1888	3,140,979	6,685	17	184,763
1889	....	.....	..	....
1890	3,791,211	6,550	5	758,242
1891	3,819,600	6,975	5	763,900
1892	4,408,471	7,600	19	232,024
1893	4,358,897	7,431	22	193,586
1894	....	.....	..	....
1895	4,202,084	7,885	23	182,699
1896	4,068,124	7,112	28	170,290
1897	4,088,100	7,984	16	262,630
1898	5,146,920	.....	22	233,950
1899	5,864,975	7,366	15	390,997
1900	6,283,063	8,858	18	349,059
1901	7,019,203	12,096	24	292,466

1. "Employes" include only those working inside mines.
2. Prior to 1897, there was no law requiring operators to report tonnage, accidents (except fatal), etc.; hence it is very probable that many mine employes received injuries which ultimately caused their deaths, but of which we have no record in this office.

SERIOUS ACCIDENTS.

The list of serious accidents as shown by Table No. 1, includes those who have received broken bones, cuts, bruises and such other injuries as we think require special mention. A majority of such accidents have been investigated by this office, and the following pages contain brief statements of, and in some instances comments on, the same.

CLAY COUNTY.

Crawford No. 5 Mine. On January 14, Edward Bruer had leg broken by flying coal from a delayed shot.

Diamond No. 5 Mine. On January 18th, John Williams had hand badly lacerated by a saw.

Diamond No. 5 Mine. On February 21st, Frank Fisher was burned about the face and hands by powder explosion.

Diamond No. 5 Mine. On April 23d, Andrew Marshall, driver, had his leg broken by falling off a mine car.

Cloverland Mine. On March 19th, Alfred Harris, Ethal Harris and Alfred Refet were seriously burned by a smoke explosion. Assistant Inspector Long investigated the accident; and after going over the matter carefully, he established beyond a doubt that the explosion was due to an excessive amount of powder used in shots which had been placed too heavy on the solid.

Cloverland Mine. On October 30th, a second smoke explosion occurred at this mine, in which Charles Steadman and George Morgan were slightly burned. This accident was investigated by myself. After carefully examining the three shots which had been fired, one of which was supposed to have caused the explosion, I found that all of them had been properly placed, and to all appearances there had not been an excessive amount of powder used in any of them. I also found an excellent current of air, 12,000 cubic feet passing the point where the explosion occurred. Taking the above facts into consideration, I can ascribe but one reason to account for the accident, that is, that the three shots had been fired simultaneously or so close together that the smoke from one had not had time to cool sufficiently when the flame from the other two, probably fired together, entered this smoke and ignited it. I am led to believe this from the fact that it was generally admitted that little regard was paid to the law governing shot-firing, and that shots were fired indiscriminately, or rather, go-as-you-please.

Brazil Block No. 1 Mine. On May 31st, Edward Burns received severe body bruises from falling slate.

Brazil Block No. 1 Mine. On November 19th, James McGoran was injured in the back and chest by falling coal from a loose shot which he was trying to work off; concussion of the brain resulted.

Diamond No. 3 Mine. On July 19th, Fred Schrefeman was badly burned about the neck, face and arms by reason of the explosion of a keg of powder, caused by its coming in contact with an electric wire.

Brazil Block No. 1 Mine. On — day of ——, William Yorke had finger cut off while coupling cars.

Brazil Block No. 1 Mine. James Stewart, on August 27th, machine runner, had foot mashed by falling slate. He was at work again within two weeks.

Silverwood No. 3 Mine. On August 22d, John Lord, driver, was injured about the legs and chest by reason of a mine car jumping the track and catching him against the rib or side of entry.

Eureka No. 4 Mine. September 30th, Thomas Philips was struck by falling draw slate, breaking a rib and causing slight injuries in his back.

Pearl Mine. On November 12th, ————————, driver, fell off of front end of loaded trip; car caught him and seriously injured his back.

Glen Mine. On December 18th, John Baird, mine boss, was seriously burned by fire-damp. Assistant Inspector Long, upon investigation, reported that Baird had gone into an old abandoned room which had fallen in, and had climbed up over a large fall for the purpose of locating a stream of water which he supposed was coming through this fall into the mine. Just before he reached the top of the fall, he ignited a small pocket of gas which had accumulated in the top of the fall. The fact was also established that Baird, as mine boss, knew that fire-damp was being given off in small quantities in some parts of the mine and that he should have taken the precaution to examine such places before entering them with a naked light.

Brazil Block No. 11 Mine. On December 26th, Antonetti Delwassis was badly injured in the breast by coal from a shot fired by himself. Investigation showed that after lighting his shot and starting to run, he dropped his lamp, and instead of continuing his way out of the room, he stopped to replace the lamp in his cap, and while so engaged the shot went off, with the above result.

Daviess County.

Cabel No. 9 Mine. On April 22d, Frank Burkhart, a driver, was seriously injured by a powder explosion.

Greene County.

Island No. 2 Mine. On February 4th, Charles Wills, a miner, had his leg broken by falling slate.

Island No. 1 Mine. On February 16th, Thomas Keene, a driver, had his right leg broken by slipping off of the tail chain and being caught by the mine car.

Island Valley No. 3 Mine. On February 26th, James Angleton, a miner, had his leg broken by falling slate at the face of his room.

Island Valley No. 3 Mine. On April 13th, Adam Vondersmit and Jacob Powell were seriously burned by an explosion of powder, caused by leaving a keg of powder lying on its side with the open end directly in range and about 24 feet distant from a very heavy shot. The keg contained about eight pounds of powder. The men though painfully burned about the face and hands were not otherwise injured.

Fluhart Mine. On April 24th, Jesse Ray, a driver, had ankle mashed by mine car jumping track; at work in a short time. Following day, James Johnson, a driver, had his foot mashed by car jumping track; idle two weeks.

Island Valley No. 3 Mine. On October 1st, Eli Rice, miner, had three ribs broken by falling slate at the face of his working place.

Wild Cat Mine. On October 6th, William Peach was injured by falling slate; injuries not reported.

Fluhart Mine. On May 11th, Adam Sutton, a miner, had shoulder broken by falling coal from a standing shot which he was working off. On June 3d, at same mine, Robert Clemitt, a miner, had leg broken in two places by falling draw-slate within three feet of the face of his room.

Templeton Mine. On March 22d, Robert Ferguson had his back broken by falling slate under almost identically the same conditions as those when Bradley was injured. An investigation of both accidents was made by myself, and in each instance I found that the men were lying down mining off loose coal and were working under loose draw-slate, which they, as practical miners, knew to be unsafe.

Hoosier Mine. On May 14th, John Starkey, a top laborer, fell into the shaft onto a descending cage. He fell about thirty feet; the force of the fall was broken by the descending cage and he escaped with but a few bruises.

Summitt No. 2 Mine. On January 11th, L. D. Heggerman, a driver, was seriously injured by being caught and squeezed between a mine car and a prop.

Island Valley No. 2 Mine. On August 13th, Charles Wonders, a miner, had back severely injured by falling slate, caused by what is known as a pot hole in the roof.

Black Creek Mine. On August 19th, John Morgan, a driver, had foot mashed by falling under a moving mine car.

Island Valley No. 1 Mine. On October 3d, J. B. Small suffered a broken leg from a fall of coal while mining off a loose shot.

South Linton Mine. On December 17th, James Dunham had his foot mashed; caused by loaded mine car jumping track and knocking a prop from under a loose piece of slate, which fell on him.

Gibson County.

Oswald Mine. On January 18th, George Carico and John Stalings, miners, were burned by a windy or misplaced shot, which had been fired by Carico. An investigation of this accident developed the fact that Carico had frequently been guilty of firing shots which were not properly placed and containing more than eight pounds of powder (the maximum amount in any one shot as prescribed by law). I am informed that the boss had attempted to discharge him for this practice a few days prior to the accident, but that the Mine Committee insisted that he be allowed to remain. On the day of the accident, he had a shot so badly misplaced and overcharged, that the miners working in adjoining places advised him not to fire it. This, however, he persisted in doing, with the result that a fellow workman was badly injured and he himself made a helpless cripple for life.

Again at this mine, on December 3d, James Stevens, head dumper, had his hand badly mashed while dumping a car of coal.

Same mine, on August 23d, John McDonald was injured by a slate-fall. His injuries consisted of left hand badly lacerated and left ankle mashed.

Parke County.

Mecca Mine. On February 7th, C. Gray, a driver, suffered a broken collar bone, caused by being kicked by a mule.

Same mine, on October 9th, William Jackson and John Caruthers, employed as shooters, were seriously burned by a blown-out or windy shot.

Lyford No. 2 Mine. On March 28th, Frank Sclachnskie, a miner, suffered severe injuries in head, back, shoulders and hips by falling slate. Investigation showed that the accident happened at his room parting, and that the roof was very bad in the room and at the point where he was injured.

Lucia Mine. On May 17th, Sandy Colerie, a driver, had his leg broken by falling under a moving mine car.

Same mine, on September 5th, Thomas West, Jr., received severe body bruises caused by falling coal while working off a loose shot.

Mary Mine. On May 31st, John Tresnittie, a miner, suffered a broken leg, caused by a premature shot.

Same mine, On June 14th, Thomas Golden had leg broken and Albert Barley received injuries in back; caused by falling slate, which they were attempting to take down preparatory to timbering.

Same mine, on July 3d, Edward Cuttie, a miner, had leg broken by falling slate; has been unable to work up to present time, and the probability is that he will be badly crippled for life.

Brazil Block No. 12 Mine. On July 30th, Richard Hendren, a driver, had leg broken; caught by mine car.

Same mine, on December 28th, Andrew Sallits, a loader, had foot mashed by falling slate.

Pike County.

Ayrshire No. 3 Mine. On February 28th, W. J. Jennings had leg mashed by a fall of slate.

Rogers Mine. On December 14th, John Everly, a miner, had thumb mashed off, caused by falling slate from under which he was mining off a loose shot.

Sullivan County.

Dugger Mine. On January 18th, Elmer Hyatt, a driver, had small bone of arm broken, caused by kick by mule.

Same mine, on November 20th, James Lawson, a miner, was injured in back by falling draw-slate.

Hymera Mine. On February 2d, Ora Sparks was kicked in abdomen by mule; injured internally.

Caledonia Mine. On February 21st, Sid Dempsey had two ribs broken, caused by being squeezed between a mule and a mine car.

Ingle Mine. On April 13th, D. Bucklew, a miner, had leg broken by falling slate.

Green Hill Mine. On May 18th, J. E. Martin had leg cut by mining machine.

Jackson Hill Mine. On July 29th, Theo. Thompson was kicked by a mule; injury not stated.

Same mine, on August 29th, George Sargent was badly crushed by falling slate.

Caledonia Mine. On ———, William Still had leg mashed between trap-door and mine car.

Star City Mine. On October 29th, H. Dodd had leg broken; caused by being struck by a mine car.

Vanderburgh County.

Ingleside Mine. On November 28th, John B. White, a driver, had leg broken and face badly cut; caused by empty car jumping track and knocking a prop from under a piece of loose slate, which fell on him.

Vermillion County.

Torrey No. 4 Mine. On March 25th, Herman Clinton, a driver, had leg broken; caused by falling under a mine car.

Willow Grove Mine. On October 17th, three miners, Paul Padoska, Adam Konskik and John Konskik were seriously burned by a blown-out shot, caused by an excessive amount of powder used in a short hole drilled behind a very heavy shot.

Buckeye Mine. On November 19th, Charles Kirkman was injured by flying coal from a delayed shot, which he had gone back on. His injuries consisted of a broken rib and flesh wounds.

Vigo County.

Lawton Mine. On March 25th, Edward Stewart was injured in hips and bowels by falling slate at a distance of about fifty feet from the face of his entry.

Same mine, on April 3d, Charles Hoffman, a cager, had bones in hand broken; caused by coal falling down shaft.

Peerless Mine. On July 11th, Frank Groat had left leg broken by falling slate.

Grant No. 2 Mine. On July 11th, Lee Centers was caught by falling slate, receiving injuries in back and hips, together with internal injuries.

Diamond Mine. On September 24th, Richard Edwards, a driver, while riding on the front end of a mine car, fell off and was caught between the car and ties; right leg broken.

Ehrlich Mine. On October 3d, ————————, had legs injured by flying coal from a shot which had blown through a pillar.

Rose Bud Mine. On October 15th, Thomas Sanders was burned by fire damp. He had gone into an old abandoned room and was climbing over a slate fall. A small pocket of gas was ignited.

Union Mine. David Black, on December 13th, fell down hoisting shaft. The gate at top of mine blew against him while he was putting trap on for mule to descend in cage. He fell in four feet of water. Commenced work January 6, 1902.

Warrick County.

Big Vein Mine. On March 19th, Ed. Rogers, a miner, had back injured by falling slate.

Star No. 1 Mine. On April 20th, Cisco Green, a driver, had nose broken; kicked by mule.

Same mine, on December 5th, William Hadley, a driver, had leg broken; fell under a mine car.

Air Line Mine. On August 10th, William Stigall, a miner, had hip crushed by flying coal; caused by irregular shot firing.

MINOR ACCIDENTS.

The list of minor accidents as shown by the foregoing table includes those where only slight injuries were sustained and which caused but little loss of time. We think no special mention need be made of them. It is probable, however, that some serious accidents may have been classed under minor, as the mine bosses differ considerably as to what should be termed a serious injury.

ACCIDENTS TO MINE PROPERTY.

During the year 1901, there were reported to this office ten accidents to mine property which are worthy of mention here. Six of them occurred in the surface plants, and the remainder in the inside workings of the mines.

At the Island No. 2 Mine, located at Linton, in March, a fire occurred which destroyed a large frame barn, wagon sheds, granaries and two mules.

A second fire occurred at this mine in October, when the new barn, which had been built to replace the one burned in March, together with about $800 worth of hay and a quantity of corn and other feed was destroyed. This fire occurred during the day, when all the mules and horses were being worked in the mine, and as a consequence, no animals were lost. The total loss incurred by reason of the two fires is estimated at about $2,700. The origin of the fire, in both instances, is unknown.

At about ten o'clock a. m., on April 2d, fire was discovered in the weigh-room at the Phoenix No. 1 Mine. The mine being idle at the time, and there being but few persons about the plant, the fire had gained such headway when discovered, that it was found impossible to do anything except to save the engine, boiler and dynamo rooms, which was done with much difficulty. The head-frame, tipple and a large coal washing plant, which had been built adjoining the tipple, together with the screens, screening machinery, scales, ropes, cages and other tipple equipment, and the machinery connected with the coal washing plant were totally destroyed.

One important feature connected with the saving of the boiler, dynamo and engine rooms in which the compressors are situate, is the fact that power for driving the machines at No. 3 and No. 5 mines and also the haulage at No. 5 Mine is furnished from the No. 1 Mine, thus enabling those mines to continue in operation.

After about two months' idleness, during which time the tipple was rebuilt, work was resumed at No. 1. Matters had barely been shaped up in good running order, however, when on August 7th, at about three o'clock a. m., the entire plant was destroyed by fire. The loss at this time was very great, as the plant was considered one of the most costly equipped in the State. A great deal of the machinery was a total loss, while that which was saved required extensive, as well as very expensive, repairs before being used again.

The fact that No. 3 and No. 5 were thrown idle by reason of the power plant having been destroyed caused a loss of trade, which, added to the loss of property, etc., makes the actual loss very hard to compute.

On November 8th, the fifth destructive mine fire occurred, whereby the entire surface plant at the Brazil Block No. 8 Mine, with the exception of the engine room and blacksmith shop, were destroyed. The origin of the fire is not known, although it is generally believed to have started in the boiler room. The total loss in property destroyed is estimated at $20,000. Power for driving the electric machines and motors at No. 10 and No. 11 mines was furnished from the powerhouse at No. 8, the burning of which caused those mines to be thrown idle for some time. Arrangements were made by which power could be furnished from the No. 12 Mine until No. 8 was rebuilt. The loss in business by reason of the three mines being thrown idle will increase the total loss to several thousand dollars.

The sixth notable accident to mine property occurred in the Ingle Mine, at Evansville, about May 1st. A general squeeze, or creep, took place, on account of which the mine was thrown idle during May and the greater portion of June, and also causing a part of the workings to be abandoned. The creep began on the east side of the mine and extended to the west, about 1,000 feet. A large expenditure of money was required to reopen the mine.

The second accident of this kind happened at the Oswald Mine, in Gibson County, during the month of May. A squeeze covering about 2,000 square yards came on the first and second south entries on the east side of the mine, completely shutting off all the workings on those two entries for a period of about four months. An expense of about $600 was entailed to reopen and repair the entries and air course.

Another similar accident occurred in the Hector Mine, Vigo County. On his inspection made May 29th, Mr. Dodds reports a very heavy squeeze as having taken place on the north side of the mine. Much narrow work was required in driving around it in order to secure ventilation.

But one fire of any consequence in the interior of mines was reported. This occurred at the Caledonia Mine, Sullivan County, in the latter part of September. The coal in one of the entries in the north side of the mine in some way (presumably from a shot) caught fire. The company has been to a very large expense in trying to extinguish it, but up to the present time has been unable to do so.

At the Nickelplate Mine, near Ehrmandale, Vigo County, on October 1st, one of the cylinder boilers exploded, completely wrecking three other boilers, hoisting machinery, engine and boiler house and blacksmith shop. Very fortunately, no persons were injured, although there were several at work within 100 feet of the boiler when it gave way.

EXAMINATIONS.

Examinations of applicants to qualify as mine bosses, fire bosses and hoisting engineers were held at three different times within the past year, with results as shown by the annexed table:

TABLE.

PLACE.	DATE.	NUMBER OF APPLICANTS.			PASSED.		
		M. B.	F. B.	H. E.	M. B.	F. B.	H. E.
Terre Haute..	April 3d.......	29	0	40	23	0	21
Evansville.....	August 6th....	12	0	14	9	0	11
Terre Haute...	November 29th	16	2	18	10	1	15
	Total,......	57	2	72	42	1	47

We give herewith the names and addresses of those who qualified and received certificates at the above examinations:

MINE BOSSES.

Name and Address.	*Per Cent.*
G. W. Knight, Terre Haute, Ind.	95
David H. Williams, Rosedale, Ind.	78
Daniel E. Davis, Linton, Ind.	79
William Stevens, Linton, Ind.	77
Ira C. Dalrymple, Silverwood, Ind.	81
Joseph Barker, Cardonia, Ind.	78½
William Green, Harmony, Ind.	75½
James W. Mason, Sullivan, Ind.	75
John Hammack, Sullivan, Ind.	76
Daniel P. Bogle, Terre Haute, Ind.	94
John A. McCallum, Clinton, Ind.	82
H. G. Conrad, Edwardsport Ind.	85
Roger Maher, St. Marys, Ind.	80
William H. Woods, Princeton, Ind.	77
Charles McGuire, Burnett, Ind.	80
John A. Overton, Raglesville, Ind.	75
Emil Uhleman, Petersburg, Ind.	78
Owen Tevlin, Cannelton, Ind.	83
Call. Whitman, Cannelton, Ind.	80
W. S. Risher, Linton, Ind.	78
James A. Fielder, Sophia, Ind.	78
John Boyle, Princeton, Ind.	84
Frank Osha, Linton, Ind.	78
Edgar Forcam, Knightsville, Ind.	80
T. C. Hilliard, Sullivan, Ind.	80
Frederick George, Brazil, Ind.	79
John Kelley, Linton, Ind.	79
David Love, Linton, Ind.	78
Edward Newport, Clinton, Ind.	89
A. Hostemeyer, Ayrshire, Ind.	80
George C. Williams, Harmony, Ind.	76
Adolph Becker, Evansville, Ind.	78

Name and Address.	*Per Cent.*
Moses Yemn, Brazil, Ind	80
Hugh Bennett, West Terre Haute, Ind	78
John Davidson, Lyford, Ind	88
Edward Davis, Rockville, Ind	80
H. C. E. Jaensch, Burnett, Ind	78
John Jenkins, Brazil, Ind	90
E. B. Rouse, Burnett, Ind	90
James Johnson, Clinton, Ind	76
John E. Jones, Linton, Ind	80
James Hurley, Linton, Ind	90
Samuel C. Watts, Burnett, Ind	76

Fire Bosses.

John Patton, Lyford, Ind	80

Hoisting Engineers.

Otis B. Lyder, Clinton, Ind	76
James Devonald, Burnett, Ind	77
John W. Squires, Jasonville, Ind	89
George G. Thomas, West Terre Haute, Ind	80
John Gilmour, Cardonia, Ind	80
Thomas N. Walker, Bicknell, Ind	89
A. S. Gill, Linton, Ind	81
Morton Grimes, Arthur, Ind	85
Portman Davis, Ayrshire, Ind	84
Preston Usrey, Linton, Ind	85
Charles A. Davis, Winslow, Ind	85
Charles Arthur, Jackson Hill, Ind	75
Otto Vaughn, Linton, Ind	76
George Lyda, Clinton, Ind	82
Harry L. Miller, Clay City, Ind	77
Joseph Combs, Linton, Ind	77
C. E. Crowder, Burnett, Ind	78
Samuel McClain, Coal Bluff, Ind	81
Howard Bolin, Coal Bluff, Ind	80
L. V. Ferguson, Marco, Ind	78
Leo Brush, Campbell, Ind	82
John McAtee, Montgomery, Ind	80
Malcolm T. Wilson, Brazil, Ind	87
Cassius C. Buck, Lena, Ind	79
Arch. Cummins, Jasonville, Ind	84
William Layman, Dugger, Ind	89
Nathan G. Squire, Linton, Ind	87
George Pirkle, Ayrshire, Ind	79
Joe Davis, Sophia, Ind	90
John Smith, Oakland City, Ind	80
Riley West, Oakland City, Ind	77

Name and Address.	*Per Cent.*
C. R. Wiggs, Oakland City, Ind.	77
George Sharitz, Linton, Ind.	93
Oscar B. Roark, Linton, Ind.	85
Herbert Stewart, Burnett, Ind.	89
Winfield E. Dickey, Dugger, Ind.	79
J. M. Shumaker, Farmersburg, Ind.	79
Alvah Hansel, Diamond, Ind.	83
Claude E. Williams, Seeleyville, Ind.	80
Herman Berry, Wheatland, Ind.	82
Charles W. Decker, Washington, Ind.	80
Alvan Chaney, Linton, Ind.	80
William Lucas, Lyford, Ind.	78
W. F. Cummins, West Terre Haute, Ind.	84
Elmer Herr, Clay City, Ind.	80
John Smith, Linton, Ind.	76
C. W. Dixon, Linton, Ind.	86

CERTIFICATES SECURED BY RIGHT OF SERVICE.

Twenty-six service certificates were granted during the year, classed as follows: Mine boss, 16; fire boss, 2; hoisting engineer, 8. Following are the names and addresses of persons to whom such certificates were issued:

Mine Bosses.

Robert Bensinger, Chandler, Ind.
C. W. Edmonson, Jackson Hill, Ind.
Mark Wilson, DeForrest, Ind.
Edward Hancock, Sullivan, Ind.
Marion W. Miller, Brazil Ind.
Joseph Gibson, Evansville, Ind.
Chas. Chesterfield, Brazil, Ind.
James Morgan, Mecca, Ind.
Enoch Atkinson, Edwards, Ind.
Richard Morgan Carbon, Ind.
Ed. Davis, Ehrmandale, Ind.
George Ruddock, Perth, Ind.
Hansford Eller, W. Terre Haute, Ind.
S. P. Douglass, W. Terre Haute, Ind.
J. B. Litell, Linton, Ind.
Harvey Wonder, Linton, Ind.

Hoisting Engineers.

Daniel Bunting, Vincennes, Ind.
Charles Mooney, Carbon, Ind.
Jay McKee, Clay City, Ind.
Jesse Shannon, Clinton, Ind.
Sylvester Winningham, Seeleyville, Ind.
J. N. Burns, Boonville, Ind.
Harry Burke, W. Terre Haute, Ind.
W. D. Evans, Brazil, Ind.

Fire Bosses.

David Harrison, Clinton, Ind.
I. H. Woolley, Shelburn, Ind.

As stated in my report for 1899, my predecessor, Robert Fisher, held an examination at Brazil in February of that year. The result of that examination, together with numerous other papers, were not turned over to me. As a consequence, the results of such examination were not reported in 1899. Since that time, however, I have ascertained the names of some of those who qualified at that examination, and I give herewith their names and addresses:

MINE BOSSES.

James Barr, Brazil, Ind.	Robert Bennie, Clay City, Ind.
Allan N. Walker, Brazil, Ind.	Charles Long, Brazil, Ind.
William Langman, Coal Bluff, Ind.	Wm. Arkiss, Coal Bluff, Ind.
Thos. Currie, Diamond, Ind.	Wm. Rosser, Diamond, Ind.
John Krickter, Brazil, Ind.	A. McTavish, Linton, Ind.

MINE FOREMAN'S EXAMINATION.

HELD AT TERRE HAUTE, INDIANA, NOVEMBER 29, 1901.

The answers to these questions as here given appeared originally in the March issue of the Mines and Minerals, of Scranton, Pa., for which they were prepared by Prof. J. T. Beard, Principal of the Coal Mining Course, of the International Correspondence Schools, of Scranton, Pa.:

Question 1.—Name the different capacities in which you have been employed at each class of work.

Question 2.—Describe in detail the plan of workings, methods of ventilation, arrangement and construction of haulage roads at one of the most successfully operated mines in which you have been employed.

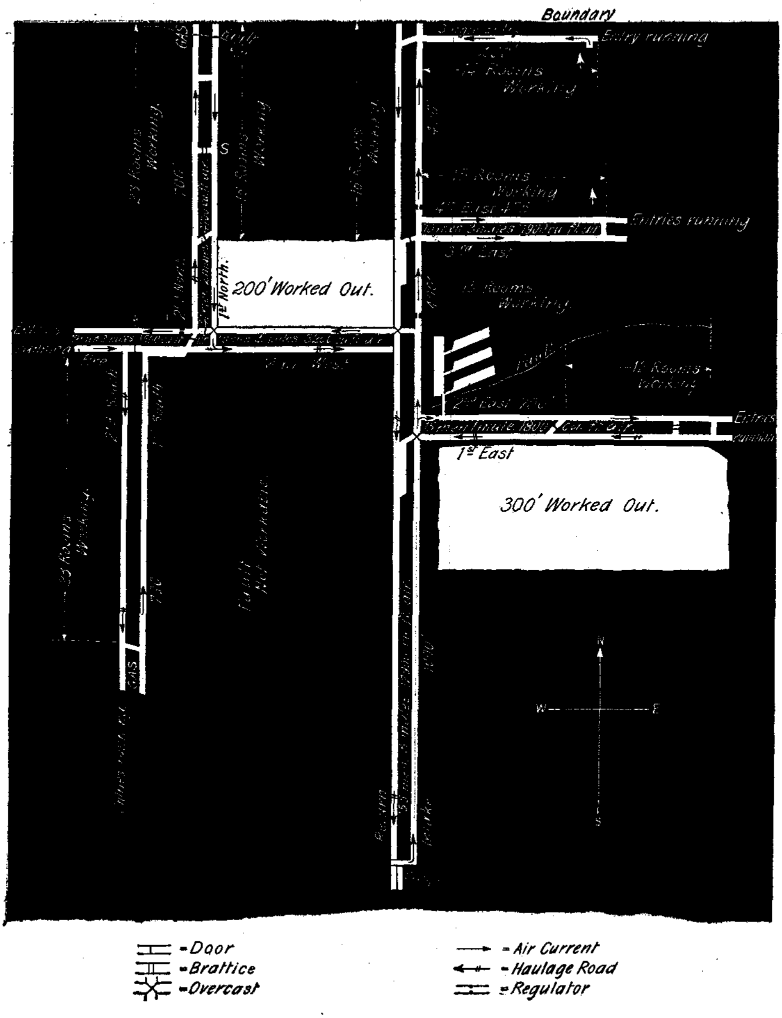
Answer 2.—A brief description of coal mining in Indiana, including a general plan of the workings of the Brazil Block Coal Company's No. 8 Mine, will be found on page 202, Mines and Minerals, for December, 1899, and page 246, January, 1900.

Question 3.—What are the laws in Indiana relative to the ventilation of coal mines?

Answer.—Section 14 of the Indiana Mining Law relating to the ventilation of mines reads as follows:

(14) That the owner, operator, agent or lessee of any coal mine, whether shaft, slope or drift, shall provide and maintain hereafter for every such mine a sufficient amount of ventilation, affording not less than one hundred (100) cubic feet per minute for each and every person employed, and three hundred (300) cubic feet per minute for each mule, horse or other animal used in said mine, measured at the foot of the downcast, and as much more as the circumstances may require, which shall be forced and circulated around the main entries, cross entries and working places throughout the mine, so that said mine shall be free from standing gas of whatsoever kind to such an extent that the entire mine shall be in a fit state at all times for men to work therein, and which will render harmless all noxious or dangerous gases generated therein. Every place where fire damp is known, or supposed to exist, shall be carefully ex-

amined with a safety lamp by a competent fire boss immediately before each shift, and in making said examination, it shall be the duty of the fire boss at each examination to leave at the face of every working place examined evidence of his presence, and it shall be unlawful for any miner to enter any mine or part of a mine generating fire damp until it has been examined by the fire boss, as aforesaid, and reported by him to be safe. The ventilation required by this act may be provided by any suitable appliance, but in case a furnace be used for ventilation purposes, it shall be built in such a manner so as to prevent the communication of fire to any part of the works by lining the upcast with incombustible material for a sufficient distance up from the said furnace.

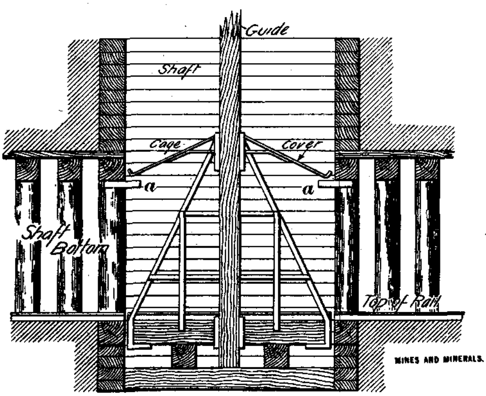


Question 4.—Copy sketch of mine as shown on blackboard. The rooms in the mine are to be driven twenty feet wide, leaving ten-foot pillars, with entry pillars twenty-one feet thick. The number and length of each entry being given, and worked out territory being shown, how many persons can be employed in the mine, using all available space and working one person in each room and entry? Use the signs given on blackboard and indicate where mine doors, brattices, overcasts and regulators should be placed, in order that the mine may be ventilated in compliance with the law. Also indicate the number of persons on each current, and the minimum quantity of air required by law.

Answer.—The rooms being thirty feet, center to center, and driven both ways off each pair of entries, assuming that no room is turned closer than twenty yards from the face of the entry, the number of persons employed in the entire mine under the conditions named will be 155, disposed of as follows: One hundred and forty-three miners and entrymen, eight drivers, two company men, one cager and one boss. Using the signs given, we have indicated in the plan of the mine the respective location of doors, brattices, overcasts and regulators to comply with the mining law. The number of men and mules employed on each current is indicated at the mouth of the split, as also the minimum quantity of air required by law to be circulated in such split. The two company men, cager and boss are added in the third and fourth E Split (they could have been added to any other split) to make the total quantity of air correspond to the total men and mules employed.

Question 5.—The above being a one-sided shaft, you will indicate in sketch the arrangement of tracks, etc., so that the greatest number of loads may be caged at the least expense.

Answer.—We would adopt the plan described in answer to Question 10 of the Illinois Examination, page ——, Mines and Minerals, February, 1902. The general arrangement of the tracks at the shaft bottom are shown in Fig. 2. The grades suitable for such a shaft bottom are given on page 33, Mines and Minerals, August, 1898.



Question 6.—What are the different causes of mine fires?

Answer.—The most prolific source of mine fires arises from the fine coal and slack thrown into the gob, waste, or abandoned workings. The moist heat of the strata promotes the distillation of gas from the fine coal, which permeates the waste and results finally in the ignition of the gas and coal due to the rise in temperature caused by the chemical action that takes place. When sulphur is present in the form of pyrites, chemical reaction is stronger and ignition more liable to occur. Other causes of mine fires are the explosion resulting from the ignition of a body of fire damp, or the accidental explosion of powder in kegs, ignition of gas feeders by the flame of a blast or a naked lamp, ignition of hay or straw in mine stables by contact with naked lamps, or the ignition of brattices, doors, overcasts, etc., by contact with flame. At times the ignition of the coal has arisen from the mine ventilating furnace, and frequently the ignition of the timbers or curbing of the furnace shaft has taken place from the same cause.

Question 7.—Referring to sketch on blackboard, we find the coal at the face of the first North, off of the main west entry, is on fire. (a) There being no dust or gob accumulations on the entry, what has been the probable cause of the fire? You will also notice (b) that gas is being driven off at the face of the second North entry; and (c) S is the nearest point to the fire, reached by the fire boss on the morning he discovers it. (d) Explain in full how you would direct the work of extinguishing the fire with the least danger to the workmen.

Answer.—It is probable that the gas issuing from the fault at the head of these entries was ignited by a blast fired at the time of quitting work the night before the discovry of the fire. The work of extinguishing the fire should proceed as follows: Assuming that the second North is the intake, and the first North the return of the current in this split, the stopping in the cross-cut at S should first be removed, which will cut off much of the circulation at the head of these entries. A temporary stopping should then be quickly erected upon the first North, just inside of this cross-cut. When this has been done, a second temporary stopping should be erected in the second North at a corresponding point just inside of the same cross-cut. These stoppings should be tightly sealed in order to cut off the admission of all air to the fire. A long piece of gas pipe should be left in each stopping, that can be closed with a wooden plug. The purpose of these pipes is to ascertain from time to time the condition of the atmosphere within the stoppings. The pipes should be kept plugged except when ascertaining such condition of the air. The order of erecting and sealing the stoppings is important, since an explosion would almost inevitably occur if the stopping upon the intake were to be erected and sealed before that upon the return of the current. Safety lamps should be used in the performance of the work. The fire boss or mine foreman should determine before beginning this work whether or not it is necessary to withdraw the men working upon the return current. If the flow of gas is light, this would scarcely be necessary, especially as fresh air is conducted through the cross-cut at S.

Question 8.—(a) How should cage bonnets or covers be arranged and fitted upon cages to insure the greatest amount of safety to cagers or other persons, from coal falling back into the shaft? (b) Why is a safety catch worked with a spring considered more reliable than one worked by a weight or lever?

Answer.—(a) The bonnets or covers to a cage should be arranged with a slight slope toward each end of the cage, and should be large enough to practically cover the entire cage. To protect the cager at the shaft bottom, the cage bonnets should be high enough that falling coal striking the bonnets would not be thrown directly into the entry. Suitable provision should be made against this by strong hoods at the shaft bottom fitting under the cage covers. (b) Spring safety catches are more reliable than those operated by weights or levers, because the prompt action of the spring is not influenced by the downward movement of the cage, as is the case with a weight or lever.

Question 9.—Under what conditions would it be advisable to hoist water from a mine by means of a tank in preference to pumps?

Answer.—In general, at small mines, where the amount of water to be handled is small, and the steam power is not more than is required for the hoisting engine. Also, where horse-power is employed for hoisting and no steam is at hand. At larger mines, where the amount of water is small and the output is such as can be readily hoisted in the allotted time, a tank swung below the cage is often employed for hoisting the water, since the emptying of the tank will not materially delay the hoisting. Water is also often hoisted in such tanks only at night or during the noon hour. By this means the expense of installing, operating and repairing the pumping plant is obviated and the annoyance of steam in the hoisting shaft, incident to pumping, is avoided. Tanks are particularly serviceable when the water is very corrosive, and there are a number of plants where the entire use of a shaft is for the purpose of hoisting water by means of tanks. (See Mines and Minerals, September, 1898, p. 49, The Gilbertson Shaft.)

Question 10.—(a) When would you deem it advisable to replace mules with mechanical haulage? (b) Under what conditions could one system of mechanical haulage be used to better advantage than another?

Answer.—Mule haulage should be replaced by rope haulage or motor haulage as early as the development of the mine will admit, for the reason that, excepting for very small mines, rope or motor haulage is cheaper and much more efficient than mules. Neither is the mine air vitiated, as when mules are employed. The electric companies calculate that under ordinary conditions a mine requiring six or seven mules can save money by the installation of an electric haulage system. (b) In the operation of a large plant, and especially where machines are run at the working face by air, air motors may often be employed for haulage to great advantage. The use of air is also especially adapted to gaseous mines, where electricity would be objectionable owing to the danger of the gas being ignited by the sparking of the wires. In irregular seams, where the roadways are very winding, the electric system possesses an advantage on account of its flexibility and ease of installment. Rope haulage is particularly advantageous in the smaller mines that would not warrant the outlay required in the establishment of the surface plants for the generation of compressed air or electricity. Rope haulage is also well adapted to steep inclines.

Question 11.—What quantity of air is passing through an airway six and one-half feet at the top, nine and one-half feet at the bottom and six feet high, with an anemometer reading of 300 revolutions per minute?

Answer.—Area of airway:

$$\frac{6.5+9.5}{2}\times 6=48 \text{ sq. ft.}$$

Assuming the reading of the anemometer to be sufficiently accurate without the correction that is sometimes made for the instrument, we have for the quantity of air circulating in the airway:

$$48\times 300=14,400 \text{ cu. ft. per min.}$$

Question 12.—A shaft bottom 16 feet wide and 200 feet long is timbered with 14x14-inch cross-bars, set two feet between centers. The roof is badly broken above, causing a great deal of weight on the bars, some of which are badly decayed. We wish to replace those with new ones of the same size. Describe in detail how you would direct such work to be done at least expense, yet insuring the safety of workmen.

Answer.—It will be necessary, in order to avoid as much as possible the falling of the roof, to place each set of new timbers in position before taking out the old set. The timbers being fourteen inches wide and set two feet, center to center, the space between them is (2x12), less 14, equals 10 inches. Before a new set of timbers can be introduced, it will be necessary to remove one set of the old timbers in order to make room for the new set. Or if this can not be done without causing a fall, it would be better to wedge two of the old sets apart a sufficient distance to permit a new set of timbers being placed between them. When this has been done, one of the old sets of timbers next adjoining may then be removed carefully, so as to cause as slight a fall of the loose material above the timbers as possible. It will now be possible to place another new set of timbers in position, after which a second set of the old timbers is carefully removed, as before. In this manner the work proceeds until the retimbering is complete.

Question 13.—The main air course in the above mine is adjacent to some very extensive old workings from which large quantities of blackdamp escape into the airway. Describe in full how brattices should be constructed to prevent this.

Answer.—Beginning at the foot of the downcast shaft or at the mouth of the intake, or the nearest point thereto at which the difficulty occurs, an air-tight brattice should be constructed by setting a line of posts, say from twelve to eighteen inches from the rib separating the airway from the old workings. The brattice is closed to the airway throughout its entire length, so that no gas can find its way into the intake current. The line of brattice is carried along the rib at an equal distance from it as far as is necessary to control the escaping gas. A connection is made between the space behind this brattice and the return airway as near to the foot of the upcast shaft as possible, by constructing a box or overcast of sufficient size to carry off the gas accumulating from the old workings. By this means the gas will be conducted immediately into the return current.

Question 14.—(a) What are the principal sources of expense connected with mining the different coal seams in Indiana? (b) What are the different causes of accidents in mines?

Answer.—Some of the principal sources of expense in mining bituminous coal may be enumerated as follows: Dead work, such as entry driving, room turning, driving break-throughs and cleaning up falls of roof; the drainage, ventilation and timbering of the mine, the movement of the coal from the face to the tipple and loading, including maintenance of roads and cost of repairs of rolling stock; management, office expense, company men, mine supplies, royalties upon coal, marketing the coal, strikes and other delays, interest upon investment, etc. (b) The principal causes of mine accidents in all coal mining in the order of their importance may be classed under the following general heads: Falls of roof and coal, explosions of gas or powder, accidents in hoisting or haulage, mine fires, falling down shafts, boiler explosions, caught in machinery.

Question 15.—The owner of a certain mine intends sinking a shaft to be used as a second outlet or manway. The shaft will be 6x8 ft. in size, and 95 feet deep; the strata to be sunk through is as follows: Fifteen feet of hard pan, forty-five feet of sandstone, thirty-five feet of gray slate. Which do you think would be the cheaper method—to sink it from the top, or drift it up from the bottom? Give reasons in full for preference, showing advantages and disadvantages of each plan; also preliminary work to be done before breaking ground, and method by which you would conduct such work.

Answer.—The comparative cost of sinking or uprising will depend upon the conditions. In upraising, the material excavated must be stowed in abandoned workings, or be transported to the foot of the shaft and hoisted to the surface. The operation of upraising, considered by itself, is in general cheaper than that of sinking, for the reason that the material is handled by gravity; pumping is done away with, lighter shots are required in the work of excavation, but the disposal of the material will add very largely to the expense of upraising if this can not be done near at hand in the mine workings. The advantages in favor of sinking are that the disposal of the material excavated is effected at the surface; there is less delay in clearing the smoke when blasting than in the operation of upraising and the ventilation is easier. The preliminary work necessary to be done in sinking before breaking ground, and the method of conducting such work, is fully described in answer to Question 6, page 280, Mines and Minerals, January, 1902.

Question 16.—Again referring to sketch on blackboard, you will notice the mine surveyor has set his stations 200 feet apart, as marked on the sides of the entries. The coal seam is five feet thick, with good roof and a hard bottom, the mine is dry, and two-ton mine cars are used, the north and east entries have a fall of 1½ per cent. grade in favor of the loaded cars, while the south and west entries dip with about the same per cent. of grade against the loads. We wish to install two electric traction motors of eight tons each. Using the stations marked on the sides of the entries and the numbers of the entries, state where you would place your turnouts or your double partings to get best results of motor haulage; the number of mules used in each section of the mine; the weight of iron per yard; size and distance apart of ties used in constructing motor roads, and the number of tons of mine run coal per day this mine should produce, worked to its full capacity. How many mules will the motors displace?

What will be the amount of saving per day to the company by the use of motor haulage?

Answer.—For the present development of the mine, turnouts should be provided, as shown in Fig. 1, on the Main N, at the mouths of the 1st E and the 3d E entries; and on the Main W at the mouth of the 1st S entry. We give below Table 1, showing the number of rooms, tonnage, length of haul and ton-feet of haul for mules before motors are employed, and Table 2, showing the length of haul and ton-feet of haul for mules and motors after the latter are introduced. Before the introduction of motors, mules hauled the coal to the bottom of the shaft, but later mules hauled the coal to the nearest side parting or turnout, from which motors hauled it to the bottom of the shaft.

TABLE I.

Mule Haulage.

Entries.	Rooms.	Tonnage.	Length (ft.) of Haul.	Ton-Feet of Haul.
2d E	12	48	1,500	72,000
3d and 4th E	30	120	1,700	204,000
5th E	14	56	2,100	117,600
Main N	16	64	1,700	108,800
1st N	16	92	2,100	134,400
2d N	23	92	2,000	184,000
2d S	23	92	2,100	193,200
Totals	134	536	....	101,400

TABLE II.

Motor Haulage.

Entries.	Mule Haul.		Motor Haul.	
	Length (ft)	Ton-Feet.	Length (ft)	Ton-Feet.
2d E	600	28,800	900	43,200
3d and 4th	300	36,000	1,400	168,000
5th E	700	39,200	1,400	78,400
Main N	300	19,200	1,400	89,600
1st N	600	38,400	1,500	96,000
2d N	400	36,800	1,600	147,200
2d S	400	36,800	1,700	156,400
Total	....	235,200	....	778,000

The work of an average mine mule upon level roads will vary from five to six ton-miles per hour. (See answer to Prize Contest Question 652, page 408, Mines and Minerals, April, 1901.) The maximum economic grade for mule haulage may also be stated as not exceeding, say 3 per cent. (See above references, and answers to Question 24, page 184, Mines and Minerals, November, 1900.) Assuming in this case an average of four ton-miles per hour per mule, or, say, 21,000 ton-feet per hour per mule, we observe that the number of mules required to perform the above work before motors are used would be, adding 50 per cent. for the dead weight of cars, and assuming 10 hours per day $\frac{1014000 \times 1.5}{10 \times 21000} = 7.2$, say eight mules. The mules required after motors have been installed in this mine will be $\frac{235200 \times 1.5}{10 \times 21000} = 1.68$, say 2 mules. Before the introduction of motors, the work will be distributed about as follows:

2d E	5	mule-hours
3d and 4th E	14.5	mule-hours
5th E	8.5	mule-hours
Main N	7.5	mule-hours
1st N	9.5	mule-hours
2d N	13	mule-hours
2d S	14	mule-hours
Total	72	mule-hours

After the introduction of motors, the work of the entire mine will practically be divided into two sections, that upon the Main N and the East entries forming one section, and the Main W, with its North and South entries, forming the other section. One mule will be required to perform the district haulage in each of these sections.

It would be hardly practicable or economical to install two motors in this mine, since one light motor, weighing, say 5,400 pounds, with a 700-pound drawbar pull, and having a speed of six miles per hour, will readily perform the entire work of the mine. Such a motor will haul three cars of the size mentioned upon these grades. With this trip the net work of the motor, if running all the time at a speed of six miles per hour, would be 6x6=36 ton-miles per hour; but reducing this to 16-ton-miles per hour to allow for delays, changing of cars, etc., we have, for the net work of the motor 16x5,280=84,480 ton-feet per hour, or 844,800 ton-feet per day, which is considerably above the work required (778,800 ton-feet per day), as shown in Table 2. The minimum size of iron allowed for this size motor (5,400 pounds) is ten-pound iron, placing the ties, which should be five-inch oak ties, twelve inches center to center. On account of the weight of the iron cars carrying a net load of two tons each, we would prefer to use not less than sixteen-pound iron, with ties placed eight inches, center to center, as before. We have assumed an average output of four tons mine-run coal per day per miner, working one man in each room, and having one helper or loader. Since there are 134 rooms in the mine (Table 1), the total output upon this assumption would be 134x4= 536 tons mine-run coal per day. The installment of motor haulage in the mine will replace 8-2=6 mules.

Cost of Mule Haulage. To ascertain the saving by the use of motor haulage as compared with mule haulage, we estimate as follows: In mule haulage employing eight mules, it will be necessary to keep at least ten mules in the stable to provide against emergency. The value of these mules may be assumed as approximately 10x$100=$1,000. It is customary to estimate a depreciation in mule stock of 25 per cent. per annum, which must be ~~added~~ to the cost of maintaining the mules in the pit, and the cost of drivers. These items, except the last, are continuous every day of the year, and must be reduced to a basis of, say 200 working days per year; thus,

Depreciation and Interest on Mules 25%,	$\frac{1000 \times .25}{200}$	= $1.25
Feed, 10 mules at .25 = $2.50		
Attendance - - - = 1.50		
$4.00 per day		
	and $4.00 $\times \frac{360}{200}$	= 7.20
Harness and repairs - - - -	say $40 per year, $\frac{40}{200}$	= .20
8 drivers - - - - - - - - - - - - - -	at $1.75	= 14.00
Total Cost of Mule Haulage - - - - - - - - - -		= $22.65

Cost of Electric Haulage.—The estimated cost of an electric plant is, say $7,000. In estimating it is customary to figure a depreciation in the cost of the plant of about 5 per cent., which must be added to the cost of operating the same, reducing as before to a basis of 200 working days; thus:

		Per Day.
Depreciation and interest 5 %................	$\frac{7000 \text{ x } .05}{200}$	= $1.75
Engineer of power house		= 1.75
Motorman		= 1.75
Helper		= 1.60
Repairs................	say $200 per year, $\frac{200}{200}$	= 1.00
Oil and Waste		= .25
Depreciation (2 mules), 25%		= .25
Feed................	$2 \times 25 \times \frac{360}{200}$	= .90
Harness and repairs................		= .05
2 drivers at $1.75................		= 3.50
Total cost Electric Haulage................		$12.80
Saving in favor of Electric Haulage		
	$22.65—$12.80	= $9.85

Question 17.—What changes in roof, bottom and coal seam are met with when approaching a fault? What other conditions may be expected?

Answer.—This depends upon the character of the fault in question. Proximity to a fault of displacement is frequently indicated by thin spars in the coal, occurring usually in the bedding plane of the seam, and having a trend or inclination in the direction in which the slip has occurred.

Pinchouts, horsebacks, etc., are usually indicated by the roof and floor in the seam gradually approaching each other. Faults of erosion are often indicated by the presence of stones or boulders in the coal, and a gradual thinning of the seam. None of these evidences, however, can be assumed as absolute indications of faults, since they betoken disturbances which may or may not have resulted in the faulting of the strata or erosion of the seam. The local character of each seam must be studied by itself in order to be able to predict, with any accuracy, proximity to a fault. In approaching a fault, a change in the gaseous condition of the mine may often be expected; as, for example, gas or water may often be encountered upon the opposite side of a fault where they have not been found in the present working of the seam, or *vice versa* these may disappear after crossing a fault.

Question 18.—By again referring to blackboard sketch, you will notice we have between the 2d and 3d E entries a rock roll or horseback. The roll affects the coal seam and roof for about 12 feet across, and rooms when driven up to it must be renecked or driven through narrow. The price paid for such narrow work is 80 cents per foot. Explain how you would work the above section, securing all of the seam, yet piercing the roll as few times as possible.

Answer.—The cost of holing through this fault would be 12x.80=$9.60 each time that the fault was crossed. This expense should be avoided by cutting through the fault in No. 1 Room only. This room may be driven, after crossing the fault, as a wide place (14 feet wide), or if the roof is good the room may be widened out to the usual width, after crossing the fault. The road should be carried along the straight rib and the room should be turned off of the entry so as to allow of being widened *outbye* instead of *inbye*, as is customary. Other rooms should be turned off this one, upon the inbye or straight rib, after crossing the fault. These rooms may be driven upon an angle so as to parallel the fault, or they may be driven square with the first room, in which case the fault will cut off each room in turn.

Question 19.—(a) What are the State laws of Indiana relative to the use of powder in coal mines? (b) What steps would you take to enforce these laws, or detect persons who may be violating them?

Answer.—(a) The Indiana mine law provides that blasting shall not be done in working hours only when opening a new mine employing not over 20 men, and being not over 100 yards in any direction from the bottom of the shaft. In such cases blasting is permitted *twice* only, during working hours. The law also provides that the firing of shots shall begin inbye upon the entry, and that no shot shall be fired till all the persons inbye from such shot shall have passed out. The law also provides that no hole for blasting shall be drilled more than one foot past the end of a cutting or a loose end, and no hole for blasting shall be located more than five feet from a loose end, measured at right angles to the direction of the hole. It also provides that not more than eight pounds of blasting powder shall be placed or exploded in one hole. A fine of not over $100 nor less than $5, or imprisonment in the county jail not exceeding six months nor less than thirty days, is provided for the violation of this act. (b) To detect violations of the law in reference to the use of powder is a difficult matter. An exact account of the number of holes fired and the powder used by each man may be kept, but this would only show the average charge of powder used. The only certain method is to employ a man to inspect or load the holes.

Question 20.—What particular points should receive the attention of the mine boss when making his daily rounds of the mine?

Answer. — The duties of the mine boss as required by the Indiana mining laws are as follows: He shall (1) watch ventilating apparatus and airways; (2) See that loose coal and rock on the traveling and airways are secured against falling; (3) Measure the air at the inlet and outlet and at the face of the entries once a week; (4) Keep a record of such measurements and report monthly to the Inspector of Mines; (5) Visit and examine all working places each alternate day when men are or should be at work; (6) See that sufficient timbers are kept at working places; (7) Order and direct that unsafe places be made safe when notified of them, and give written acknowledgment when he receives such notice; (8) Give immediate notice to the Inspector of Mines when a serious or fatal accident occurs at any mine in his charge.

In addition to the above duties as prescribed by law, the mine boss having first acquainted himself with the condition of the working places of the mine as indicated by the report of the fire boss, should proceed to assign to the company men or shift hands their several duties at the different points in the mine. If the ventilating apparatus, pumps and hoisting arrangements do not require his special attention at the shaft bottom, he proceeds to the inside workings and gives his attention first to the work of the drivers to see that the coal is moving properly toward the shaft. He inspects closely the timbering of the rooms and airways as he proceeds in his rounds.

Question 21.—If a fan running 50 revolutions per minute produces 25,000 cubic feet of air, what quantity will it produce if the speed is raised to 75 revolutions per minute?

Answer.—According to the usual method of calculation, the quantity ratio equals the speed ratio; thus, $\frac{x}{25000}=\frac{75}{50}=\frac{3}{2}$; or

$$x=\frac{3}{2}\text{ x }25000=37500 \text{ cu. ft. per min.}$$

More accurately, however, the fifth power of the quantity ratio equals the fourth power of the speed ratio; thus, $\left(\frac{x}{25000}\right)^5=\left(\frac{75}{50}\right)^4=1.5^4$; or

$$x=25000\sqrt[5]{1.5^4}=34580 \text{ cu. ft. per min.}$$

TABLE

Showing Names of Mines Which Were in Active Operation on January 1, 1902, Operators and Addresses, Mine Bosses and Addresses, by Counties.

CLAY COUNTY.

MINE.	OPERATOR.	ADDRESS.	MINE BOSS.	ADDRESS.
Brazil Block No. 1	Brazil Block Coal Co	Brazil	John Bolin	Brazil.
Brazil Block No. 8	Brazil Block Coal Co	Brazil	Henry Payne	Brazil.
Brazil Block No. 11	Brazil Block Coal Co	Brazil	James Burt	Brazil.
Gart No. 5	Brazil Block Coal Co	Brazil	Andrew Gilmour	Cardonia.
Gart No. 7	Brazil Block Coal Co	Brazil		
Gart No. 10	Brazil Block Coal Co	Brazil	William Rosser	Diamond.
Briar Hill	Clay City Coal Co	Chicago, Ill	Alex. Ferguson	Clay City.
Cloverland	Zeller, McClellan Coal Co	Brazil	George Donie	Cloverland.
Columbia No. 5	Zellar, McClellan Coal Co	Brazil	Mike Huffman	Asherville.
Cornwell	Jackson Coal Mining Co	Brazil	Moses Marks	Cardonia.
Crawford No. 2	Crawford Coal Co	Brazil	Walter Knox	Asherville.
Crawford No. 3	Crawford Coal Co	Brazil	William Penz	Asherville.
Crawford No. 5	Crawford Coal Co	Brazil	Grif. Howells	Center Point.
Dewey	Jackson Coal and Mining Co	Brazil	John Cox	Brazil.
Diamond No. 3	Diamond Block Coal Co	Brazil	W. G. Spears	Brazil.
Diamond No. 5	Diamond Block Coal Co	Brazil	J. C. Winn	Brazil.
Eureka No. 2	Eureka Block Coal Co	Terre Haute	Thos. G. Marshall	Carbon.
Eureka No. 3	Eureka Block Coal Co	Terre Haute	John T. Summers	Carbon.
Eureka No. 4	Eureka Block Coal Co	Terre Haute	John A. Boling	Carbon.
Fortner	C. Ehrlich	Turner	E. L. Tibbetts	Turner.
Gifford	Collins Coal Co	Brazil	August Norkus	Brazil.
Gladstone	Brazil Mining Co	Chicago, Ill	Oran Long	Coal Bluff.
Klondyke	C. Ehrlich Coal Co	Turner	Jacob Ehrlich, Sr	Staunton.
Monarch	American Clay Manufacturing Co	Brazil	James A. King	Brazil.
Pearl	Cloverland Coal Mining Co	Cloverland	M. D. West	Cloverland.
Pratt	Coal Bluff Mining Co	Terre Haute	H. W. Jenkins	Perth.
Glen	Coal Bluff Mining Co	Terre Haute	H. W. Jenkins	Perth.
Rob Roy	Andrew Coal and Mining Co	Brazil	James Andrews	Brazil.
Silverwood No 3	Indiana Bituminous Coal Co	Terre Haute	William Myers	Turner.
Crawford No. 7	Crawford Coal Co	Brazil	Samuel Lindsay	Hoosierville.
Lawrence No. 6	Zeller, McClellan & Co	Brazil	Fred George	Harmony.

DAVIESS COUNTY.

MINE.	OPERATOR.	ADDRESS.	MINE BOSS.	ADDRESS.
Cabel No. 4	Cabel & Co	Washington	Anthony Kocher	Washington.
Cabel No 9	Cabel & Co	Washington	Anthony Kocher	Washington.
Hoosier No 4	Raglesville Coal Co	Raglesville	Grant Stoy	Raglesville.
Montgomery No 2	Daviess County Coal Co	Montgomery	J. H. McKenna	Washington.
Montgomery No. 3	Daviess County Coal Co	Montgomery	Thos. Small	Washington.
Mutual	Mutual Mining Co	Cannelburg	Daniel Davis	Cannelburg.
Black Diamond	Black Diamond Coal Co	Washington	Henry Osha	Washington.
Union	J. M. Winkelpleck	Raglesville	A. W. Stuckey	Raglesville.
Logan Grove	Wilson Bros	Washington	Simeon Grill	Washington.

FOUNTAIN COUNTY.

Silverwood No. 4	Indiana Bituminous Coal Co	Terre Haute	William Dalrymple	Silverwood.

GIBSON COUNTY.

Oswald	Princeton Coal and Mining Co	Princeton	James Anderson	Princeton.

GREENE COUNTY.

Gilmour	Southern Indiana Coal Co	Chicago, Ill	James Stewart	Jasonville.
Black Creek	Black Creek Semi-Block Coal Co	Linton	Reuben Small	Linton.
Fluhart	Linton Coal and Mining Co	Linton	James Dunn	Linton.
Hoosier	Hoosier Coal Co	Bloomfield	Michael King	Linton.
Island No. 1	Island Coal Co	Indianapolis	S. C Risher	Linton.
Island No. 2	Island Coal Co	Indianapolis	John Eddy	Linton.
Island Valley No. 1	Island Valley Coal Co	Linton	Joseph Fennel	Linton.
Island Valley No. 2	Island Valley Coal Co	Linton	Geo. Epperson	Linton.
Island Valley No. 3	Island Valley Coal Co	Linton	Peter May	Linton.
South Linton	South Linton Coal and Mining Co	Linton	William James	Linton.
Summitt Nos. 1 and 2	Summitt Coal Co	Linton	Thos. McQuade	Linton.
Templeton	Western Indiana Coal Co	Bloomfield	John A. Templeton	Bloomfield.
Wild Cat	L. C. Dickason Coal Co	Terre Haute	Thomas Thomas	Linton.
Midland	Midland Coal Co	Chicago, Ill	Wm. Davidson	Linton.
Victoria	Victoria Coal and Mining Co	Jasonville	Frank Lockhart	Jasonville.
		Linton		Linton.

KNOX COUNTY.

Bicknell	Bicknell Coal Co	Bicknell	R. M. Freeman	Bicknell.
Edwardsport	Vulcan Coal Co	Indianapolis	Harvey Conrad	Edwardsport.
Knox	Knox Coal Co	Bicknell	Chas. Harting	Bicknell.
Prospect Hill	Sugar Loaf Coal and Mining Co	Vincennes	Frank Freeman	Vincennes.
Lynn	Lynn Coal Co	Bicknell	W. H. Lynn	Bicknell.

PARKE COUNTY.

Anthony	George Anthony	Fontanet	George Anthony	Fontanet.
Brazil Block No. 12	Brazil Block Coal Co	Brazil	R. F. Jenkins	Diamond.
Cox No. 3	Brazil Block Coal Co	Brazil	Oscar Busler	Coxville.
Lucia	Rock Run Coal Co	Montezuma	Victor Allais	Montezuma.
Lyford No. 2	Wabash Valley Coal Co	Lyford	John Mushett	Lyford.
Mary	Otter Creek Coal Co	Chicago, Ill	John Chesterfield, Jr	Brazil.
Mecca No. 1	Otter Creek Coal Co	Chicago, Ill	James Skene	Mecca.
McIntosh No. 3	I. W. McIntosh & Co	Brazil	Samuel Holden	Brazil.
Parke No. 8	Parke County Coal Co	Rosedale	George Mitch	Rosedale.
Standard	Standard Block Coal Co	Terre Haute	H. V. Sherburne	Brazil.
Superior No. 1	Zeller, McClellan & Co	Brazil	George Myers	Brazil.
Superior No. 2	Zeller, McClellan & Co	Brazil	John Chesterfield, Sr	Brazil.

PERRY COUNTY.

Troy	Bergenroth Bros	Troy	George Briggs	Troy.

PIKE COUNTY.

Aberdeen	Aberdeen Coal Co	Littles	James Fielder	Ayrshire.
Ayrshire No. 3	D. Ingle Coal Co	Ayrshire	Bart Stinson	Ayrshire.
Ayrshire No. 4	D. Ingle Coal Co	Ayrshire	W. L. Smith	Ayrshire.
Ayrshire No. 5	D. Ingle Coal Co	Ayrshire	D. Ingle, Jr	Ayrshire.
Blackburn	S. W. Little Coal Co	Evansville	John Willey	Petersburg.
Hartwell	S. H. Wulfman Coal Co	Huntingburg	C. C. Roland	Cabel.
Littles	S. W. Little Coal Co	Evansville	Herman Rose	Littles.
Woolley	J. Woolley Coal Co	Petersburg	H. T. Brewis	Petersburg.
Rogers	S. W. Little Coal Co	Evansville	Jno. R. Willey	Petersburg.

SULLIVAN COUNTY.

Mine.	Operator.	Address.	Mine Boss.	Address.
Bunker Hill	Washington Fuel Co.	Farnsworth	William Mason	Sullivan.
Caledonia	Rainbow Coal and Mining Co.	Sullivan	Henry Butler	Farnsworth.
Dugger	Indiana-Chicago Coal Co	Dugger	Reese Griffiths	Dugger.
Green Hill	Green Hill Coal and Mining Co.	Sullivan	William Mason	Sullivan.
Hymera	Hymera Coal Co.	Hymera	Wm. Davidson	Hymera.
Ingleside	Indianapolis and Sullivan Coal Co.	Dugger	C. C. Hall	Dugger.
Jackson Hill No. 2	Jackson Hill Coal and Mining Co.	Terre Haute	Ed. Stewart	Jackson Hill.
Phoenix No. 1	New Pittsburgh Coal and Coke Co.	Chicago, Ill	Jos. Peters	Alum Cave.
Phoenix No. 3	New Pittsburgh Coal and Coke Co.	Chicago, Ill	Alex Faulds	Alum Cave.
Phoenix No. 5	New Pittsbuegh Coal and Coke Co.	Chicago, Ill	Asa Roberts	Alum Cave.
Star City	Harder-Hafer Coal Co.	Chicago, Ill	Simeon Woolley	Del Carbo.
Shelburn	Keystone Coal Co.	Shelburn.	Wm. Norton	Shelburn.
White Ash	White Ash Coal Co.	Terre Haute	Wm. Britton	Hymera.
Jackson Hill No. 3	Jackson Hill Coal and Mining Co.	Jackson Hill	William Evans	Jackson Hill.

VANDERBURG COUNTY.

Mine.	Operator.	Address.	Mine Boss.	Address.
Diamond	Diamond Coal Co.	Evansville	Adolph Becker	Evansville.
First Avenue	H. A. Losier Coal Co.	Evansville	Frank Guenther	Evansville.
Sunny Side	Sunny Side Coal and Coak Co.	Evansville	Henry Baetz	Evansville.
Ingleside	John Ingle Coal Co	Evansville	John Odell	Evansville.
Union	Evansville Coal Mining Co.	Evansville	P. Schultheis	Evansville.
Unity	Crescent Coal Co.	Evansville	Fred Sutheimer	Evansville.

VERMILLION COUNTY.

Mine.	Operator.	Address.	Mine Boss.	Address.
Crown Hill	Crown Hill Coal Co.	Clinton		
Bruiletts No. 3	Bruiletts Creek Coal Co.	Clinton	Geo. A. Davis	Clinton.
Bruiletts No. 4	Bruiletts Creek Coal Co.	Clinton	J. C. McInnes	Clinton.
Bruiletts No. 5	Bruiletts Creek Coal Co.	Clinton	F. P. Christy	Clinton.
Buckeye	McClellan, Sons & Co.	Clinton	Wm. Chesterfield	Clinton.
Cayuga	Cayuga Press Brick Co.	Cayuga	Robert Irving	Cayuga.
Oak Hill	Oak Hill Coal Mining Co	Clinton	Wm. Hutchinson	Clinton.
Prince	Keller Coal Co.	Chicago, Ill	John Mushett	Clinton.
Torry No. 4	Torrey Coal Co.	Voorhees	George Davis	Clinton.
Willow Grove	Willow Grove Co	Clinton	James Boskill	Clinton.

VIGO COUNTY.

Chicago No. 6	Big Vein Coal Mining Co	Chicago, Ill	Thos. Gregory	Fontanet.
Rose Bud	Seelyville Coal and Mining Co	Seeleyville	Wm. Gray	Seeleyville.
Brick Works	Terre Haute Brick and Pipe Co	Terre Haute	J. F. Irwin	Terre Haute.
Broadhurst	H. Burke & Co	W. Terre Haute	Wm. L. Erwin	W. Terre Haute.
Diamond	Coal Bluff Mining Co	Terre Haute		
Ehrlich	J. Ehrlich Coal Co	Seeleyville	John P. Acree	Seeleyville.
Grant No. 2	Grant Coal Co	Burnett	James Lewis	Burnett.
Glen Oak	Glen Oak Coal and Mining Co	Burnett	Ed. Jaensch	Burnett.
Hector	Loughner Coal Co	Seeleyville	Thos. Maxwell	Seeleyville.
Nevins	Nevins Coal Co	Clinton	Thomas Clement	Burnett.
Miami	Miami Coal Co	Brazil	M. McMarrow	Brazil.
Woodland Valley	Woodland Valley Mining Co	Terre Haute	J. A. Erwin	Terre Haute.
Nickelplate	Brazil Mining Co	Brazil	C. E. Peck	Brazil.
Peerless	Coal Bluff Mining Co	Terre Haute	Chas. Nash	Burnett.
Parke No. 10	Parke County Coal Co	Rosedale	Thos. Bingham	Heckland.
Red Bird	Fauvre Coal Co	Indianapolis	R. F. Bieler	W. Terre Haute.
Ray	Vigo Coal Co	Seeleyville	George West	Seeleyville.
Royal	Seeleyville Coal and Mining Co	Seeleyville	John Scott	Seeleyville.
Union	Coal Bluff Mining Co	Coal Bluff	Jas. Johnson	Fontanet.
Vigo	Meneely Bros	Ehrmandale	Ed. Davis	Ehrmandale.
Larrimer	Peter Krachenberger	W. Terre Haute	Josiah Hodges	W. Terre Haute.
Lawton	Coal Bluff Mining Co	Terre Haute	Jas. Devonald	Burnett.

WARRICK COUNTY.

Air Line	T. B. Hall & March	Chandler	T. B. Hall	Chandler.
Big Four	Big Four Coal Co	Boonville	Jno. E. Kelley	Boonville.
Big Vein	J. Woolley Coal Co	Evansville	Louis Schultz	Boonville.
Caledonia	Caledonia Coal and Mining Co	Boonville	L. M. Gaisser	Boonville.
Chandler	J. A. Bryan	Evansville	Win Huber	Evansville.
DeForrest	Chas. Menden	Evansville	M. Wilson	DeForrest.
Star No. 1	Jno. Archbold Coal Co	Evansville	G. F. Archbold	Newburg.

TABLE

Showing Names and Addresses of Persons Operating Small Mines in Indiana, the Number of Persons Employed Therein, the Tons of Coal Mined and Wages Paid at Each Mine Reported, During the Year 1901.

CLAY COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Anderson & Brown	Brazil		(No Report.)	
Whitmarsh & Price	Cardonia	16	3,800	$3,940 00
Total		16	3,800	$3,940 00

DAVIESS COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Raglesville Coal Co	Raglesville	9	1,933	$2,590 65
Burke Bros	Washington	6	5,614	2,083 28
A. M. McClintick	Washington		(No Report.)	
Mandaback Bros	Washington	6	550	....
Raglesville Standard Coal Co	Raglesville	10	1,400	945 00
Total		31	9,497	$5,618 93

FOUNTAIN COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Tilley & Son	Silverwood	1	656	$440 00
Total		1	656	$440 00

GREENE COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Kates & Holder	Lyons	4	2,832	$2,150 00
Robertson Bros	Linton	11	4,000	1,225 00
Robertson Bros	Linton	8	5,800	3,400 00
James Dunn	Linton	7	5,200	4,400 00
Total		30	17,832	$11,175 00

GIBSON COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Ross Herbert	Oakland City	4	100	....
James Johnson	Oakland City	6	1,708	$2,000 00
Total		10	1,808	$2,000 00

OWEN COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Schor & Thomas	Patricksburg	8	1,508	$600 00
Total		8	1,508	$600 00

KNOX COUNTY.

Operator.	Address.	Number of Persons Employed.	Tons of Coal Mined.	Wages Paid.
Bensinger & Marty	Freelandsville	4	1,015	$625 00
Caldwell & Curry	Rockville	10	2,200	1,910 00
Total		14	3,215	$2,535 00

PIKE COUNTY.

William Sargins	Winslow	3	100	$240 00
C. Myers	Winslow	4	500	
W. H. Fitenger	Winslow	3	1,200	1,050 00
Total		10	1,800	$1,290 00

SULLIVAN COUNTY.

L. S. Eaton	Sullivan	5		
Total		5		

VIGO COUNTY.

Jesse Winn		8	303	$275 00
William Harkes	Coal Bluff	1	500	
Bennett Bros	W. Terre Haute	9	4,000	
John Jones	Terre Haute	10	4,180	3,492 00
George Koch	Coal Bluff	6	2,200	1,600 00
Total		40	11,183	$5,367 00

VERMILLION COUNTY.

Wm. Hustowne		9	2,500	
Thos. Williams	Cayuga	9	3,680	$3,080 00
Total		18	6,180	$3,080 00

WARRICK COUNTY.

Sargeant Bros	Newburg	9	4,950	$4,150 00
Louis Stock	Boonville	6	2,711	1,355 50
Total		15	7,661	$5,505 50
Grand total		198	67,140	$41,551 43

REPORT OF STATE NATURAL GAS SUPERVISOR.

LETTER OF TRANSMITTAL.

OFFICE OF NATURAL GAS SUPERVISOR,
KOKOMO, IND., January 13, 1901.

Prof. W. S. Blatchley, State Geologist:

Sir—I herewith transmit to you the tenth annual report from this department. It is made in obedience to Section 7504 of the Revised Statutes of the State of Indiana, and is for the year ending December 31, 1901.

For reasons that are patent to every person at all acquainted with the present condition of the gas field, and that are made plain in the body of the report, it is not as comprehensive as former reports, or as I would like to have made it. As the chief interest at this time centers around the condition of the gas field, most space is given to that subject.

In closing this, my seventh year's work, I am pleased to acknowledge the very cordial support that I have received from you from the beginning. Yours respectfully,

J. C. LEACH,
State Natural Gas Supervisor.

THE INDIANA NATURAL GAS FIELD.

Before this report is published, sixteen years will have elapsed since the first gas well was drilled in what is known as the Indiana Natural Gas Field. For persons who are acquainted with the history of this field, it is difficult to believe that people living in this section of the State have ever fully considered or appreciated the wealth and happiness that that first well opened to them. To give the early history of this field now would simply be to give a rehash of former reports, and as the chief interest now centers around present conditions rather than past history, most space is given to the former subject. However, it may not be amiss to again state that soon after the first gas well was drilled and it was known that the Trenton limestone, over a small area of the State, at least, was a gas-producing rock, numerous companies were organized to seek the new fuel. Though the explorations for gas were not confined to any one section of the State, it was only in the east central section that gas was found in commercially valuable quantities. The productive gas area was soon located. The development of the field, the location of factories and the phenomenal growth of cities and towns within the gas area are all common history—a history in many respects worthy of the intelligence and energy of those who helped to make it, and one of which the entire State may be proud. But, while this is true, there is no denying the fact that the history of this section of the State might have been much different; that the manufacturing and commercial prospects might have been brighter, if this fuel resource had been used from the beginning in a manner such as is warranted by its value. This statement will be fully understood by those manufacturers who have been short of gas, or who have been compelled to seek another fuel.

THE WASTE OF NATURAL GAS DURING THE EARLY HISTORY OF THE FIELD.

The seeming indifference throughout the gas field regarding the waste of gas that prevailed for a number of years after its discovery is well known to most readers of this report. It is a subject that has been given much space in former reports, and one that has merited more serious consideration from all classes of consumers of this gaseous fuel than it has received. And, however useless it may be at this time to speak of the subject, and however humiliating it may be in the face of present conditions to those who encouraged the vandal-like waste of the past, it is but just, I think, that it be held up before the public once more that the responsibility for the present condition of the natural gas supply, in so far as the waste of this fuel has contributed to it, be placed where it belongs. I do not intimate that the supply was sufficient for all time, provided it had been used as economically as other fuels are used, but I do believe that such use would have added a number of years to the life of the field. This statement will certainly not be questioned by people who are at all acquainted with the history of the field.

That natural gas is one of the most valuable resources of the State will not admit of argument. That its value warrants great care in using it to prevent waste is equally true. That the greatest indifference was manifested for many years toward the way it was used throughout the field, on the part of those that should have been most interested in the life of the field, and that in some places the most inexcusable classes of waste were really encouraged, are matters of common knowledge to those at all acquainted with the past of this field. At one time different localities seemed to vie with each other as to the amount of gas they could waste. Gas wells with a daily capacity of from 5,000,000 to 10,000,000 cubic feet were permitted to flow "full head" into the air for weeks at a time. At some places the burning gas from these open wells illumined the country for miles around. Arches of gas pipe, supporting hundreds of natural gas torches, were raised over the principal streets of cities and towns. Farm yards throughout the field were made light as day with natural gas, and where the use was for legitimate purposes it was most extravagant. At the present time, when there is a shortage of gas on every hand, it is indeed difficult to believe that conditions such as have been stated, ever existed.

In thinking of these conditions, it is but natural that we inquire the cause; the purpose in permitting this natural resource that has brought so much wealth to this section of the State to escape into the air without even a small per cent. of its value being realized. While most of the waste spoken of was willful and the possible effect upon the supply stored in the gas reservoir received but little consideration, it is certain that there was no thought of a final exhaustion of the field. Indeed, questions relating to the economic use of natural gas and the future of the supply received scant consideration from any one except geologists. While but little effort was made to account for the origin of the new fuel, nearly all reached the happy conclusion that its life would be equal to all time. Why give any attention to questions involved in the generation, storage or pressure of natural gas when the supply is inexhaustible? Most consumers at the time of which I am speaking knew but little about this fuel, except what they saw at the point of consumption, and to those within the gas area there was but little evidence for many years that the supply was gradually being exhausted. It seems that for a number of years everything conspired to create a feeling of security in the minds of the people regarding the supply of this fuel, and tended to encourage open-handedness in dispensing its privileges. I think, then, that the prevailing opinion during the early history of the field, that the supply of gas was inexhaustible, and also the feeling of security regarding the fuel problem that was created thereby, caused much of the indifference that seemingly existed toward the waste of gas. With no desire to show a spirit of "I told you so," I believe it to be due this office to say that from the beginning the annual reports of the State Natural Gas Supervisor have *stated* and *restated* that the stock of natural gas was practically complete; that when once exhausted, there was no provision in nature for its renewal. The public has not been asked to accept these statements, only as logical conclusions based upon unquestionable facts. But, however logical a conclusion given out from this department might be, if it intimated that the supply of gas would even *ever* show signs of exhaustion, it was cast aside, and the Natural Gas Supervisor was branded as an enemy to the gas belt.

Laws Enacted to Prevent Waste.

As early as 1889, the General Assembly of the State took cognizance of the great value of natural gas as a fuel and the possibility of a final exhaustion of the field, and enacted a law prohibiting the transportation of natural gas out of the State. Afterward, various other laws were enacted to protect the gas field. Some of these laws have been held to be unconstitutional by the courts, especially the first mentioned; but most of those enacted to prevent waste are valid, and a rigid enforcement of the same from the date of enactment would have done much to prolong the life of the field. For a number of years it was most impossible to enforce the law, primarily because the people had decided that there was enough gas to last forever.

As those who chose to accept this theory were unable to give valid reasons for so doing, they gave as a further reason for opposing the enforcement of the law that natural gas is property, and, as such, the owner has a right to use it as he desires. This was the prevailing opinion, and is yet of some people on whose land gas wells are located; notwithstanding the fact that the courts have held that the enforcement of the law is but a judicious exercise of the police powers of the State; that the welfare and prosperity of the public overshadows the good of the individual. After all, the chief opposition to the enforcement of the law came from the erroneous idea prevailing regarding the permanency of the supply of gas. To dislodge this idea and create a business-like sentiment in favor of a reasonable economy in the use of this fuel has been a difficult task.

The one thing that has brought the public to a proper realization of the truthfulness of the statements in the various reports from this office, to wit, that the supply of gas is limited, and that the best interests of all concerned demand a strict economy in its use, has been a short gas supply. That is one condition that has been very convincing, indeed, and I may say that it has been a condition that has been extremely impartial during the past year. When it comes, sentiment changes quickly. The cry then is to stop waste, quit extravagance and let the law be enforced.

By the waste heretofore referred to I have meant the escape of gas into the air at places other than at the point of consumption or the use of gas with no legitimate purpose in view. It must be plain now that a very large amount of gas has been wasted by these methods. As to the responsibility, it must rest largely with those to whom I have referred, who were seemingly wholly indifferent to it when, had they so chosen, they could have been a power to prevent it.

Among those to be counted directly responsible for the large and unreasonable waste that was permitted during the first two or three years of the history of the field, none were more active than land companies and "boomers," who desired to profit by the discovery of the new fuel. In 1886, when natural gas was discovered, that part of Indiana known as the "gas belt" was devoted almost exclusively to agriculture. Besides the customary flouring and saw mills, the factories were few and confined almost exclusively to woodenware. Manufacturers throughout the country were not slow to learn the advantages of natural gas as a manufacturing fuel. Factories located in other gas fields, where the supply had become limited, were first to seek locations. In a short time glass factories, tinplate mills, iron mills, and, in fact, all kinds of factories began to knock at the door of the gas belt. The citizens of the gas belt were not long in realizing its possibilities as a manufacturing center, and began in a systematic way to locate factories. It was but a short time until a friendly rivalry sprang up between the various gas belt cities, each claiming to be the center of gas production, and the amount of the new fuel wasted to prove it can not be estimated. To locate factories, liberal subsidies were given. Propositions and counter-propositions were made by rival cities, and in nearly every case free gas was stipulated. Land companies were organized in nearly every city and town, and through their efforts many factories were located. At times the excitement ran high, and fabulous prices were paid for real estate. Free gas for factories was heard on every hand, and at places it seemed that the ingenuity of the "boomer" had been sorely taxed to contrive methods to advertise the gas field, which in every case involved waste, that the prospective manufacturer might see the enormous pressure and flow of the wells. These conditions under which the first factories were located are responsible to a large extent for the manner that these institutions treated the gas field in after years, for every one at all acquainted with the field and the factories located therein knows that most manufacturers, to say the least, have been very negligent regarding the manner of using this fuel. In many cases it came "free" and has been used in the same spirit.

Waste of Gas in Factories.

So far I have referred to the willful waste of gas only; that is, waste having no legitimate purpose. It is fair to say that this class of waste did not continue very long. There is another way in which an enormous amount of gas has been wasted and to which nearly every consumer has been a party. I refer to the gas wasted through extravagant consumption, and, I need not say, *"has been wasted,"* for it is being wasted in that manner now.

Natural gas has fulfilled its highest mission when it has been used for the comfort and benefit of mankind. When it is burned under such conditions that its full heating power is not attained, there is waste and it has not fulfilled its mission. Of all consumers of this fuel, it would seem that manufacturers have reason to be most economical. This is not true, nor never has been. In some factories I have found the most crude appliances in use; appliances unscientific in every detail, and with which it was impossible to secure perfect combustion. A very slight expense and a little consideration of the principles of combustion would have saved fifty per cent. of the fuel.

In some factories these same conditions exist today, even where the factory is closed for lack of fuel. The presence of these conditions can not be charged, I think, to a positive desire to waste gas, but rather to negligence or a lack of knowledge of how to use it on the part of the parties having these matters in charge. There being no law governing the consumption of this fuel, the best that I have been able to do has been to advise. In this way some good has been done. Some manufacturers have responded cheerfully to suggestions, and have made an honest effort to treat their fuel supply in a business-like manner, but in a majority of cases promised improvements never come.

Enforcement of the Flambeau Law.

The question of light has presented many difficulties for manufacturers. Natural gas makes a very convenient light, but through lack of attention the ordinary light becomes very wasteful. For a number of years all factories were lighted with flambeaux. The average amount of gas consumed by one of these lights is 100 cubic feet per hour. This is certainly a very extravagant use, if not absolute waste. In line with this idea, the General Assembly of 1891 enacted a law prohibiting the use of these torches for illuminating purposes. This law encountered a silent, but determined, opposition from the first. Manufacturers, oil operators, drillers, farmers, and, in fact, every one who needed an outside light or a light where glass globes could not be used, resorted to natural gas torches. With all classes of people using these lights and a strong public sentiment against the enforcement of the law, it was not possible to do much. In some cases, juries refused to convict where there was no conflicting evidence, and many were the schemes resorted to by all classes of consumers to evade the law. As with other classes of waste, it was only when the diminution in the supply became noticeable that the law received the support of the public. At present the flambeau law is very generally observed, and a vigorous enforcement of the same is approved by nearly all. I speak of the co-operation of the public in the enforcement of the law, because I have found it almost impossible to enforce it as it should be without the sympathy of the public. It is doubtless noticeable that manufacturers and others who have been most active in condemning the waste of gas have, in some places, been most persistent in violating the flambeau law.

Most of the large factories in the gas belt have their own fuel supply plants. They control large tracts of gas territory; have planned their pipe line systems and located their wells systematically. Such usually employ a superintendent of fuel supply and lines and everything used in the distribution and consumption of their fuel is kept in good condition. Those manufacturers, and there are quite a number, who have not planned for the future, who have drilled wells at the most convenient point, with no pipe line system in view, and only when it was absolutely necessary to have gas, usually give but little attention to waste. Neither wells nor pipe lines receive any attention so long as the supply of gas is sufficient, and when it fails the enormous waste of other people is proclaimed to the public.

Waste of Natural Gas by Domestic Consumers.

Manufacturers are not the only class of people that have wasted natural gas in this field. Much has been wasted by private consumers. In but few furnaces, stoves or grates is the combustion perfect, and it must be or more gas will be used than is necessary. Universally, in the past, and in most places at the present, natural gas is sold by the contract system, and where that system prevails, the incentive to economize in the use of this fuel is small. Imperfect combustion, overheating of houses and the absence of dampers in chimneys have been the cause of much waste. For many years after the discovery of natural gas, it is safe to say that 50 per cent. of the gas used by domestic consumers was wasted. I am sorry to say that practically the same conditions prevail today in localities where the supply of gas is sufficient, where there is gas to waste, and frequently where the supply is short one-half of the gas used is wasted.

I have devoted considerable space to the waste of gas during the early history of the field. And, as I have intimated, my purpose in so doing has been to make it plain, if possible, that all waste can not be charged to any one industry; that manufacturer, domestic consumer, drillers, and, in fact, all consumers of this fuel have in some degree contributed to the present condition. And I also want to emphasize the fact that I have no desire to excuse any industry for wasting this fuel. Some oil operators have been guilty of willful waste, and have been punished for it. While this is true, all the gas that has been wasted can not be charged to them.

The Development of the Field.

So far, I have referred to the past history of the field only as it relates to the use of its resources. The manner of the development of the field, and the ever varying conditions that each year has brought forth, have been given in the annual reports from this office. Though it is not what the resources of the field have been, but what they are now that interests us, it is necessary that slight reference be made to some subjects that have been reviewed very fully in former reports that the present condition of the field be at all understood. The geological conditions in this part of the State, and the manner in which the field has been developed must be kept in mind.

The natural gas in this field is found in Trenton limestone, a universal formation in Indiana, but not a universal gas-producing rock. The fact that this formation is gas-producing over a comparatively small area, though underlying the entire State, is due to the textural and structural formation of the rock in this area. The gas is held in a porous stratum in the upper part of the limestone. This gas rock seldom reaches the surface of the limestone, and in some parts of the field it is less than five feet thick, while in other parts the drill has penetrated it 100 feet without reaching the lower surface. Both the lower and upper surfaces of the gas rock are very uneven, and especially is this true of the top, which has numerous ridges, with corresponding valleys.

The development of the field was natural, under the conditions. The first wells were drilled in the vicinity of cities and towns by companies organized to supply gas for domestic consumption. Soon "farmer companies" were supplying the rural districts, and natural gas was a universal domestic fuel throughout the field. Factories were supplied from wells nearby.

Natural Gas Piped to Cities Outside of the Gas Field.

Natural gas is too valuable a fuel to be kept within the boundaries of the field. From 1888 to 1892 pipe lines were constructed from the gas field to Indianapolis, Lebanon, Crawfordsville, Frankfort, Lafayette, Logansport, Peru, Wabash, Huntington, Bluffton, Fort Wayne, Decatur, Union City, Connersville, Richmond, Shelbyville and Chicago. Later, two lines were built from the eastern part of the field to Ohio, there, in addition to supplying a number of cities and towns, to supplement the rapidly diminishing supply of others that had formerly received an adequate supply from the field in the western part of that State. Prior to the construction of these pipe lines, there had been but little systematic drilling of wells and very little effort to pre-empt territory. Naturally, these lines, radiating in every direction from the gas belt, tapped it at the nearest point. Thus, an outer zone surrounding the entire gas territory was first to be systematically drilled and to show signs of exhaustion. As the wells near the edge of the gas area became exhausted, or the rock pressure reduced below that of the pipe lines, it was necessary for these lines to be extended toward the center of production. As rapidly as has been necessary, the various pipe lines and lines tributary thereto have been extended, thus reducing the area of undeveloped territory. Then, as the wells supplying factories began to show signs of failure, the owners awakened to the true condition, and began to lease territory and plan for the future. Soon the entire gas field was either under lease or was controlled by land that was leased. Of course, there is some land that is not leased, and there is probably some under lease that will never be drilled, for gas companies sometimes lease land to keep other companies from interfering with their plans. But at this late day, the fact that a gas company has paid rentals on a large per cent. of the land in any particular locality for years does not deter other companies from invading this territory, if sufficient well sites can be secured. Scant courtesy is accorded any person or company in the location of wells now.

Effect of the Salt Water.

To understand the condition of this field, it is necessary that the effect of the salt water which is so universally present be understood. Introductory to this subject, I will quote parts of a paragraph from my first annual report (1895): "In order that petroleum and natural gas may accumulate in valuable quantities, it is not only necessary that a rock, the formation of which is suited to the storage of these products, be present, and that it be covered with an impervious roof, but it is equally necessary that the rock containing these hydrocarbons possess a structural relief sufficiently elevated to allow the various substances occupying the reservoir to arrange themselves in the order of their specific gravity, that is, the water, the oil (if any) and the gas on top. The required elevation of the relief is relative and not necessarily absolute. The productiveness of the reservoir seems to depend upon its elevation as related to the adjoining territory. The Cincinnati arch meets this requirement in the Indiana field. Its boundaries and structural peculiarities have been practically defined from the records of a number of wells drilled in the territory which it occupies. It is a low, broad elevation that crosses the eastern boundary of the State between Lawrenceburg and Liberty, and extends in a northwestern direction across the State. Its surface is very uneven in places, consisting of numerous small ridges or folds, with occasional spurs extending at various angles from the main elevation. The presence of this arch supplies one of the very necessary conditions for gas yield in this State, for the reason that it acts as a trap in which the gas accumulates. In this arch or dome the gas is held under an enormous pressure, due to the weight of a column of water back of it. The Trenton limestone, which comes to the surface in New York and Pennsylvania on the east, Iowa and Wisconsin on the west, Kentucky on the south, and Michigan on the north, forms a large basin, in which the Cincinnati arch is located. The water entering at its outcrops flows towards its center and rises in the dome of the arch, driving the gas and oil before it until the resistance of these products is equal to the weight of the column of water. The cause of the pressure of the gas is plain."

Then, as the salt water is the force back of the gas, there is a constant conflict between the gas and water, and when the former is exhausted the latter will take its place in the rock. As the supply of gas diminishes, the salt water horizon advances toward the highest point in the reservoir. In some parts of the field it has seemingly been more aggressive than in others, which can probably be charged to the structural condition of the rock and the unequal draught on the various sections. In some parts of the field it appeared very early and overcame wells with a rock pressure of 260 pounds.

As the upper surface of the gas rock is undulating, it is plain that the salt water advancing meets it at the lowest points first, and thus, different localities of the field become hermetically sealed, one from the other. This condition is becoming more marked each year, and if the drill strikes a valley in the gas rock, a place where it is completely occupied with salt water, the certain result is known. Also, the per cent. of failures is becoming greater each year.

Generally speaking, the condition of a gas field must be judged from the condition of the wells; that is, the volume of flow, rock pressure, presence of salt water, etc., must be considered. During the early history of the field, and, in fact, until the salt water became such a prominent factor, the general conditions surrounding the field were easily determined. The salt water had not reached the top of the gas rock at any point, and the rock pressure of the entire field tended to equalize during periods of light draught. It was but necessary to test a few wells located in different parts of the field to ascertain the rock pressure of the entire area. While the volume of flow of the various wells was never uniform, owing to the difference in the textural condition of the rock, the failures were few, and most wells were vigorous producers. With the changed conditions, a heavy draught on one section of the field may not affect localities nearby. Wells on adjoining farms frequently differ very materially in volume of flow, rock pressure, etc. It is plain, I think, that it is impossible to make anything like an accurate or satisfactory statement of the present condition of the field. In fact, the conditions are so varied and continually changing that it is not possible for me, being in the field all the time, to keep in touch with every section. I can only speak of conditions in a general way.

Present Condition of the Field.

In the brief review of the history of this gas field that I have given, it has been necessary to refer incidentally to present conditions, and in the special reference that I make to this subject I will avoid rehashing as much as is possible. In former reports I have referred to the "center of the field" and to "undeveloped territory," that is, that territory not invaded by pipe lines. While the center of the field, that section where the wells are uniformly most productive, remains at about the same locality, there is, strictly speaking, no undeveloped territory. That is, there is no territory that is not directly influenced by pipe lines. Practically the entire field is threaded with these lines, and there is but little room or excuse for further main line extensions. Of course, there are many, many small tracts of territory that have not been drilled in the usual systematic way, but future wells can be reached by lines tributary to the main lines now laid.

As the volume of the wells has been decreasing, the number of wells drilled yearly has been increasing, and the past year has been no exception. There was a time when there was but little drilling during the winter season; now the drill is busy in most localities the year around. As virgin territory has become scarcer, and wells drilled therein less productive, the tendency is to redrill old territory. Usually, wells located in territory that has been drawn upon for a considerable time are small producers and comparatively short-lived, but most of them can be used with little pipe line expense. One of the very noticeable conditions at the present time is that wells, without regard to where they are located, are very sensitive to a continued heavy draught. When first drilled, they seem vigorous, and usually show a creditable production, but the resources of the gas rock are so limited that they fail to honor even a moderate continuous heavy draught. They are easily overworked.

The decrease in the rock pressure of the field has been very marked during the past year. It must be understood, as has been stated frequently in former reports, that while a decrease in the rock pressure of a given area of the gas field indicates a general diminution in the supply of gas in that area, that rock pressure is not an index of the capacity of a well, and as the supply of gas becomes more nearly exhausted, its relation to the same usually decreases. The velocity of the gas at the well mouth is the only true index of the capacity of a well; but, as it is not possible for me to secure this information from every well in the field, or even a majority, reference is made to the rock pressure. As I have said, this shows the general drift of conditions. For reasons that have been stated, it is much more difficult to gain any information along this line than formerly, for it is necessary to ascertain the pressure of numerous wells in the various sections of the field to obtain any information at all.

In taking rock pressures this year, I have not considered those small areas of gas territory located on the edge of the field that have been explored for the first time this year. Some of this territory has been held under lease for a number of years, and abandoned as worthless, and then taken up by another company and developed with profit, as the territory south of Middletown, Henry County, now being drilled by the Richmond Natural Gas Company. Another instance is the territory north of Marion, Grant County. This territory had been given but little consideration by any one, and was considered very light gas territory, if not worthless. During the past year, while being explored for oil, a number of productive gas wells were drilled. It is from this territory that Marion is supplying a large per cent. of her domestic consumers. Though some of the wells, on account of the large amount of salt water present, show sign of early decline, the rock pressure when the first well was drilled was 240 pounds. It is these exceptional cases of high pressure that have not been considered in computing the average rock pressure of the field.

The initial rock pressure of the Indiana gas field was 325 pounds. January, 1896, the average of the field was 230 pounds. This had decreased to 115 pounds in January, 1901, an annual decrease of 23 pounds. As near as I can ascertain, the average rock pressure of the field now is 80 pounds. The lowest pressure found was 30 pounds, and the highest was 120 pounds.

COMPRESSING STATIONS.

With the decrease in the rock pressure in this field came the necessity for using compressors on pipe lines. Quoting from my last annual report, I say that the pressure required to transport natural gas depends primarily upon the consumption. With no consumption and the pipe line perfectly tight, the pressure at the outlet of the line must be the same as at the wells, and with the line wide open at the point of consumption the loss of pressure is at a maximum. The amount of natural gas that can be transported in any pipe line a given distance depends upon the size of the line and the pressure in the same, the former governing the volume of gas and the latter the velocity. Thus, as the field pressure decreases, the question presented to both gas companies and manufacturers is, whether to build compressing stations or increase their pipe line capacity. Some have adopted the former, others the latter, while occasionally it has been necessary to resort to both.

The law prohibits the transportation of natural gas through pipe lines at a pressure exceeding 300 pounds. With the present conditions in the field it is doubtless impossible to maintain the maximum pressure allowed by law. However, I have taken the precaution to test the pressure in all lines where it would seem that an excessive pressure would be desirable, or even possible, and have not found an unlawful pressure in a single line.

The following companies have stations as indicated below in this field:

	Company.	*Number of Stations.*
1.	Indianapolis Gas Company, Indianapolis	2
2.	Consumers' Gas Trust Company, Indianapolis	2
3.	Manufacturers' Natural Gas Company, Indianapolis	5
4.	Indiana Natural and Illuminating Gas Company, Lebanon, Frankfort and Crawfordsville	2
5.	Lafayette Gas Company, Lafayette	3
6.	Logansport and Wabash Valley Gas Company, Logansport, Peru, Wabash and Decatur	4
7.	Fort Wayne Gas Company, Fort Wayne, Bluffton and Anderson	4
8.	Portland Natural Gas and Oil Company, Portland	1
9.	The Ohio and Indiana Consolidated Natural and Illuminating Gas Company, Lima, Ohio	2
10.	The Redkey Transportation Company, Dayton, Ohio	2
11.	Richmond Natural Gas Company, Richmond	1
12.	Indiana Natural Gas and Oil Company, Kokomo, Ind., and Chicago, Ill	4
13.	Muncie Glass Company, Muncie	1

	Company.	Number of Stations.
14.	Pittsburg Plate Glass Company, Elwood and Kokomo	1
15.	Anderson Fuel Supply Company, Anderson	1
16.	Penn-American Plate Glass Company, Alexandria	1
17.	The J. M. Leach Gas Company, Greentown and Kokomo	1
18.	The American Sheet Steel Company, Muncie	1
19.	Ball Brothers' Glass Company, Muncie	1
20.	Muncie Pulp Company, Muncie	1
21.	Citizens Gas and Mining Company, Elwood	1
	Total	41

The Waste of Gas During the Past Year.

In a former section of this report I referred to the waste of natural gas during the early history of the field. My desire is that, at this time, when so much is being said about the waste of gas, that it be understood by every one that during the early history of the field this enormous reservoir of gas, with its 325 pounds' pressure was opened into the air for weeks at a time, just to show to the world what an inexhaustible supply of natural gas Indiana possessed, and that much of this valuable fuel has been wasted through the extravagant use of it that has characterized this field from the beginning. At this time, when the evidences of final exhaustion are so plentiful, manufacturers and others who are experiencing a shortage in fuel for the first time, and are brought face to face with a subject to which they have given but little attention in the past, are inclined to charge present conditions to the oil operator, who is encroaching upon the gas field. If the blame is to rest there, those who contributed so much during years past to bring about this condition are not brought to account, nor is the extravagant consumer. The tendency is to charge the responsibility to those who may be caught wasting gas *now*. Natural gas is one of the most valuable resources of the State, and any one who deliberately wastes it at any time is not acting in accord with the best interests of the commonwealth.

The avenues through which natural gas may be wasted from the well to the consumer are many, and it requires constant watchfulness to prevent it. I am pleased to say that at present the necessary precautions to prevent waste from these sources are generally observed. Under ordinary circumstances there is but little gas wasted at the well while it is drilling, and in most localities the pressure is low in the lines, and there is comparatively little waste.

The manner of consuming natural gas, especially by the private consumer, has not improved much. While there has been less gas used during the past year than formerly, it can be charged to a short supply rather than to economy in using it. It is seldom that a fire is found in either private house or factory where the combustion is perfect, where all the gas is consumed under proper conditions, and the heat placed where it belongs. Incomplete combustion involves waste and fails to give the most satisfactory service, though the supply of gas is ample. It is admitted that the prevailing method of selling natural gas, the "contract system," is largely responsible for the indifference manifested by the average consumer regarding methods of consumption and the amount of gas consumed. By the terms of the contract, the charges are the same regardless of the amount of gas consumed. It is unfair to both parties. Where the supply is short, the consumer may pay for gas that he does not use. The system is wrong, and would not be tolerated in any other business. The only just method of selling gas is the one under which I am compelled to pay for the gas I consume and no more. The introduction of meters at this late day would improve the service in most localities, if it did not materially prolong the life of the field. Where the benefit is to the consumer, economical appliances are usually introduced. With perfect combustion less gas is necessary. Where the supply is apparently short, the trouble in most cases is with the manner of using gas, rather than with the service.

Of all classes of natural gas consumers, the manufacturer is certainly the one that would be least expected to use it extravagantly, much less permit it to be wasted; yet, in many instances, I have found both conditions existing. As a business proposition it would seem that a factory, the life of which depends upon this fuel, would practice as rigid economy in its consumption as is observed in the use of the other constituents of the factory product. It is difficult for manufacturers who have been victims of a "free gas" subsidy to realize the necessity of a business-like economy in the use of their fuel until they have been brought face to face with a short gas supply, and then the disposition is to increase the supply of gas, if possible, rather than adopt economical appliances and change methods of consumption, which, in most cases, would effect the same purpose and be less expensive. Of course, these statements do not apply to all manufacturers, but to a majority.

Notwithstanding what has been said regarding the use of natural gas in factories, I am pleased to note that there has been a very noticeable change during the past year, partly due to the scarcity of gas and partly to the law which has been as rigidly enforced as was possible with the field force at my command.

The Waste of Gas by Oil Operators.

In what has been said about the waste of natural gas but little reference has been made to the oil field, not because it does not merit it, but because I have thought it proper to call *especial* attention to it in the proper connection. More complaints have come to this office the past year regarding the waste of gas by oil operators than any previous year. By many people, the oil industry is considered a most dangerous enemy to the natural gas field. The reason for this rests primarily in the fact that where gas and oil are found in the same rock, it is difficult to produce the oil without wasting the gas, inasmuch as only a limited pressure can be held in an oil well without materially reducing the production; and, in the further fact that a few oil men have shown a bitter opposition to the laws enacted to preserve the gas, and have seemingly taxed their ingenuity to invent ways to evade the provisions of the same. I am pleased to say, however, that the class of oil operators mentioned above are greatly in the minority, for many are in positive sympathy with every effort to enforce the law, and a large majority are making an honest effort to obey its provisions. I could not say as much one year ago. Previous to the past year, drilling for oil was principally by oil companies, many of which had but little respect for the natural gas industry. During the past year much of the new oil territory developed has been by manufacturers and others interested in protecting the natural gas supply, and who were prepared to care for any surplus gas.

While it is not within the scope of this report to give a detailed description of the oil territory in Indiana, it is proper to refer to it in a general way in this connection. What is generally known as the Indiana oil field is located on the northeastern border of the gas territory, and embraces parts of Adams, Jay, Wells, Huntington, Blackford and Grant counties. This is distinctively oil territory, and in most wells there is not enough gas for fuel purposes, pipe lines from the main field being necessary to supply fuel for drilling and pumping purposes. The territory in Blackford and Grant counties referred to above embraces the north one-half of the former and Van Buren Township in the latter.

The past year has witnessed a great change in this part of the field. In Blackford County the oil territory now extends south of Hartford City, and in Grant County some of the most profitable oil territory is in Monroe, Mill, Franklin and Center townships. In Madison County comparatively few oil wells have been drilled since my last report, there being fewer than 100 oil wells in the county. Under ordinary conditions about one-half of these are being operated. A very small per cent. of these show more gas than is necessary to operate them. Those showing the most gas are owned and operated by gas companies that have never spared any trouble or expense to protect the gas supply. A few profitable oil wells have been drilled in Monroe Township, Randolph County, and Liberty Township, Delaware County.

Referring to all of the new territory that has been developed for oil during the past year, it may be said that it has been gas territory; that is, nearly all of the wells produce some gas, and a number gas only, and in profitable quantities. True, some of this territory had been condemned for gas years ago by both manufacturers and gas companies, but that was at a time when more productive territory was available. If the large number of wells that have been drilled, especially in Grant County, are taken into consideration, the difficulties that I have experienced in protecting the natural gas interests the past year will be plain. It is altogether probable that there have been many violations of law in both the gas and oil field that have not been detected by this office. What law is there that is not violated? There are laws prohibiting murder, theft, drunkenness, etc., and yet men are murdered, theft is not uncommon, and men continue to drink to excess. Of course, wherever there is natural gas there is danger of waste through accidents or negligence, if nothing else, but that part of the original gas area where there are most wells being drilled, where the pressure is highest and the opportunity to waste gas is greatest, contains about 1,000 square miles. Is it possible for two men to keep in touch with all parts of this territory and prevent the waste of gas if there is a disposition so to do on the part of those operating? I have employed my time diligently, and have done everything possible to preserve the natural gas supply, and when I have done this I have done my duty.

The fact that many factories have experienced a shortage in their supply of gas during the past year, and this has been true whether the factory was located in the oil field or not, and the further fact that there has been considerable drilling for oil in territory upon which these factories were depending for their fuel supply, accounts in no small degree for the complaints from manufacturers regarding the waste of gas. It is true that in some cases there has been just cause for complaint, but in many cases the complaint was the offspring of an imagination quickened by a short fuel supply. No complaints have come to this office that have not been thoroughly and honestly investigated, and where the facts have warranted it, vigorous prosecutions followed. During the year I have filed 49 affidavits charging a violation of the gas-waste law. A majority of the cases have been tried and a conviction secured in all except two.

CONCLUSION.

There was a time when the regulation questions in the gas field were: Is the gas failing? How long will it last? But little interest attaches to the former question now, for there are but few consumers, indeed, that do not know from actual observation and experience that the supply is rapidly being exhausted. Chief interest at this time centers around the latter question: How long will natural gas last? I can not answer this question. Who can? We can say positively that the time when natural gas has ceased to be a universal domestic and manufacturing fuel within the gas field is here. The end will be gradual, and the beginning is here. If, after using this fuel for 16 years, a change to other fuels is necessary, it is well that we have been forewarned, that the decline has been gradual, where it is possible to use other fuels, the manufacturer has had time to prepare for the change. A few factories have closed on account of the short gas supply this year. Others have been compelled to shut down during the extreme cold weather or have used coal to supplement the supply of gas. At least three of the principal factories in the gas belt are preparing to manufacture gas.

The time is here when all classes of consumers should prepare to supplement the supply of natural gas during extreme cold weather with other fuel. To insure comfort this is a precaution that should not be neglected.

REPORT OF STATE SUPERVISOR OF OIL INSPECTION.

INDIANAPOLIS, IND., January 13, 1902.

Prof. W. S. Blatchley, State Geologist:

Dear Sir—In compliance with Section 5154, R. S. 1881, I have the honor to submit herewith the report of this department, showing the inspection of petroleum oils and miners' oil for the year 1901.

The total inspection of petroleum oils amounted to 302,122 barrels. Of this number 301,594 barrels were approved for illuminating purposes, and 528 barrels were rejected for use in the State.

Of miners' oil there were inspected and approved for use in the mines of the State 1,764 barrels. Respectfully submitted,

W. C. ZARING,
State Supervisor of Oil Inspection.

DEPUTY STATE SUPERVISORS OF OIL INSPECTION.

Andress, E. H	Lafayette, Ind.
Bell, T. E.	Hammond, Ind.
Blatchley, F. H	Bainbridge, Ind.
Bowman, M. J	Madison, Ind.
Cooper, W. V	Evansville, Ind.
Crabbs, O. W.	Muncie, Ind.
Davenport, J. B	Elkhart, Ind.
Derr, Walter	South Bend, Ind.
Dorsey, C. B	New Albany, Ind.
Dorsey, W. C.	Terre Haute, Ind.
Johnston, J. M	Logansport, Ind.
Lane, C. R.	Ft. Wayne, Ind.
Lockwood, C. W	Peru, Ind.
Markley, G. W.	Crawfordsville, Ind.
Schutt, M. A.	Michigan City, Ind.
Weems, R. F.	Vincennes, Ind.
Zehrung, P. H	Cambridge City, Ind.

TABLE SHOWING THE TOTAL NUMBER OF BARRELS OF PETROLEUM OIL INSPECTED, AND WHERE INSPECTED, FOR THE YEAR 1901.

Station.	*Bbls.*
Anderson	2,044
Angola	2,372
Argos	282
Attica	1,931
Auburn	1,562
Aurora	2,516
Batesville	882
Bedford	4,403
Bloomfield	2,164
Bloomington	1,524
Bluffton	2,053
Boonville	866
Bourbon	1,133
Brazil	3,118
Bremen	460
Brook	646
Brookville	1,865
Butler	500
Brownstown	835
Churubusco	460
Cincinnati, Ohio	3,892
Clay City	802
Cleveland, Ohio	8,085
Clinton	1,337
Coal City	41
Columbia City	1,368
Columbus	2,989
Connersville	1,731
Corydon	561
Crawfordsville	3,272
Crown Point	1,304
Danville, Ill.	374
Danville	1,862
Decatur	1,719
Delphi	1,313
Elkhart	3,856
Elwood	1,150
Evansville	16,396
Fort Wayne	9,140
Fowler	1,927
Frankfort	2,922
Franklin	1,934
Fremont	21
Garrett	500
Goshen	2,085
Greencastle	1,549

Station.	Bbls.
Greenfield	1,069
Greensburg	1,571
Hammond	3,548
Hartford City	836
Hobart	466
Huntingburg	1,118
Huntington	3,459
Indianapolis	40,247
Jeffersonville	2,763
Jasper	212
Kendallville	2,051
Knox	587
Kokomo	2,859
Lafayette	9,735
Lagrange	1,032
Laporte	1,997
Lebanon	3,076
Liberty	670
Ligonier	1,399
Lima, Ohio	671
Logansport	3,416
Louisville, Ky.	2,530
Madison	3,049
Mansfield, Ohio	2,206
Marion	1,838
Martinsville	1,396
Medaryville	369
Michigan City	1,909
Monticello	1,056
Monroeville	244
Mount Vernon	886
Muncie	2,062
Nappanee	1,103
New Albany	3,753
New Castle	1,732
New Paris	30
Newport	823
North Manchester	1,419
North Vernon	1,234
Oakland City	795
Osgood	845
Paoli	1,079
Peru	2,512
Petersburg	596
Pierceton	461
Plainfield	1,097
Plymouth	1,071
Porter	731
Portland	2,034
Poseyville	722

Station.	*Bbls.*
Princeton	1,091
Remington	787
Rensselaer	918
Richmond	5,163
Roachdale	280
Rochester	1,543
Rockport	943
Rockville	1,991
Rushville	1,032
Salem	1,077
Scottsburg	981
Seymour	1,442
Shelbyville	2,821
South Bend	8,003
Spencer	787
St. Joe	632
Sullivan	1,634
Tell City	846
Terre Haute	11,371
Tipton	1,195
Toledo, Ohio	2,290
Topeka	240
Union City	2,593
Valparaiso	2,063
Veedersburg	1,486
Vevay	187
Vincennes	6,367
Wabash	2,336
Walkerton	1,219
Warsaw	1,608
Washington	2,705
Westfield	1,545
Whiting	5,009
Winamac	1,221
Williamsport	6
Total	302,122

TABLE SHOWING NUMBER OF BARRELS OF MINERS' OIL INSPECTED FOR THE YEAR 1901.

Where Inspected.	*Bbls.*
Evansville	214
Indianapolis	40
Terre Haute	1,350
Vincennes	160
Total	1,764

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources

TWENTY-SEVENTH ANNUAL REPORT.

W. S. BLATCHLEY,

STATE GEOLOGIST.

1902

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.
1903.

State of Indiana, Department of Geology and Natural Resources.

INDIANAPOLIS, IND., February 23, 1903.

HON. W. T. DURBIN, *Governor of Indiana:*

Dear Sir—I have the honor to transmit herewith the manuscript of the Twenty-seventh Annual Report of the Department of Geology and Natural Resources, the same being for the calendar year 1902.

Respectfully submitted,

W. S. BLATCHLEY,
State Geologist.

ASSISTANTS.

George H. Ashley, Charleston, S. C.	Field Assistant.
James A. Price, Fort Wayne	Field Assistant.
L. E. Daniels, Laporte	Clerk and Field Assistant.
J. C. Leach, Kokomo	State Supervisor of Natural Gas.
B. A. Kinney, Marion	Assistant State Supervisor of Natural Gas.
W. C. Zaring, Indianapolis	State Supervisor of Oil Inspection.
James Epperson, Linton	State Mine Inspector.
Charles Long, Coal Bluff	Assistant State Mine Inspector.
Andrew Dodds, Oakland City	Assistant State Mine Inspector.
Isadore Kessler, Indianapolis	Stenographer.

TABLE OF CONTENTS.

INTRODUCTORY.

The present report is the twenty-seventh in serial order issued by the Department of Geology and Natural Resources of the State of Indiana, and the eighth issued under the auspices of the present director of the department.

The first paper of the present volume, entitled "Gold and Diamonds in Indiana," has been prepared with a view to bring before the public in an official manner what is known regarding the presence of these two valuable mineral products in the State. While both undoubtedly occur, the paper shows that they are not native, but are of glacial origin, i. e., were brought in with the sand, clays, gravel, boulders and other drift material from some point in British America. The gold is widely disseminated throughout the drift-covered area of the northern two-thirds of the State, but occurs in commercial quantity only in Brown, Johnson, Morgan and one or two other counties near the southern edge of the glacial boundary. Here the gravel deposits, forming the base of the lowlands along the streams, in places yield 25 to 40 cents of gold per cubic yard. Under improved methods of hydraulic mining, these gravel deposits would, in places, perhaps well repay the working. The present water supply is, however, too limited to carry on the work for more than three months in the year. A permanent supply of water can, however, be obtained within a distance of 20 miles. In some of the western states water is piped a much greater distance for working placer deposits less productive of gold.

As to the diamonds, a few small ones have been found by the natives of the same counties while panning gold, but their discovery is only of scientific interest, as they are far distant from their original home. It is only by chance, at long intervals, that one is happened upon, and a search for one would be like seeking the proverbial "needle in the haystack."

Dr. George H. Ashley, the former efficient chief assistant of the writer, spent the last year of his work on the survey in an investigation of the "Lower Carboniferous Area of Southern Indiana." He was directed to pay especial attention to the outcrops and deposits of the noted "Indiana Oölitic Limestone" in those counties south of the area covered by the paper of Messrs. Hopkins and Siebenthal on this valuable building stone, published in the report of this department for 1896. Dr. Ashley, assisted by Mr. E. M. Kindle, made a careful survey of Washington, Harrison, Crawford and parts of Orange and Floyd counties, and the paper, accompanied by two large maps and numerous illustrations, forms the second part of the present volume.

It has been the custom of the present director to publish from time to time, in the reports of the department, papers on the natural history of the State. These have been prepared by specialists, with the view of furnishing the teachers and pupils of the public schools of the State authoritative sources of information regarding the more important animals and plants which surround them. Papers on the fishes, batrachians and reptiles, butterflies, birds, shells, dragonflies and flowering plants have been heretofore published. Following this custom, a paper entitled "The Orthoptera of Indiana" has been prepared for the present volume. The order Orthoptera includes the insects commonly known as grasshoppers or locusts, katydids, crickets, cockroaches, etc., all of which are injurious to the farmer or the housewife. The present paper will, it is hoped, enable the student to readily determine any species of this group of insects which he may find in the State, and thus lead to a more detailed study of its habits and life history.

A paper giving the statistics of the petroleum industry in Indiana for the year 1902 is followed by the annual reports of the State Natural Gas Supervisor, the State Mine Inspector, and the State Supervision of Oil Inspection, in the order mentioned. The Legislature of 1901 removed the State Supervisor of Oil Inspection from the jurisdiction of the Department of Geology, and the included report of Mr. Zaring is the last report of the State Supervisor of Oil Inspection which will appear in the volumes issued by this department.

In the report of this department for 1899 was published an extensive paper on "The Mollusca of Indiana," by Prof. R. E. Call. Careful collecting by Mr. L. E. Daniels in different parts of the State during the past two years has brought to light nearly 100 species of mollusks not mentioned by Call. These are described, and, in part, figured in the final paper of the present volume. By combining this paper with that of Call's, above mentioned, the student of Indiana shells will have as nearly a complete descriptive list of the State's mollusca as it is possible to make.

GOLD AND DIAMONDS IN INDIANA.

By W. S. Blatchley.

For a half century or longer it has been known that free gold in the form of minute grains and flakes occurs in a number of Indiana counties. Within the past few years this gold has been the subject of numerous articles in the newspapers, and public curiosity and attention have, therefore, been drawn to it. Many letters and inquiries relative to it have been received at the office of the State Geologist, and a large number of persons have called there to secure information regarding the distribution and quantity of gold in the State.

Moreover, the natives of Brown and Morgan counties have, while washing gold, happened upon a half dozen or more small diamonds, most of which have been found in the past five years. The finding of these has given additional interest to the question, and has led me to prepare the present paper, giving in detail what is known concerning the occurrence and distribution of gold and diamonds in the State. In company with Mr. R. L. Royse, of Martinsville, who has given the subject more careful study than any other one man, a special trip was made in May, 1902, through those portions of Brown and Morgan counties where the most gold is thought to occur. A second trip was made to Morgan County in October of the same year. From the information gathered on these two trips, as well as from all available printed matter on the subject, the present paper has been prepared.

ORIGIN OF INDIANA GOLD.

All gold found in the State up to the present time is "free" or "placer" gold, the particles ranging in size from those too small to be seen with the naked eye up to nuggets whose value was five to six dollars. Occasionally, a piece of quartz or other igneous rock is found which contains particles of gold, but in each instance this quartz is a pebble or boulder of drift origin. In one or two places, horizontal strata of a conglomerate occur, which have been said to show gold upon assay. This gold, if present, has found its way into the conglomerate through interstices in the overlying strata, or was a component part of the sedimentary material which originally formed the conglomerate. The rocks underlying the surface of Indiana are all of them sedimentary limestones, shales or sandstones. No igneous dikes or vertical veins are known in the State, and no quartz, slate, schist, granite, gneiss, mica or other igneous rock with which native gold is found associated occurs except in the form of boulder or pebble of glacial origin. Gold has, up to the present, been found in about twenty counties of the State. In almost every instance these counties lie within or along the border of the drift-covered area. In one or two counties which lie in the driftless area, gold has been found in small quantity in regions covered by the alluvium or washings from the melting glaciers. There is little doubt but that gold occurs in greater or less quantity in the gravel or sand deposits of every county whose surface is wholly or partly covered with glacial debris. It is, however, only along or near the borders of the glaciated area that it has been found or is known to occur in sufficient quantity to pay for the labor of its separation from the sand, gravel, and other rocks and minerals with which it is found associated.

Taking into consideration its distribution, as above given, and also the fact that we have in Indiana no native beds of igneous rock which could give origin to the gold, there remains but one conclusion as to its source, namely: *It was brought in by one or more slow moving glaciers from some point far to the north or northeast and deposited by the melting of those glaciers on or near the places where it now lies.*

A number of these great glaciers or moving masses of ice invaded Indiana during the so-called "Glacial Period." They had their origin in British America, in and about the region now occupied by James and Hudson bays, and their movement and the work which they did has been made clear by the study of similar glaciers now existing in Greenland, Alaska and other countries. Before the first of these glaciers invaded our State, the surface of its northern two-thirds was very similar to that of the present southern unglaciated portion. The bed or sedimentary rocks, composed of limestones, sandstones and shales, now buried deep beneath hundreds of feet of clay, sand and gravel, then formed most of the surface. Decay and erosion were in action then as they are today. Sunshine and rain, wind and frost, trickling rills and strong streams, were ever at work, softening and sculpturing and wearing down the exposed rocks—forming clays and sand and gravel and bearing them away to lower levels. At the close of that period this area of surface rock resembled that of today in the driftless area of southern Indiana, being cut up by erosion into a complex network of valleys, ridges and isolated hills. Over these was a thin soil—formed from decaying rocks and vegetation—poorer, perhaps, than much of that which at present covers the surface of the driftless area, where the underlying limestones and shales have been the parent rock.

During this long period of erosion and decay, mild climatic conditions had prevailed. But a change in these conditions came gradually to pass. For some, as yet unknown, reason the mean annual temperature of the northern hemisphere became much lower. The climate of the regions to the east and south of Hudson Bay became similar to that of Greenland today, or even colder. The snow, ever falling, never melting, accumulated during hundreds of centuries in one vast field of enormous thickness. Near the bottom of this mass a plastic, porous sort of ice was gradually formed from the snow by the pressure from above. This ice mass or glacier took upon itself a slow, almost imperceptible motion to the south or southwestward. As it moved thus onward, great masses of partly decayed rock and clay from hillsides and jutting cliffs rolled down upon it and were carried on and on until, by the melting of their icy steed, they were dropped hundreds of miles from the parent ledge. Large, irregular masses of rock from the region in which the glacier was formed were either frozen into its nether portion or rolled along beneath it, and as the ice sheet moved they served as great stone drags, grinding down and smoothing off the hills and ridges and filling up the valleys, until the irregular, uneven surface of the old preglacial rocks was planed and polished. In many places these imprisoned rocks cut deep scratches or grooves—the so-called "glacial striae"—in the surface ledges over which they passed. These, to the geologist, are excellent guides to the direction in which the glacier moved.

From these striae, and from other evidence which it is difficult to otherwise explain, it is now believed that there were several distinct epochs in the glacial period. The great ice sheet which was first formed several times advanced and as often—by an increase in the temperature of the region which it entered—melted and receded; its retreat or recession being each time as gradual as its advance had been. Like a great army which has attempted the invasion of a country and has been compelled to withdraw, it would again assemble its forces and start in a slightly different direction. But perchance before it had reached the limit of its former invasion a force of circumstances would render a retreat necessary. Its advancing margin was not in a straight line, but in lobes, or long, gradual curves.

The first invasion of Indiana by one of these glacial lobes was from the elevated districts to the east and south of Hudson Bay. It, in time, covered a greater area of the State than any one of those which followed, and by it much of the gold and most of the diamonds of Brown, Morgan and other counties were brought where they now exist. When this glacier had assumed its maximum size, its southern or front edge extended across the northwestern corner of Pennsylvania and central Ohio to a point a little southeast of Cincinnati, where it crossed the Ohio River into Kentucky. Passing through Campbell, Kenton and Boone counties on a line nearly parallel with the Ohio River, and some five to eight miles south of that stream, it entered Dearborn County, Indiana, a little below Aurora, whence it passed in a southwesterly direction through Ohio and Switzerland counties and crossed into Trimble County, Kentucky. Here it turned more to the west, recrossed the Ohio into Clark County, and reached its southernmost point in this portion of the State near Charlestown. From here it bore to the north through Scott and eastern Jackson counties, and then followed approximately the line shown on the accompanying map until it entered Illinois. Since this first or oldest glacier covered most of the latter State, the name "Illinoian" has been given to the drift material which it brought down. The terms "older glacier" and "older drift" are sometimes also used when referring to it and its deposits. It is probable that the margin of this first ice sheet occupied only a portion of the glacial boundary, as shown in Indiana, at any one time.

Mr. B. F. Taylor has given the following graphic account of this first ice sheet at the time of its greatest advance into the region now comprising Indiana.

"When the glacier covered most of Indiana and crossed the Ohio River into Kentucky, the ice was at least 500 or 600 feet deep over the present site of Terre Haute and nearly as deep over that of Indianapolis, and it thickened gradually northward. If an observer could have stood on one of the hills in Brown County at that time, he would have seen to the east of him the great wall of the ice front extending south toward Kentucky, while toward the west it would have been seen in the distance stretching away toward the southwest. For hundreds of miles to the east and west, and for 2,000 miles or more to the north, the glaring, white desert of snow-covered ice, like that seen in the interior of Greenland by Nansen and Peary, would have appeared, stretching away out of sight, with not a thing under the sun to relieve its cold monotony. It is hard to think of Indiana and her neighboring sister states as being clothed in such a shroud-like mantle as this. But it was in large part this same ice sheet, coming perhaps four or five times in succession, that covered the State with the inexhaustible soil of the drift, and made Indiana the fertile agricultural State that she is today."*

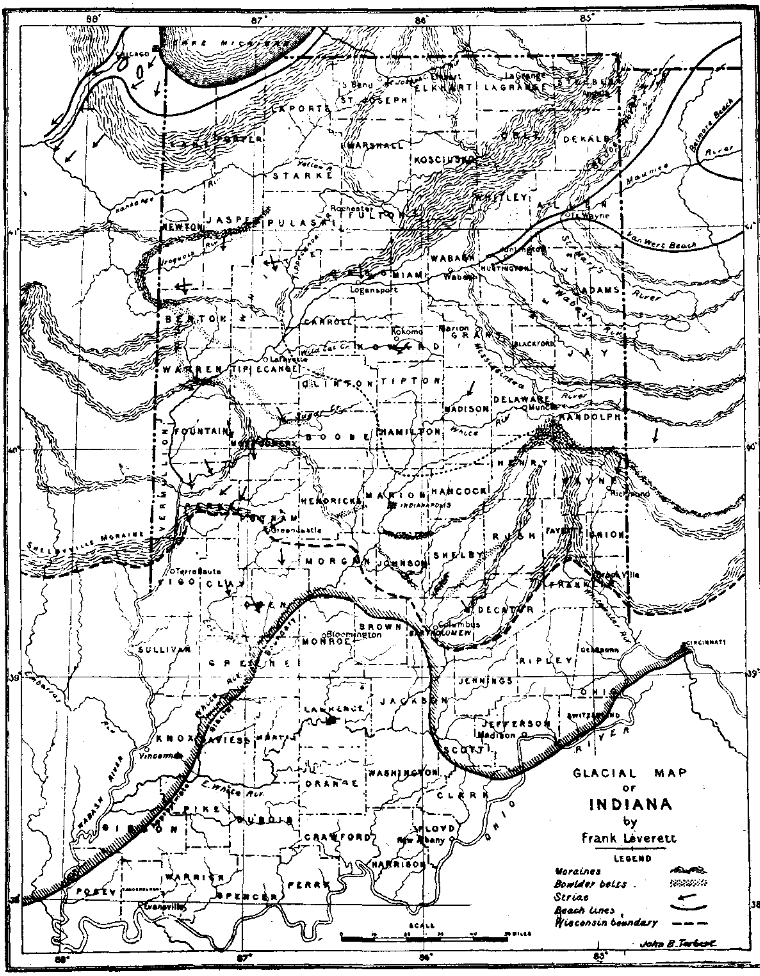


Fig. 1. Map showing the Approximate Glacial Boundaries in Indiana. (From "Studies in Indiana Geography," p. 28.)

After reaching the line marked on the map as the "Approximate Glacial Boundary," the ice of this first glacial invasion melted away and left its drift, composed of a motley mass of materials, exposed

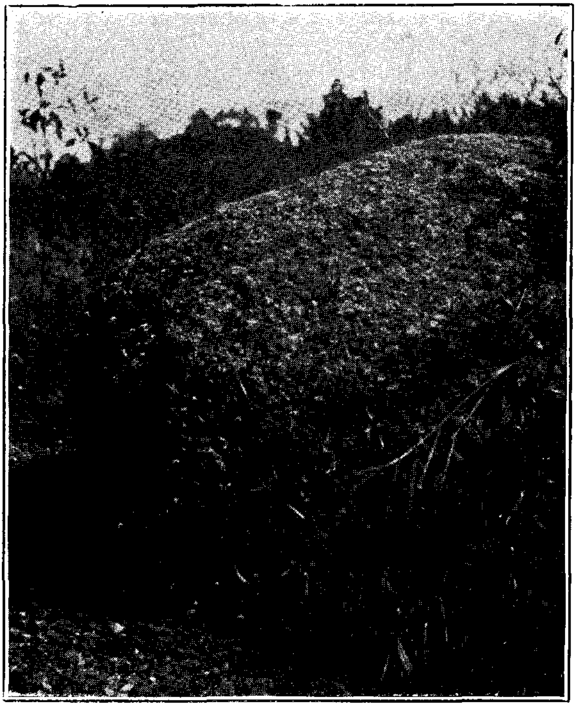
*Studies in Indiana Geography, 1897, p. 102.

to the agencies of water, wind and frost. What is known as the "*First Interglacial Interval*" then ensued, during which a vegetation arose on the surface of the Illinoian drift and for a long period flourished and decayed, in the manner as does the vegetation of our present surface. As a result a black mold or soil was gradually formed, which is now concealed beneath deposits of silt called "loess" in southwestern Indiana, and beneath the drift of later glacial invasions in the northern part of the State. How long this "interval" lasted no one knows, but evidently hundreds of years, as shown by the thickness of the soil mentioned and by other evidence which the geologist can take into account.

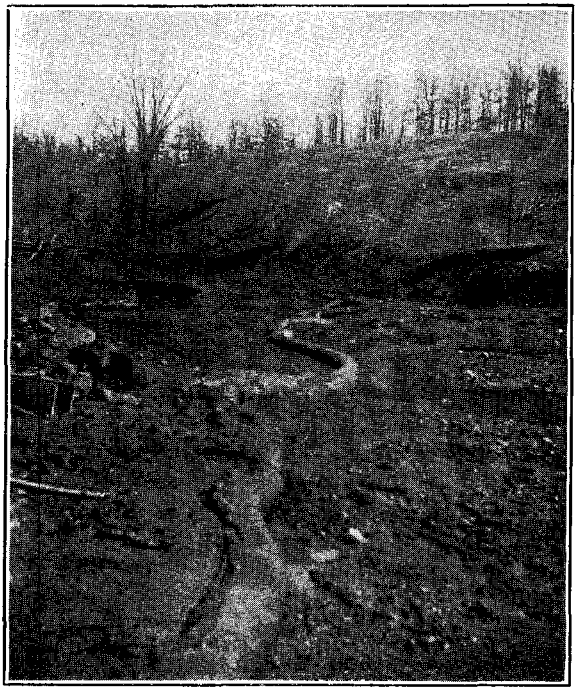
A "Second Glacial Epoch" or invasion then occurred, during which the ice brought down much thicker deposits of drift than in the first. At many points east of Indiana this second glacier extended much farther south than the first, but in this State its southern border only reached the dotted line shown on the map and named by Professor Chamberlain, the "Wisconsin Boundary," because this glacier invaded the driftless area of that State farther than any other. Of the drift in Indiana brought down by this second glacial invasion, Professor Chamberlain has written in part as follows: "The border of the 'newer drift,' slightly ridged, may be traced diagonally across the northeastern part of Montgomery County, the center of Hendricks, the northeast corner of Morgan, the southwest portion of Johnson, striking the basin of the East White River near Edinburg. It here closely approaches the border of the unglaciated area of south-central Indiana; but, if my discriminations are correct, it does not come in contact with it. There are heavy accumulations of drift near the northern border of Brown County, and along the eastern border of Morgan County, which take the form of morainic hills, especially in the latter region; but these, I think, belong to the 'older drift,' since they have suffered much erosion, resulting in complete drainage, deep oxidation, and seeming ferrugination of the subsoil. The newer drift is composed of fresher clays, less deeply oxidized, and but feebly modified superficially by drainage erosion. The aspects of the older and newer drifts are here, as elsewhere, quite clearly differentiated, though the border limit is not always clear and conspicuous. On encountering the basin of East White River, the newer drift border comes in association with the remarkable fluvial phenomena of 'Collett's Glacial River.' This was one of the great avenues of discharge from the ice border, and has left its record in broad belts of gravel gathering into a great trunk stream. The edge of the newer drift sheet is interrupted and ob-

PLATE I.

a



b



(a) Large Gneissoid boulder in the valley of Gold Creek, Morgan County.

(b) Iron pipes and hose used in sluice-box operations on scured by these fluvial deposits, but it seems to have formed a lobe, reaching down the basin into Jennings County, the glacial river lying on its western border. The eastern edge of the loop runs north diagonally across Decatur County, the southeastern portion of Rush, the northwestern part of Fayette and of Wayne, in the northern portion of which, and the southern part of Randolph, it recurves to the southeast to form the Great Miami loop in Ohio."*.

Between the time when the ice sheet of this second glacier melted and retreated from Indiana, and the final disappearance of ice from the State, several other glaciers invaded the territory now included within her borders. The boundary or terminal moraines of these, as far as determined, are shown on the map. Whenever a glacier has reached the limit of its advance and there halted a sufficient length of time to deposit a large amount of debris, such an accumulation is called a "terminal moraine." This moraine does not consist, as is often supposed, of numerous large boulders, which have been dropped on the surface in more or less regular concentric lines. Such boulders are only an accompaniment and constitute but a very small fraction of the moraine proper. The main portion usually consists of a thick bed of compacted tough clay in which are many pebbles and boulders of small size, and often pockets of gravel and sand. Such a moraine may be a number of miles in width and consist of many small parallel ridges, or it may have a number of subordinate ridges branching off in every direction from the main one. These unite, interlock, separate, appear and disappear in an intricate and eccentric manner. Several of these subordinate ridges are often plainly discernible. The component ridges are themselves exceedingly irregular in height and breadth, being often much broken and interrupted. When very complex, the term "morainic system" is often given to a terminal moraine.

I have been thus explicit regarding the two principal glacial invasions of Indiana, because it is along their terminal moraines or boundaries, and in the narrow strip of territory separating these moraines, that most of the gold and all of the diamonds of the State have been found. This gold and these diamonds were skimmed or swept up by the advancing glaciers from their original home somewhere in the Hudson Bay region, and were brought down by these glaciers and deposited in their terminal moraines. Gold is liable to be found in the glacial gravel deposits of any portion of the State and especially in those which lie directly on the bed rock. It is,

*"The Terminal Moraine of the Second Glacial Epoch," in Third Annual Report U. S. Geological Survey, 1883, p. 333.

however, only at the edges of these main terminal moraines, where the material composing the drift has been most weathered and washed, and where streams flowing from the moraines have deposited beds of gravel over the bed rock in their valleys, that the gold has been accumulated in greatest quantity.

MINERALS ASSOCIATED WITH THE GOLD.

The particles of gold are always found associated with a fine, black magnetic iron sand. Along the border of the moraines mentioned this sand can be seen in gullies along the roadsides and on bare places on the hills. Every heavy rain washes it out of the clay and other loose material and carries it, with the associated gravel, pebbles, gold particles and other minerals down into the lower levels. This sand is composed of fine particles of magnetite, a very rich ore of iron, whose composition is oxygen 27.6 per cent., iron, 72.4 per cent. The ore in its native home occurs in extensive beds and also in crystals or particles, widely scattered in granite, gneiss, mica schist, and clay slate ledges. It is in such rocks that gold is found native, and it is very probable that the gold and iron sand now found intimately associated in Indiana were at one time constituents of the same ledges in the wilds of the country now known as British America.

Besides the black sand, one of the most common minerals found in the residue of the gold seeker's pan is *"menaccanite."* This is an ore of iron and titanium, iron-black in color, and resembling hematite in general appearance. The pieces found mingled with the black sand and gold vary much in size, sometimes weighing several ounces, but usually less than that of a navy bean in bulk. It is an axiom among the gold seekers that the larger the pieces of this mineral found in the pan, the richer the yield of gold. Menaccanite occurs usually in thin plates or seams in quartz and doubtless had its origin in the same locality as the gold.

In the residue of every pan, in company with the black sand and gold, are also numerous minute "garnets" of various shades of red, ruby red, purple, greenish and black. There are none of them transparent enough to be termed precious garnets. Their original location was in the mica and horneblende schists, gneissoids and other igneous rocks of the far north.

The above mentioned minerals are the common ones which are always found associated with the gold. Those of less common, or even rare occurrence, are pieces of native copper, pebbles or rounded pieces of sphalerite or zinc blende, pyrites, marcasite, hematite, limonite, corundum, quartz of many varieties, red jasper, amphibole, zircon and cyanite. None of these, unless it be the pyrites and limonite, are native of Indiana. All others were brought in from far northern regions, thus furnishing additional evidence as to the original home of the gold which they accompany.

THE DISTRIBUTION OF GOLD IN INDIANA.

Under this heading will be given in detail such facts as are known concerning the presence of gold in those counties of Indiana where it has been noted.

The earliest printed record of the finding of gold in Indiana which has come to my notice is in the Journal of the Franklin Institute for June, 1850, as follows: "Professor Frazer read to the meeting (of the Franklin Institute, May 17, 1850) a letter from Prof. T. A. Wylie, of the University of Indiana, announcing the discovery of gold in the vicinity of that place, and exhibited specimens of the gold, and of the black sand in which it is found. 'The gold has been found in the beds of the rivulets in Morgan County, about twenty miles northeast; in Jackson County, about twenty miles southeast; in Brown County, about twenty miles east, and in Greene County, about fourteen miles west of Bloomington, as well as at certain intermediate points, but not in the immediate vicinity. Where it has been found it is always in connection with a black sand which the *washers* call "emery." This sand is found at the bottom of the streams, usually at the upper end of the sandbars, or on the margins of the streams where there is a sudden turn, and in such places as it would be naturally deposited on account of its density. The coarse gravel is sifted and washed in the usual way until nothing remains but the dense black sand. On examining closely with the microscope, there are to be perceived interspersed through it red particles of different shades, and some few yellow and green particles; of the red particles some appear to be merely colored quartz, while others are plainly distinguished by their crystalline form as garnets, and some of the darkest probably pyrope. The black particles are readily separated into two sorts by the magnet. Those attracted by the magnet, which amount in some specimens to 5 per cent. of the whole, are evidently *magnetic oxide of iron*. The remaining black grains agree precisely with Dr. Thompson's description of *titanate of iron* or menaccanite.' The gold is in flat scales, a good deal resembling in its appearance that from California."

"Professor Frazer remarked that from the account of Professor Wylie, it did not appear that this new gold field was likely to prove profitable in the working, but that it was of great interest, both in a geological and mineralogical point of view, and gave rise to an interesting inquiry as to the original locality of the minerals associated with the gold, since they are of a nature inconsistent with the rock formations of that portion of the United States."

Brown County.

The northern boundary of this county is about 30 miles nearly due south of Indianapolis. The county is bounded east by Bartholomew, south by Jackson and Monroe, west by Monroe and north by Morgan and Johnson counties. It contains an area of 320 square miles, the surface of which is very broken, except in the southeastern corner, where there is a large area of level table land. The "Knobs" of southern Indiana, stretching northward from Floyd County, attain in "Weed Patch Hill," south of Nashville, the county seat, their highest elevation—1,147 feet above sea level.*

Salt Creek, the principal stream of Brown County, is composed of three main branches, the "North," the "Middle," and the "South" forks, which unite near the southwest corner of the county, and flow thence through Monroe and Lawrence into East White River. Thus almost the whole watershed of the county, together with a considerable portion of Jackson on the south, is drained by this stream. Bean Blossom Creek has its source in the northeastern part, its principal tributaries in northwestern Brown being Bear and Lick creeks, both flowing nearly south. Just across the northern boundary in Morgan County, and in a valley nearly parallel with the county line, is Indian Creek, flowing in a general western direction. High ridges surround Brown County on all sides, while from east to west and southwest three similar ridges traverse the county, all connecting on the divide near Trafalgar, in Johnson County. The first and most northern constitutes the southern bluff of Indian Creek, and is called "Indian Creek Ridge;" the second, south of Bean Blossom is known as "Bean Blossom Ridge," and the third, passing nearly through the middle of the county, is named "Central Ridge." All

*Weed Patch Hill is thought by many persons to be the highest point in Indiana, but it is exceeded by a number in Randolph County—the actual height of the most elevated one measured being 1,234.4 feet above tide. This is what is known as the "Summit" on the Peoria Division of the Big Four railway, between Green's Fork and Martindale Creek. Several hills south of the "Summit" are thought to be 50 feet higher, so that the highest point in the State is about 1,285 feet above tide, or 138 feet higher than Weed Patch Hill.

these ridges slope gently to the south and west but present steep faces to the north and east.

The bed rock composing the body of most of the ridges and hills of Brown County is a soft, bluish knobstone shale, which weathers readily into a plastic clay. In places beds of sandstone occur; while the crests of the hills are capped with a chert-like bed of Keokuk limestone with its characteristic accompaniment of "geodes." This limestone forms the surface rock in the eastern part of Monroe County, and its presence on the tops of the hills of Brown shows that this county was once covered by a level surface of limestone continuous with that of Monroe to the westward. The valleys of the county, now containing its richest soil, have been eroded by flowing streams, leaving the strata of the hills as they were originally deposited by sedimentation in an ocean which covered this region ages before the dawn of the "Glacial Period."

Only the northern third of Brown County is within the glaciated or drift area. The northwestern part of Hamblin Township and the greater portion of Jackson Township are covered with drift accumulations as far south as Bean Blossom Ridge, the drift being found on the slope of this ridge nearly 200 feet above the water in the stream. Boulders of granite, gneiss and jasper, three to five feet in diameter, occur frequently in this region. In the Salt Creek valley, northeast of Nashville, but little drift was seen. Bean Blossom Ridge, then, marks the southern limit of the first and only glacial invasion of Brown County, and it is only north of this ridge that gold in anything like paying quantities has ever been found in the county. Collett, in his "Report on Brown County,"* calls attention to this fact, and says: "Against and upon this *wall-like* ridge the stranded ice seems to have been continually massed; and, melted by each recurring summer's sun, it sent torrents of water south across the county, wearing slight depressions in the ridges, as at Low Gap and the source of Greasy Creek, bearing fine sediment, some gold dust and black sand, and but few or no pebbles or boulders. This flood was long continued—first flowing clear across the county, at a high level, and even across parts of Jackson—next following the synclinal axes of the underlying rocks, it excavated South and Middle Forks of Salt Creek, and finally following another synclinal, adopted the direct line of dip by the North Fork.

"During this time the underflow from the glacier was also working a channel in the disintegrating shale along the east side of the county, by Bean Blossom, and finally left the interior basin of the

* Geological Survey of Indiana, 1874, pp. 77-110.

county subject only to the action of its own water-shed. Down these side cuts to White River immense bodies of water, bearing some ice with boulders and gravel, have flowed. The long continued melting of ice loaded with the most enduring debris of the Laurentian rocks, as greenstone, quartzite, quartz, gold and magnetite, deposited large quantities of these imported materials in Bean Blossom Valley. The rapid current of the ice water would naturally carry down stream the lighter sand and gravel, and sort out and leave behind the heavier rocks, gold and magnetite in considerable quantities. Afterwards as *the ice foot withdrew toward the north, this melting, sorting,* sifting process was carried on north of Indian Creek Ridge, for a *longer time,* as is indicated by the greater width and depth of that creek valley, where gold and the heavier minerals will only be found beneath the present surface, which is largely built up above the bed rock."

The earliest mention of gold in Brown County which I can find in print, other than that of Professor Wiley above quoted, is that of Richard Owen in 1862,* which is, in part, as follows:

"The chief interest of Brown County attaches to its gold region, which we were enabled to examine advantageously. Although some prospecting has been done on 'Bear Wallow Hill,' on head waters communicating through Lick Creek to Salt Creek, as also in what they term the gravel of Greasy Creek (a deposit of disintegrated shales), the main localities in which success has attended the gold washings in this county are on Hamblin's fork of Salt Creek, three-quarters of a mile in a direct line from the west limit of Bartholomew near Mt. Moriah postoffice. Here we found extensive preparations in the way of sluices and hose, rockers and 'long toms,' picks and shovels, etc. Notwithstanding the rain, we panned out enough *to convince ourselves that the black sand in many of the pockets* contains a considerable amount of gold particles.

Occasionally they pan out flat scales worth from a dollar to a dollar and a quarter. Judging from what I saw here and elsewhere in Indiana of the gold localities, I should venture the opinion that the gold is invariably associated with drifted quaternary materials, derived from a matrix, which finds its mountain home at least from 400 to 600 miles distant, and more probably double that distance, in a northerly direction."

Collett, in his "Report on Brown County," treats the subject more in detail. In part, he says: "Gold is found in the bed or on the bars

*Geological Reconnaisance of Indiana, p. 119.

of all the brooks that flow into Bean Blossom from Indian Creek Ridge, and on the streams which flow from the foot of the "drift backbone" in the northeast corner of the county, as South Bean Blossom, North Salt Creek, etc. Fine dust and minute scales may be found further within the county wherever black sand and small pebbles indicate former currents of ice water, even as far south as Elkinsville. Single individuals, at favorable points, by hard, patient labor, have been able to make from $1.00 to $1.50 per day. Companies and careless workers have not averaged more than 25 cents per day. During the excitement a few years since, several companies took leases, made sluiceways and prepared long toms and rockers. The returns were not satisfactory. It is probable that the best "pay dirt" lies at the deepest part of the rocky trough in which the creeks now have their course. By bores the line of greatest depth may be ascertained, and by shafting the richest dirt—possibly in paying quantities—may be brought to the surface. Reasoning from the facts observed, this would be true of Bean Blossom, and especially, from its greater width and probable great depth, also of Indian Creek Valley. This is mentioned as a reasonable deduction, warranted by the facts and not for the purpose of exciting a mining fever. It is estimated that the amount of gold found in the county to date (1874) will equal $10,000 in value, and the best nugget weighed at one dollar and ten cents."*

During our trip in May, 1902, Mr. Royse and myself drove over the greater portion of Jackson and Hamblin townships, which form the northern third of Brown County. We conversed with a number of men who do little else than pan gold along the streams, and incidentally "panned" in a number of places ourselves. In the gutters along the roadsides, especially those on the ridges below the top level of the drift, the black magnetic sand could be seen in quantity. Our first panning was done one-half mile west of Georgetown, the material being taken 15 feet above the level of a fork of Bean Blossom Creek. The residue showed a quantity of black sand and four "colors" of gold. Another pan taken from the creek bed showed 11 colors. Mr. Royse has had assayed a conglomerate found in the hillsides and bluffs along this and neighboring streams, with a result of $1.40 per ton, flour gold. This conglomerate is formed of iron oxide, pebbles, geodes and pieces of shale cemented together with carbonate of lime, and lies just above the shale composing the hills.

The valleys of the streams in Brown County are, as a rule, much narrower than in Morgan County. Along each side of the stream is

* Loc. cit., p. 107.

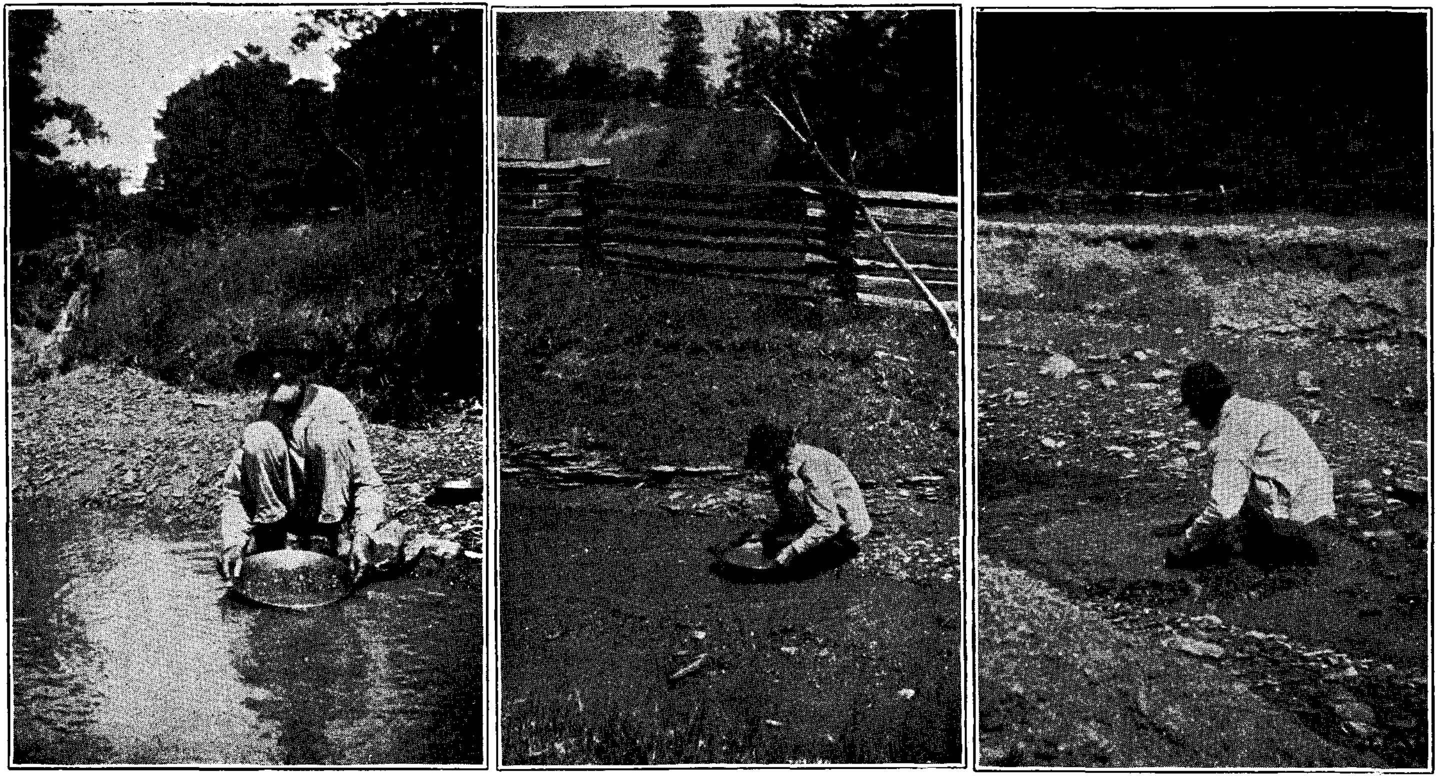
a strip of bottom land of varying width, composed of gravel, clay and soil, the gravel resting upon the bed rock or blue shale. It is this gravel, next to the bed rock, that is richest in gold. Most of the surface of these strips is cultivated, and the owners will not allow the "gold hunters" to pan except in the beds of the streams. These beds have most of them been washed many times in succession, a new supply of gold being eroded during each freshet from the gravel beds along the banks. These beds, which form the base of the lowlands or cultivated bottom lands of the valleys, were formed during the melting of the glacier, when the streams flowing through the valleys were much wider and stronger than now. The gravel and sand composing them was then deposited, and the soil, for the most part has been formed since then by decaying vegetation and annual overflow.

After every freshet the children seek gold along the rocky bottom of each rill and stream and often find pieces worth 25 to 40 cents. Much of this is found lodged in minute crevices at the bottoms of small waterfalls. I was told that two boys, just east of Spearsville, had sold $42 worth in a single season, which they had thus gathered along the smaller tributaries of the north Branch of Salt Creek.

One of the best known and most reliable gold hunters in Brown County is W. J. Merriman, better known as "Uncle John" Merriman. He is 69 years of age, has panned gold more or less each year for 49 years, and has done little else for the past 20 years. He resides near a branch of Lick Creek, about six miles northwest of Georgetown, and has washed gold along every stream in northern Brown and part of Morgan counties. The largest "nugget" he ever found was taken on Bear Creek and weighed 132 grains, valued at $5.50. He has found a number of pieces which ran as high as $1.00 to $1.25 in value; but most of what he secures is in the form of "colors" or minute flattish particles. He states that the coarsest gold in Brown County is found in what is known as "Gosport Hollow," a tributary of Bear Creek. He also estimates that the gravel beneath the soil of the lowlands will average 25 cents per cubic yard in gold.

On two different occasions Mr. Merriman has kept a careful account of the results of a month's work—Sundays excluded. One month yielded him $34; the other, $40. He claims that he can average $1.25 a day during the panning season, which runs from March to November, except in times of summer drought. During his panning he has found several diamonds, which will be mentioned on another page.

PLATE II. a b c



(a) Uncle John Merriman, the veteran Brown County gold hunter, at his favorite work.
(In b and c are seen the typical lowland deposits of gravel resting on the bed rock—here the Knobstone shale.)

We took dinner with Mr. Merriman and then accompanied him along the creek below his home. Armed with a trowel, gold pan and small basin, his only working outfit, he began operations by scooping up with his trowel a pan full of sand and gravel. After thoroughly mixing it with water by stirring it for a minute or two, he began the process of "panning," or washing. In fifteen minutes he had reduced it to a tablespoonful of black sand in which were 14 colors, or fine particles of gold. The next pan yielded 24 colors, and the third one 16, one of which was large enough to make a noise when it fell against the bottom of the pan. The residue of black sand and gold in each pan was dumped into the small basin, to await a complete separation at some future time. The thought came to me while watching "Uncle John" at his pan, as it has many times since, "If a man, by working thus, ten hours a day, can secure $1.25 from gravel picked up in the bed of a stream, what could be done with advanced machinery working on the richer virgin beds of gravel which underlie the lowlands of all the valleys hereabouts?"

Leaving "Uncle John" at his favorite labor, we drove across to Spearsville, in the northwestern corner of Hamblin Township, noting on the way the black sand in many places in the roadside gullies. From Spearsville we went three miles in a southeasterly direction along one of the tributaries or sources of Salt Creek. Here we found at work another gold hunter, W. W. Young, who has spent many years in the mining regions of the west, but for the past five years has been washing gold in Brown and Morgan counties. On the day we met him, he had dug to the shale or bed rock a trench 24 feet long, two and a half feet wide and six inches deep, along a bar at one side of the bed of the stream. From this he had taken almost $2.00 worth of gold. Another man who had worked alongside of him, but who was inexperienced, had secured but 40 cents worth. Young, as well as most other gold seekers of Brown and Morgan counties, scouts at the theory of the gold being brought in by glaciers. He declared that "it was born and raised right there,"—in other words that it was native to the rocks, but he has never been able to find a vein of it to prove his assertion.

Mr. Young showed me a report from the United States Mint at Philadelphia, dated July 12, 1901, showing that the mint had received from him 14.05 ounces of gold, the fineness of which was 909½. For this he received $250.07, aside from the charges of $1.56 for melting and refining. Silver to the amount of 61 cents was found as a natural alloy of the gold, by the mint authorities. He stated that he had panned this gold in nine months' time, working probably three-fourths of the period.

The quality of the drift gold found in Indiana is of the best, as it will average 22 or more carats, as against 16 to 18 for California gold, and 14 to 16 for Klondike gold. The largest piece found at any time by Mr. Young, weighed sufficient to bring $2.00.

At least 70 square miles of northern Brown County lies within the drift-covered gold-bearing region of the "First Glacial Invasion." The gold occurs in the clay, gravel and sand beneath the soil on the hills, and more abundantly in the gravel deposits which underlie the lowlands in the valleys. The latter will probably not aggregate more than three or four square miles of this area, for the streams are small and the valleys narrow. It is in this gravel of the lowlands, if anywhere in the county, that advanced processes of placer mining could be made profitable. The question of a permanent water supply would be a serious one, as most of the streams are dry several months in summer. By constructing permanent dams in several of the valleys enough water could probably be conserved to tide over the dry season. There is no doubt but that large quantities of gold exist in the county. Only a person experienced in hydraulic and placer mining, who is conversant with the latest improved machinery for that purpose, will be able to state whether the process of its separation can be made a profitable one.

Cass County.

This county lies about 85 miles a little west of north of Indianapolis. It contains 420 square miles, and is wholly within the drift-covered area, but the Devonian and Niagara limestones outcrop in a number of places along the Wabash and its large tributary, Eel River, which joins it at Logansport, the county seat. In the vicinity of Logansport, numerous beds of gravel ranging in thickness from one to 32 feet, lie immediately above this bed rock. From one of these beds, near the northern part of the city, Dr. Robert Hessler has secured a number of small flakes of gold. These were picked up, incidentally, without panning, and go to prove that gold is widely distributed in the drift gravel deposits of the State. Most of these deposits are, however, so deeply buried beneath clay, sand, soil and other material that there is no way of determining the presence of gold and no way of securing it were it present in large quantity. It is only along the edges of the moraines or in places where the gravel deposits rest on outcrops of bed rock, that the gold-bearing gravel is accessible.

Clark County.

This county lies in the southern part of the State, opposite Louisville, Kentucky. The first glacial invasion covered its northeastern third as far south as Charlestown. From near Fourteen Mile Creek, three and a half miles northeast of this place, Rudolph Bastian has recently sent me a quantity of black magnetic sand containing large numbers of small garnets and a few grains of free gold. He states that he has opened up a shaft 15 feet in depth in a hill composed of soil, sand, clay and gravel, a section of the shaft being as follows:

	Feet.
Soil, yellow	2
Sand, black magnetic	4
Clay, blue	6
Sand, white	2
Clay, blackish	1

In the black sand of the stratum, he states that he can find numerous particles of gold in every panful which he washes. The black sand and garnets are finer than those found farther north, and it may be that the deposit is but the diluvium or wash from the streams which flowed from the melting glacier of the Brown County region.

Dearborn and Ohio Counties.

These counties lie along the Ohio River in the southeastern corner of the State. The edge of the Great Illinoian, or first glacier which invaded Indiana, passed through Ohio County. Dearborn County is, therefore, wholly covered by the drift of that glacier, and lies within the interval separating its border from that of the Wisconsin boundary. Boulders are common in each of the counties and a piece of native copper weighing 26 ounces was found near Tanner's Creek, Dearborn County, a number of years ago. Of the presence of drift and gold in the two counties Prof. E. T. Cox has written: "The most remarkable prolongation of glacial drift southward is seen in Dearborn and Ohio counties, Indiana, and Boone County, Kentucky. In the two first named counties the drift is found in greatest force along the hillsides bordering Laughery Creek, resting upon the bluish clay shale beds of the Hudson River group, and 150 feet above the bed of the stream. The entire drift deposit is fully 50 feet thick, and is made up of the usual material, stratified clays, sand and gravel, above which there are numbers of massive granitoid boulders. One of these boulders I estimated to contain over 100 cubic feet.

"The lower bed of sand and gravel, which rests upon the Silurian bluish clay shale, contains a portion of gold dust, and gold washing has been carried on here in a small way for some years. When I visited this locality, about one mile a little north of west from Hartford, Ohio County, there was to be seen the ruins of what had been extensive preparations for washing this gold sand in sluice-boxes, but the scheme had fallen through for want of funds and the confidence of those who had at best lent it but feeble financial support.

"Dr. George Sutton, accompanied me from Aurora, and we went to Mr. Miller's house, close by, and had him bring his spade and a tin pan, and try to wash out some gold in our presence. After scraping off a small portion of the surface, a spade full of gravel and sand was thrown into an old pan with coarse holes in the bottom and the fine material that would pass through the holes was sifted out into the washing pan. In a few moments Mr. Miller succeeded in separating some particles of gold mixed with a quantity of black, magnetic sand. There is no means of getting water to this place in sufficient quantity and at a reasonable cost, but if hydraulic washing could be resorted to it is possible that considerable gold might be washed out. It is not my object, however, in saying this much of the drift gold in the vicinity of Hartford, to incite capitalists to take hold of the property with a view of profitable mining, but to call attention to the fact that gold is found there, and as one of the evidences that the whole deposit has been brought from ancient rock beds that are not found in places south of the great lakes, and that it is veritable glacial drift. This is not the only spot where gold has been found on this creek. I am told that it has been washed out of the sands on the opposite side of Laughery Creek, in Dearborn County, on the farm of Preston Conway."*

In 1882, Dr. George Sutton, of Aurora, who had accompanied Professor Cox to the gold-bearing deposit described above, wrote of it as follows:

"Along the valley of Laughery Creek, a stream which enters the Ohio River a few miles below the mouth of the Miami, may be seen deposits of auriferous drift. They are not stratified like the terrace formations seen along our rivers, but lie in irregular accumulations along the valley. At the bottom of the small streams that have cut across this drift are seen deposits of black sand which principally consist of magnetic iron ore. It is in this sand that gold is found. Seven miles from the mouth of Laughery may be seen a deposit of this drift about a mile and a half in length, nearly half a mile in

* Geological Survey of Indiana, 1878, p. 106.

width, and about 100 feet in thickness. Some portions of this Laughery drift are so rich in gold that it is seen with the unaided eye, and almost pays a fair remuneration washing for it. My attention was directed a few weeks since, by the owner of the farm on which this drift is found, to a small excavation which had been made in washing for gold. It was by measurement six feet long, five feet broad and about two feet deep. He informed me that from this place $8.00 worth of gold had been obtained, and that a man had washed from the drift on his farm gold to the value of $16.50. The gold is found in the form of dust, flattened scales and small nuggets. Only that which could be seen with the unaided eye was saved."*

In a recent letter, Dr. J. B. Miller, of Laughery, Ohio County, one of the owners of the farm near Hartford on which the gold occurs, gives the following account of the attempts at washing the gold since the time of Dr. Sutton's visit: "In 1885 we leased the mine to a company, which prospected for about eight or ten days and took out $8.00 worth of gold, but they had not sufficient water, and could not raise enough money to put in pumping works and force the water to a reservoir on the top of the hill. The owners themselves afterwards worked the mine for three days and took out $6.00 worth of gold, but had not sufficient water to run it half the time. We used a sluice box, and if we had had water, we could have made $1.50 a day per man, just from surface mining. This gold is on three farms in Ohio County, and one in Dearborn County. The soil is black, sandy, and consists of freestone and boulders, no limestone, but much conglomerate, run together by action of heat. The limestone is all around it but none on the gold producing land; you can see gold on the large stones on a sunny day. We never tried to go to bed rock, but intend to sink a shaft this coming fall. The largest piece of gold which we found was the size of a grain of wheat. It is mostly in fine scales, but of a very fine quality."

Franklin County.

This county lies northeast of Dearborn County in the southeastern part of the State; and wholly within the bounds of the "First Glacial Invasion." Drift from the Wisconsin Glacier also covers the northwestern corner, and the northeastern third, as will be seen by the accompanying map. Of this drift and of the presence of gold in the county, Dr. Rufus Haymond has written: "The superficial material

*"The Gold-bearing Drift of Indiana," in Proceedings of the Association for the Advancement of Science, XXX, 1881, pp. 177-185.

resting upon the rocks consists mostly of yellow clay, mixed more or less with small pieces of broken limestone, gravel from primitive rocks, and, in a few localities, almost pure gravel is found, in others sand, and frequently sand and gravel mixed. In no instance upon the uplands or tops of the hills do the bed rocks penetrate through these materials, and we find them only where the drift has been worn away by the action of the streams. The drift varies from four or five feet to 40 or 50 in thickness upon the uplands. The slopes of the valleys and side hills seem to be covered with drift similar to that upon the high grounds, but not of equal thickness. Boulders of granite, hornblende, greenstone, syenite, gneiss and, in fact, of almost every species of metamorphic rock, are found all over the county, upon the highest as well as the lowest grounds. They are always found upon the surface and never beneath, except under slides or where gravel in the terraces has been washed over them. A single piece of native copper has been found in the county, weighing about six pounds. It was no doubt transported with the drift from Lake Superior, as it was rounded, and bore other evidences of attrition.

"In the northwest part of the county, in Laurel and Posey townships, upon Sein Creek and its branches, gold is generally disseminated in very small particles. A common panful of gravel and sand, when washed out, generally shows from two to three particles of gold in thin scales. None has ever been found larger than a grain of wheat. Though so generally disseminated, it is doubtful whether the quantity is sufficient to pay the expenses of washing it out. Gold has also been found upon Little Duck Creek, and here, as elsewhere, is found associated with black sand."*

Greene County.

This county lies west and south of the center of the State. The border of the first or Illinoian Glacier passed in a northeast-southwest direction through its eastern half. The only mention of gold within the county which I can find recorded, is that of Prof. T. A. Wylie in the Journal of the Franklin Institute where he mentions gold as occurring with black sand in Greene County.

* "The Geology of Franklin County," in Geological Survey of Indiana, 1869, pp. 185, 190.

Jackson County.

Lying below Brown County and south of the central portion of the State is Jackson, a county comprising 520 square miles. The border of the Illinoian glacier passed through its eastern half, and alluvium from that glacier covers much of the county. Gold has been found in a number of localities, chief among which is the bed of a stream on the farm of George A. Waggoner, near Freetown. Scales and particles to the value of about $5.00, which had been panned from the gravel and sandbars of this branch, were brought to my office by Mr. Waggoner in 1899. From his statement I should judge that the gold is not present in sufficient quantity in any part of Jackson County to pay for working, other than by panning by parties who have little else to do.

Jefferson County.

In this county, which lies in the southeastern part of the State, along the Ohio River and wholly within the boundary of the Illinoian drift, gold has been found, as far as known, only on a stream about six miles north of Madison, the county seat. From the gravel in this stream, Mr. Clement J. Raffanf, of China, sent me several small quartzite boulders which contained free gold. These boulders, he states, were found in small numbers in the gravel bars, and attracted his attention on account of the yellow particles in them. He has made no attempt to pan gold from the gravel of the stream.

Jennings County.

This county comprises 375 square miles of southeastern Indiana. It lies wholly in the interval separating the boundaries of the Illinoian and Wisconsin drift areas, that of the latter just touching its northwestern corner. The only record of gold within its bounds which has come to my notice is that made by W. W. Borden, who prepared a report on the geology of the county, and is as follows: "Some particles of gold have been panned from the bed of the south fork of the Muscatatuck. This gold was found in combination with the black sand washed down from the glacial drift of the uplands. The excitement occasioned by its discovery was very great at the time, and some useless labor was spent in sinking a shaft, as the drift and accompanying gold dust was foreign to the State."*

* Geological Survey of Indiana, 1875, p. 178.

Montgomery County.

This county lies in the western-central part of the State, about 45 miles northwest of Indianapolis. The main stream flowing through it is Sugar Creek, which enters south of the northeast corner and passes diagonally across the county in a general southwesterly direction. It has a number of tributaries which, with their branches, are fed by springs which flow out of the great masses of clay, gravel and other drift material which form a thick bed above the underlying sedimentary rock. This drift belongs mainly to the Wisconsin sheet, as the county lies wholly within the bounds of the second glacial invasion. Professor Collett, in his report on the geology of the county, has given an interesting account of the effects of this glacier upon the surface of the county, in which he says: "The boulder drift deeply covers the eastern, northern and northwestern parts of the county, bearing internal evidence of its origin, as polished, striated and rounded pebbles and rocks imported from the Laurentian beds north of Lake Superior. When long concentrated by currents of water some notable deposits of gold dust and magnetite occur, associated on account of their approximate specific gravity, on the bars and riffles of the water courses."*

Again he says that just above the Iron Bridge across Sugar Creek, about a mile west of Crawfordsville, is a great mass of boulders capped with lacustral silt. The violent washing process that sorted these huge boulders, ground and pulverized some of the crystalline rocks, and considerable quantities, more than fifty dollars worth of gold dust and magnetite have been "panned" out by amateur collectors, on the ford bar.

Near the junction of Lye and Sugar creeks in the northeastern part of the county, he states that "on the land of Mrs. J. Naylor, Section 6 (T. 19 N., R. 3 W.), Mr. Edwin Cadwallader has collected several dollars worth of gold in flat scales, each pan showing 'color.' "*

Morgan County.

Morgan County lies just southwest of Marion County, near the center of the State, and comprises 409 square miles. It is bounded on the north by Hendricks and Marion, on the east by Johnson, on the south by Brown and Monroe and on the west by Owen and Putnam counties. The West Fork of White River flows diagonally through the county from northeast to southwest, and, with its tributaries, drains

*Geological Survey of Indiana, 1875, p. 370.

*Loc. cit., p. 407.

the entire area except the northwestern corner, from which three small streams pass westwardly into Eel River. The principal tributaries of White River from the north, along whose beds and lowlands most of the gold of the county occurs, are White Lick, Sycamore Creek and its tributary, Gold Creek, Highland Creek, Lambs Creek, Burkhart's Creek, Fall Creek and Butler's Creek. Each of these streams has a number of smaller branches running into it, which are fed by springs. Most of them are dry in part of their courses during a portion of each summer.

The northern third of Morgan County, in which most of the gold occurs, is covered by the drift of the second or Wisconsin glacier, and the gold is a part of that drift. In the southern part of the county the drift is that of the first or Illinoian glacier, which embraced all the territory now included within the county. Of the Wisconsin drift Dr. Brown, who made a careful survey of the county, wrote as follows: "On the northwestern side of White River, in the northern tier of townships, the drift is deep and continuous, with its base of blue clay, and its upper member of yellow clay, with water-worn pebbles interspersed and an occasional boulder of granite on the surface. Some of these are very large. On Section 4 (T. 12, R. 2) I measured a boulder of flesh-colored granite, whose dimensions were: Length, 15 feet 4 inches; greatest breadth, 13 feet; height above ground, 11 feet 9 inches. South of an irregular line from Brooklyn to Eminence, the boulders almost entirely disappear, and, with them, the upper drift also leaving an irregular deposit of blue clay, constantly broken by the deep ravines which lay bare the underlying strata and cut the country into knobs."*

The "Lake" or valley, ranging from one to five miles in width, which extends from a little north of Eminence in a northeasterly direction past Hall and Monrovia, marks the point where the southern margin of the Wisconsin glacier rested for a long period, and down this valley much of the water from its melting ice was carried. The Indian Creek Valley in the southern part of the county was likewise the resting point of the southern edge of the Illinoian glacier. From each of these glaciers, whose crests doubtless towered far above the hills which prevented their farther movement southward, rapid streams flowed and bore down the gravel, clay and sand, with their accompanying gold, now found in beds beneath the lowlands of the present existing streams.

*Thirteenth Annual Report Indiana Department of Geology and Natural History, 1883, p. 79.

Of the gold of Morgan County, Dr. Brown wrote: "In the year 1850, some returned California gold miners observed the characteristic black sand in the ravines of northern Morgan County and immediately commenced "prospecting." They found gold in the tributaries of Sycamore and Lamb's creeks, and some of the more skillful miners were able to wash out $2.00 or $3.00 worth of gold per day for several weeks. But the excitement of an actual "placer mine" in Indiana brought together so many fortune hunters that every ravine was directly occupied and the sands were soon washed out, and the "gold fever" subsided. Within the last few years the excitement has been revived, and gold washing, to a limited extent, has been resumed, paying from 50 cents to $1.00 per day. The gold is in very thin scales or in almost invisible grains, and is remarkably free from alloy of any kind.

"The origin of this gold is a geological problem of some importance, as the underlying rock is of comparatively recent date and shows no indications of trap dykes, quartz veins, or other geological disturbances. The only rational solution of the problem appears to be that which refers the gold to the blue clay, which is the lowest member of the drift. Where the clay forms the summits or sides of the hills, it is washed into gulches by the rains. The lighter and finer particles are borne onward with the current, while the heavy black sand and gold lodge among the rocks in the bottom. Fortunes, however, will never be made by gold mining in Morgan County."*

In our trip over a portion of northern Morgan County in May, 1902, Mr. Royse and I first saw black sand in the roadside gullies about one-half mile northwest of White River, in Section 17 (T. 12 N., R. 1 E.) and, washing a panful of gravel, found several colors of gold. From here we passed northwestwardly to Wilbur, stopping in a number of places along the west branch of Highland Creek, to prospect with our pans. From the gravel underlying a strip of lowland along the creek, about a mile south of Wilbur, we washed several pans, one of which yielded 41 colors, and all of the others from 10 to 20 each.

From Wilbur we passed eastward across the ridges to the breaks of Sycamore Creek. Here the best known of the Morgan County gold seekers, Wm. Stafford, or "Wild Bill" Stafford, as he is more commonly known, has washed gold for 30 years. He spent one afternoon with us along Gold Creek, a tributary of Sycamore. One pan which he washed contained 64 colors, several of which were larger than grains of wheat. He showed us one place on this stream where he and

* Loc. cit., p. 81.

a partner secured 272 pennyweights of gold between March 3rd and June 17th, by using a three and a half foot rocker. He stated that where one can get an average of 20 colors to the pan, it will always pay to run a sluice box or rocker. On the Thos. Staton farm along Gold Creek (northwest quarter and southwest quarter Section 27, 13 N., 1 E.), now belonging to Moses Gunter, six pans of gravel washed on April 8, 1903, yielded $1.25 in gold.

Like most other gold hunters of Brown and Morgan counties, Stafford washes only the bars of the streams, paying no attention to the gravel deposits underlying the lowlands, mainly because the soil above this gravel is cultivated and the owners forbid its disturbance. He says that it pays much better to work out and pan a whole bar, sweeping the bed rock and cleaning out all the cracks where the coarsest gold has lodged, than to pan a little here and there as many do. The tyro can make but 25 to 40 cents a day panning along the streams of this region; the old experienced washer, $1.50 to $1.75 per day. He showed us a piece of gold whose value was $4.70, which was the largest he had ever taken.

During our investigations in Morgan County we gave especial attention to the lowlands bordering Highland, Sycamore and Gold Creeks and their tributaries. In most places these lowlands are composed of two to three feet of gravel resting upon the blue shale or bed rock. Above the gravel is a foot or two of clay and above this a sandy or alluvial soil, ranging in depth from six to 12 inches, on which crops of corn and other cereals are raised. The streams, whenever full and swift, erode out a portion of the gravel, with its accompanying gold, carry it forward and build up bars farther down their courses. In this manner the annual supply of gold particles in and along the immediate stream beds is added to, or replenished, when lessened by the workings of the gold hunters.

About 45 square miles of northern Morgan County are overlain with the gold bearing drift. Mr. Royse has made practical tests of the material in a number of the lowlands of this area and has proven that it runs from 30 to 80 cents per cubic yard in gold.

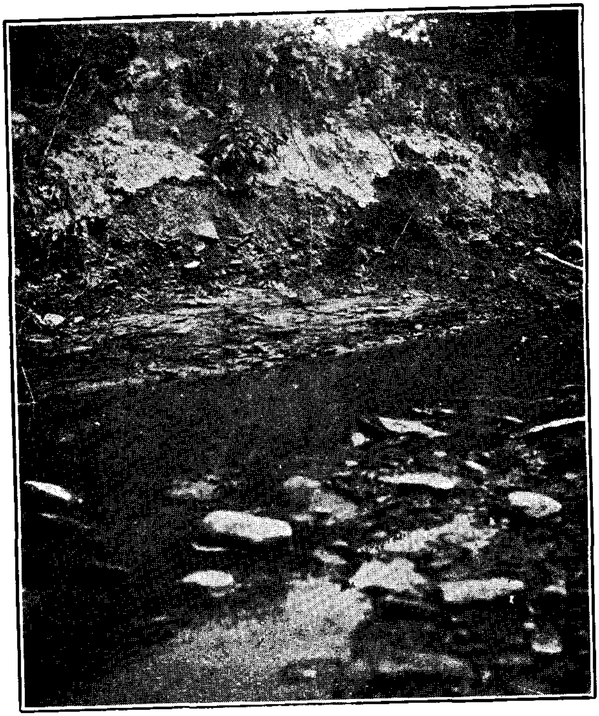
The most thorough of these tests was made on the land of Dr. Clark Cook, Section 30 (13 N., 1 E.), just north of the postoffice of Brey. Here 25 holes were dug through a strip of lowland to bed rock, the average depth being 3 feet 9 inches. From each of these holes 75 pounds of gravel was carefully panned, one-third being taken from the top, one-third from the middle and one-third from the bottom of the gravel stratum. In addition, miscellaneous gravel from the holes was added to bring the total up to 2,000 pounds. From this, gold to the value of $1.54 was secured. Allowing 3,000 pounds as the weight of a cubic yard of gravel, and deducting two-thirds for soil and clay, which were barren of gold, but must be handled, he had 77 cents per cubic yard for the matter composing the lowland.

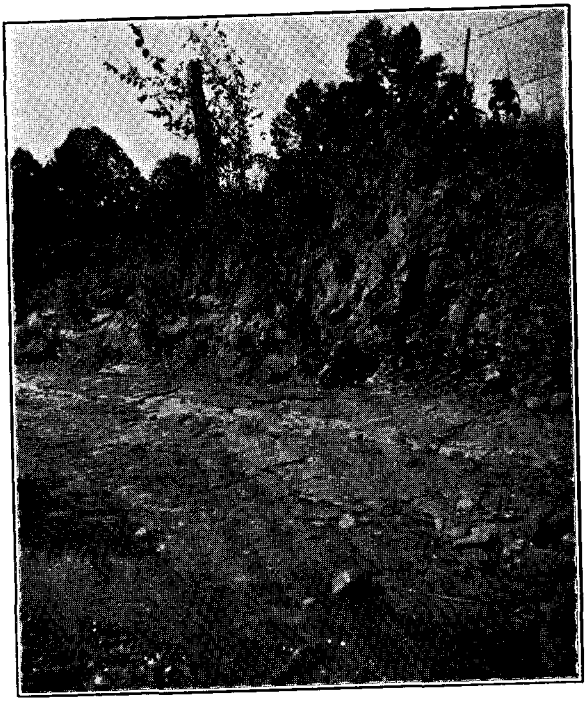
In the winter and spring of 1903, a small dam of logs and stone was built across the east fork of Highland Creek, which runs through Dr. Cook's farm. The water which collected above the dam was guided through 550 feet of 8-inch iron pipe and 150 feet of canvas hose, and was used in tearing down and forcing through sluice boxes, a portion of the lowland clay and gravel deposits, near where the above mentioned tests were made. Three sluice boxes, each 30 feet in length, were constructed, with mercury at the bottom to catch the flour gold. The fall from dam to sluice boxes was but four to six feet, dependent upon the stage of water above the dam. This water supply was usually sufficient to allow working only a few hours a day, and before the final clean-up, a great freshet washed out both dam and sluice boxes, so that no definite results were obtained. The capital invested was too small to make a practical test of the richness of the deposits. It is understood that Dr. Cook will construct a more permanent dam, higher up the stream, and renew his efforts to determine just what the placer deposits will yield.

I visited the site of this embryo hydraulic plant on March 26, 1903, and found a number of gentlemen from a distance who had been attracted by the newspaper articles regarding the work. Among them was Adam Linn, of Tucson, Arizona, a miner in California and Oregon since 1854. He had made for a Chicago company a careful investigation of the lowland deposits of the surrounding region, and stated that the gold was more abundant than he expected. He gave it as his opinion that these deposits would yield from 25 to 40 cents per cubic yard, and thought that it would well pay to pipe in water 20 or 30 miles, provided a company could control a thousand or more acres of the lowlands. Otherwise, the expense would be greater than the output.

In the southern part of Morgan County, gold also occurs along all the streams. In what is known as "Dead Man's Hollow," in Washington Township, seven miles south of Martinsville, on a tributary of "Little Indian Creek," George Boardman, of Martinsville, and three other parties, washed out $8.00 per day with a "blanket rocker" for a short time in February, 1903. Mr. Royse went down a week later, and panned in a number of places in this and intersecting hollows, securing 5 to 40 "colors" in every pan. He estimates the lowlands to equal in richness those of the northern part of the county.

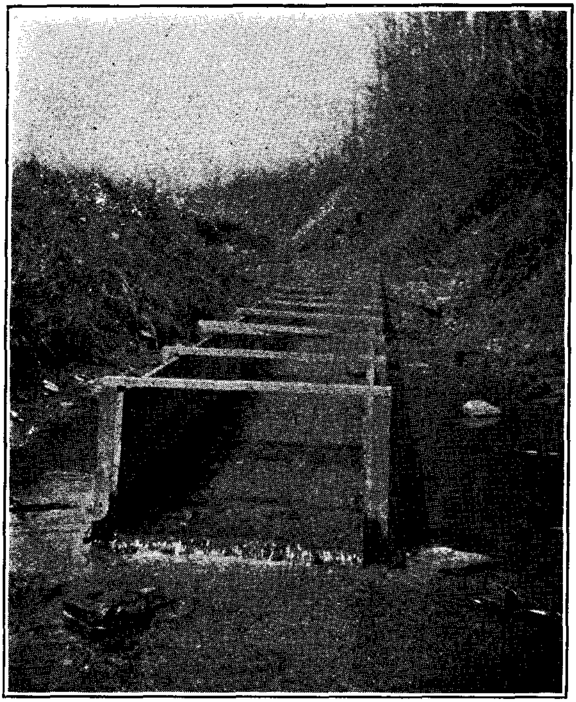
PLATE III.

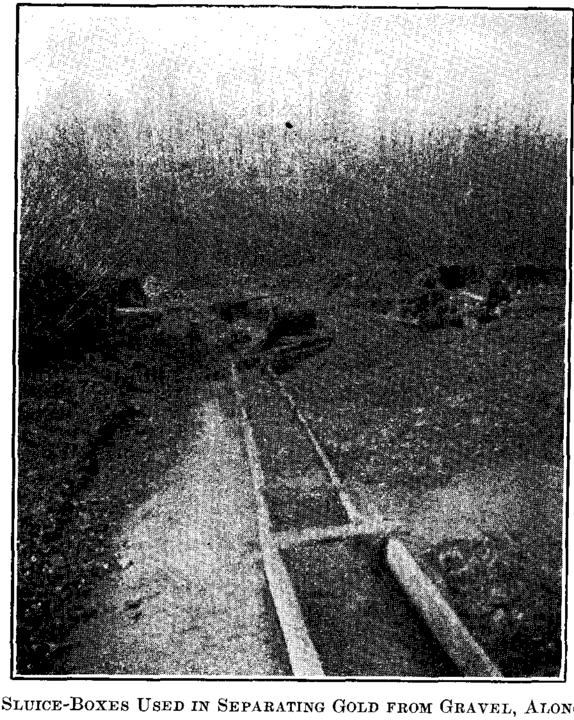




VIEWS ON GOLD CREEK, MORGAN COUNTY.

PLATE IV.





SLUICE-BOXES USED IN SEPARATING GOLD FROM GRAVEL, ALONG HIGHLAND CREEK, MORGAN COUNTY, MARCH, 1903.

In western Morgan County, in what is known as the "Burkhart Settlement," Ashland Township, four to five miles northwest of Paragon, the gold is equally abundant in the lowlands along the streams. John Merriman, the veteran Brown County gold seeker mentioned above, here once secured 264 colors, by actual count, in one pan.

From what I could see and learn, there is little doubt but that these lowlands of Morgan County are richer in gold than those of similar tracts in Brown County. The valleys in northern Morgan are also wider and more extensive than in the gold bearing portion of Brown. The accompanying illustrations will show the manner in which the lowlands bordering Gold Creek are composed. If in the western States similar deposits which yield only 12 to 20 cents per cubic yard pay for working, as it is claimed they do, I see no reason why, with improved dredges and machinery, these gravel deposits of Morgan County would not also pay. While Dr. Brown was doubtless right in saying "that fortunes will never be made by mining gold in Morgan County" under the methods in vogue when he wrote, those methods have materially changed, and what was considered worthless ore or placer deposits in the West a score of years ago, are now yielding riches to many men. Gold is undoubtedly present in Morgan and Brown counties, and perchance some day a mining engineer with experience and up-to-date machinery will prove that it is present in paying quantities.

Putnam County.

This county lies south of Montgomery, and about 40 miles due west of Indianapolis. It is wholly within the "Illinoian drift" area, and the border of the Wisconsin drift passes from northwest to southeast across its center. In the valley of a small stream flowing into Big Walnut Creek, two miles east of Bainbridge, some prospectors found gold about 40 years ago, and washed out several dollars' worth. My boyhood days were passed near this place, and I have often seen the holes which they had excavated. In November, 1902, I took a gold pan to the place, and with the aid of Ami Michaels, who now owns the land, washed out a number of colors, one panful of gravel producing 11. Mr. Michaels found quite a thick bed of the black magnetic sand in a well which he sunk near this spot. The gold does not probably exist in paying quantities in this region, but its presence is undoubted.

Vanderburgh County

Lies in the southwestern corner of the State, on the Ohio River, and wholly outside of the drift area. Collett, in his report on this county, says that "very minute quantities of gold and nuggets of copper are sometimes found. They were imported with the modified detritus of the glacial drift."*

Warren County.

This county lies on the western border of Indiana, north of the center of the State, and wholly within both drift areas. Of the presence of gold within its bounds, nothing is known beyond what Collett has written as follows: "Virgin copper and gold are found in small quantities. These metals, with small nuggets of galena, were imported from the north with the rocks of the boulder drift. At Gold Branch of Pine Creek, N. W. quarter Section 23 (22 N., 8 W.), on a gravel bar formed of debris washed from the boulder drift, a quantity of gold, reported at $70, was collected. An energetic Californian can 'pan out' from $1 to $1.25 per day at this and several other gravel bars in the county. An equal amount of labor expended at any ordinary avocation will bring better returns."†

Besides the above mentioned counties, gold has been found in minute quantities in Gibson and Pike, both lying along the border of the drift area, and in Sullivan, which lies in the interval separating the borders of the Illinoian and Wisconsin areas.

Enough has been said to show that gold doubtless occurs in every county within the drift area, but it is very improbable that it is accessible in paying quantities in any except Brown and Morgan; and there only under improved methods of separation.

DIAMONDS IN INDIANA.

While panning gold from the gravel and sand in the beds of the streams of Brown and Morgan counties, a number of small diamonds have been found by the gold seekers. I have seen eight of these and have credible information concerning several others. The earliest printed mention relating to any of them which I can find is that by Prof. E. T. Cox, as follows: "There have also been found in the drift of Brown County several diamonds, one of which weighed four

*Geological Survey of Indiana, 1875, p. 294.

†Geological Survey of Indiana, 1873, pp. 224, 244.

carats. On Little Indian Creek, in Morgan County, Mr. J. J. Maxwell found, some ten years ago, a diamond which weighed three carats. These are interesting facts, and point to the existence of a true diamond field somewhere in the beds of crystalline rock to the north."*

A second record occurs in the Report on Morgan County, by Dr. R. T. Brown, as follows: "Two diamonds have been found in the drift of the Indian Creek valley. One is now in possession of Mr. Harry Craft, a well-known jeweler of Indianapolis. It is cut and set. It had a weight of three carats in its rough state. It was found near Morgantown. The other is somewhat larger and is uncut. It is in the possession of Mr. Maxwell, who resides three miles south of Martinsville. It was found on his farm. Both of these stones appear to have had an original connection with the drift of Indian Creek Valley."†

The Maxwell diamond, mentioned by both Cox and Brown, is evidently the same, but they do not agree as to its weight. It was found in Washington Township, on Goss Creek, one of the tributaries of Little Indian Creek, in 1863, by Peter Davis, an old gold hunter, and by him sold to Mr. Maxwell. This diamond is without a flaw or blemish, and of a greenish hue. It is now owned by Mrs. James Maxwell, of Martinsville, Ind.

Dr. George F. Kunz, in his work, entitled "Gems and Precious Stones of North America," states that "two diamonds have been on exhibition for several years at the store of Frederick N. Herron, Indianapolis, and are reported by him to have been found at some locality in Indiana. They are perfect elongated hexoctahedrons of two carats each. The stones are genuine diamonds, but the particulars of their occurrence and discovery have not been obtained, and therefore nothing definite can be stated regarding them."

Besides these references, I have heard of the following Indiana diamonds which I have not seen: One George M. Tuterrow is said to have found two diamonds about 20 years ago while panning gold on Lick Creek, Brown County. One of them was sold in Indianapolis, and the other for $15 to a jeweler named Butler in Morgantown. He is said to have resold it for $75.

Mr. John Merriman, the pioneer gold hunter of Brown County, before mentioned, states that he sent several small diamonds which he had taken in Brown County to New York about 18 years ago. They were returned to him with the statement that they were genuine diamonds, but were too small to cut. He afterwards gave them to Harry

* Geological Survey of Indiana, 1878, 116.

† Thirteenth Annual Report Indiana Department Geology and Natural History, 1883, p. 83.

Craft, a jeweler of Indianapolis. Mr. Merriman has since found four small ones, which I have seen. He also reports that a Mr. Blevin found a diamond on the headwaters of Salt Creek, in northeastern Brown County, for which he received $50.

The diamonds which I have seen from Brown and Morgan counties are as follows:

I. *The Stanley Diamond.* Found in September, 1900, by Calvin Stanley, on a branch of Gold Creek, Morgan County, in Section 28 (13 N., 1 E.), three miles northwest of Centerton and three miles west of Brooklyn. It was found in the bed of the stream at the base of a high cliff of blue shale, while panning gold. The stone was an octahedron of four and seven-eighths carats weight, with a yellow tinge, and had a small black spot, not quite central. Mr. Stanley showed it to jewelers at Mooresville and Brooklyn, and in time sold it to Mr. Royse, from whom it was purchased by C. E. Nordyke, of Indianapolis. The latter gentleman had it cut in Cincinnati into two stones. Their color is a peculiar greenish yellow and their weights are one and one-eighth and one and one-sixteenth carats respectively.

As noted on a previous page, the place where this diamond was found is along the border of the newer or Wisconsin drift area. It thus corresponds to the Kettle Moraine localities of Wisconsin, in which most of the drift diamonds of that State occur.

II. *The Young Diamond.* The second largest diamond which I have seen from Indiana was found by W. W. Young, a gold hunter mentioned above, in 1898, on Lick Creek, Brown County, four and a half miles south from Morgantown. It is an oblong dodecahedron of the "silver cape" variety; i. e., between a white and yellow in color, and weighs one and twenty-one-thirty-seconds carats. It is a very clear or "pure water" stone, without flaw or carbon speck, and is still in possession of its finder.

III. An almond shaped, pink hexoctahedral stone, weighing but one-eighth carat, was found by John Merriman on Lick Creek, Brown County, and is now in the possession of Chas. Nordyke.

IV. A small yellow hexoctahedral stone, weighing three-sixteenths carats, found by Mr. Merriman on Lick Creek, is now in the possession of R. L. Royse.

V. A small light brownish-yellow hexoctahedron, weighing five-thirty-seconds carats and found by Mr. Merriman on the same creek, is also in the possession of Royse.

VI. A blue rhombic dodecahedron, weighing eleven-sixteenths carats, was found by Mr. Merriman on Gold Creek, Morgan County, in the vicinity of the place where the Stanley diamond was found. It is now owned by Royse.

VII and VIII. Two small, pinkish diamonds, weighing one-eighth carat or less each, were taken near Brey, Morgan County, in May, 1903. They were secured by Mr. Royse from the tailings below the sluice boxes operated on the farm of Dr. Clark Cook.

It will thus be seen that four of the diamonds came from the "older" or Illinoian drift, and four from the "newer" or Wisconsin drift. The minerals found associated with these diamonds have been mentioned on a preceding page. The diamonds, like the gold, are not native to Indiana, but came in as glacial drift from some point in British America.

The Original Home of the Diamonds and Gold.

Not having made a special study of glacial geology, I am unable to give an opinion, based on personal investigation, of the approximate location of the original home of the gold and diamonds found in the drift of this State. I have, therefore, brought together under this last heading the views of some of the more prominent glacial geologists of the United States regarding the subject.

Sixteen or more diamonds have, within the past 20 years, been found in the drift-covered area of Wisconsin and one near Milford, Clermont County, Ohio. These range in size from twenty-one carats down. The most of those taken in Wisconsin were found while washing drift gold. Their discovery has created much interest among people who are studying the glacial problem in this country and also much speculation as to the original source or home of the diamonds and gold. Prof. W. H. Hobbs of the University of Wisconsin, has given especial attention to the subject and has published two papers regarding the diamonds and their probable source.* From the first of these papers I quote at length as follows. After giving a short history and description of the different stones he says:

"All of the Wisconsin diamonds, with the exception of those from Plum Creek, were obtained from the deposits of glacial drift. The Plum Creek diamonds were obtained from the bed of the stream in immediate proximity to glacial deposits. It is clear, therefore, that the stones must have reached their late resting places in the drift through the agency of the ice mantle, and we should, therefore, study the directions of glacial movement throughout the region to discover the law of their distribution and to glean any facts that may be within our reach regarding the ancestral home, or homes, which

*"The Diamond Field of the Great Lakes," in Journal of Geology, VII, 1899, 375.
"Emigrant Diamonds in America," in Popular Science Monthly, LVI, November, 1899. Reprinted in Annual Report Smithsonian Institution, 1901, 359-366.

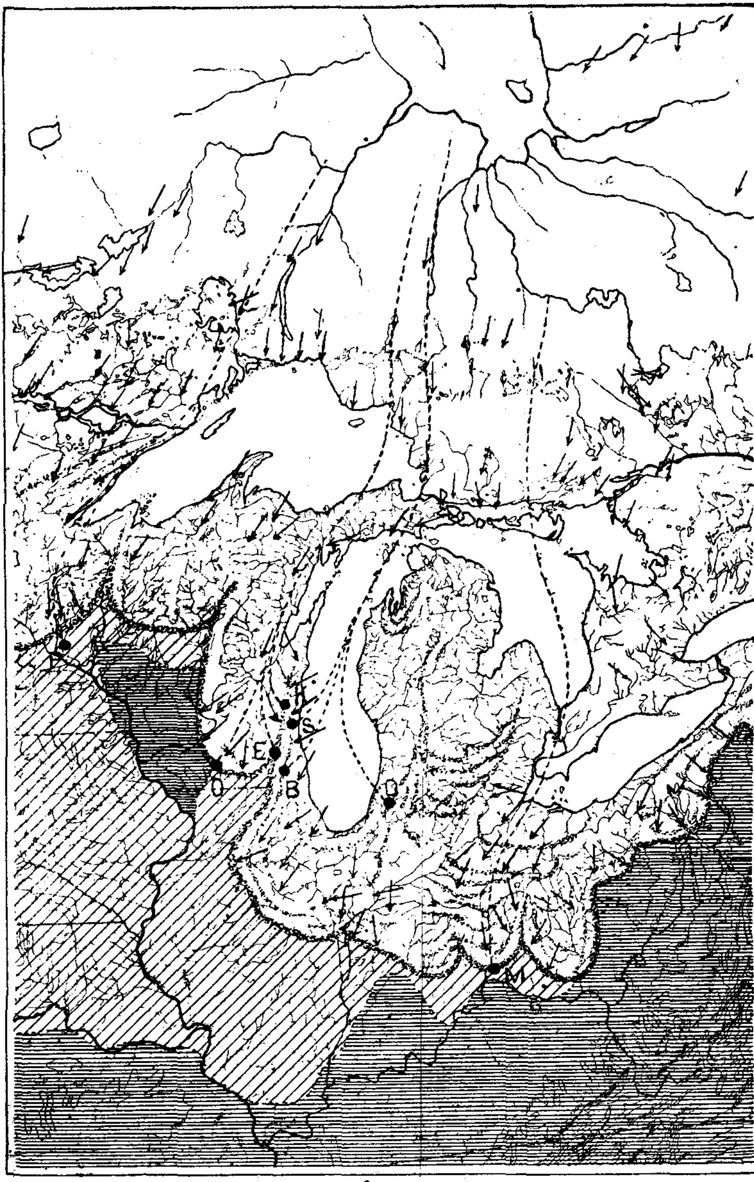
they occupied before they were carried away by the ice. The accompanying map of the lake region is based on the glacial map of Chamberlin, but revised and also extended to the north so as to include the results of later studies. * * *

"Within the domain of Canada the great wilderness region has been covered only by reconnaisance surveys and except in the territory bordering on the lakes there exist only a few scattered observations from which to construct a map of glacial movement. In the district to the southeast of James Bay some surveys have been made, but the material is not yet in print. In the region southwest and west of James Bay, which possesses also great interest, no data are available. * * * By plotting the diamond localities on the map it is seen that all but the Plum Creek locality are situated on the moraines of the "newer" or later ice invasion, and that the latter locality is quite near to the moraine, within the area of overwash. It is also worthy of note that all but one of the stones were found in one of the marginal moraines which marked the greatest advance of the ice during its later invasion. * * *

"The material from which the diamonds were derived must clearly have been to the northward beyond the lakes, in the wilderness of Canada. To explain the occurrence of so large a proportion of the stones in or near the outermost moraine, it is necessary to assume either that at the beginning of the second great advance of the ice the diamonds were imbedded in a loose material easily transported, and hence largely removed before the stages of retreat, or that they were imbedded in their matrix, which, from its limited extent, was largely abraded and removed by the ice during its initial stage.

"The first is the more reasonable assumption, by reason of the wide fan of distribution of the diamonds, and the number which has been found warrants the assumption that the number of stones at the source of supply must have been very considerable. It is likely that for every diamond that has been found there are a thousand still undiscovered in the drift.

"Professor T. C. Chamberlain has given his views in regard to the explanation of the occurrence of the diamonds in the large moraines near the outer limit of the later invasion as follows: 'The diamonds were probably separated from their original matrix in pregalcial times by disintegration and accumulated in the bottoms of the valleys in the vicinity of their origin. The first glaciations were not sufficiently abrasive to remove the diamond-bearing gravels in the bottoms of the valleys, or at least not able to do so completely. The diamonds, therefore, do not occur frequently in the earlier drift mate-



GLACIAL MAP OF THE GREAT LAKES REGION

Driftless Areas. Older Drift. Newer Drift

Moraines. Glacial Striae Track of Diamonds.

Diamond Localities 0 100 E, Eagle. O, Oregon

K, Kohlsville D, Dowagiac. M, Milton P, Plum Crk. B Burlington

Fig. 2. (From Journal of Geology, VII, 1899, p. 382).

rial. Furthermore, the earlier drift material was less subjected to wash and now appears less abundantly as clean gravel, and hence a less proportion of the diamonds that may have been embraced in it have been found. The chances of finding diamonds scattered throughout the till is, of course, relatively small.'" * * *

"The problem of locating the area from which the diamonds of the drift have been derived is a fascinating one, and while the data now available are insufficient for its complete solution, they are of a kind to indicate that, with the increase of our knowledge likely to come in the next decade, the desired end may be reached. The first question which naturally arises is whether all the diamonds that have been found in the lake region have been derived from a common source. While there is no certain evidence that they have, nevertheless it would seem to be probable. Diamond bearing rocks are not so numerous that there is much likelihood of two unconnected areas being discovered in the region in question. Moreover the occurrence of diamonds with somewhat similar crystal habits over so large a territory would seem to be significant. * * *

"Provided a common source is assumed for all the diamonds of the region, this can only be located at the apex of the fan of diamond distribution on the hither side of the névé from which the ice moved. The wider this fan of distribution is found to be, the nearer is its apex carried toward the ice summit. The radial sides of the fan must be largely determined from the direction of striae within the Canadian wilderness, of which an adequate number have been recorded only from the immediate vicinity of the Great Lakes. Beyond these borders the *tracking* of the diamonds can be carried out only with a certain approximation to correctness. * * * The tracks of the lake diamonds which have been delineated show that the apex of the fan of diamond distribution probably lies somewhere in the strip of territory bordering James Bay on the east."*

From a recent letter from Prof. G. Frederick Wright, of Oberlin, Ohio, an eminent authority on glacial geology, I quote as follows regarding the probable source of the drift gold: "Gold has also been found, as you see in my reports, in southern Ohio, and since then I have learned of its creating excitement in the glacial border of western Pennsylvania. We have done considerable work in Oberlin in tracing Canadian boulders to their probable source. The red jasper conglomerates found north of Lake Huron, and so far as I know limited to that region, are distributed all the way from the eastern border of this State to Keokuk, Iowa. I have seen many of these

* *Journal of Geology*, May–June, 1899, pp. 383–388.

boulders in Boone County, Kentucky, and in Brown County, Indiana. We have found Lake Superior copper as far south and east as Columbus, Ohio; or, at any rate, copper like that near Lake Superior. The evidence seems to be that the movement radiated chiefly from the region north of Lake Huron, extending from the 'Soo' to the Ottawa River. We have identified very closely 30 specimens from that region in our boulders in this State, and, with a fair degree of probability, 30 more."

Mr. F. B. Taylor, of Fort Wayne, Indiana, has for years, made a special study of glacial problems, especially of those pertaining to the glaciers which formed or modified the beds of the Great Lakes.

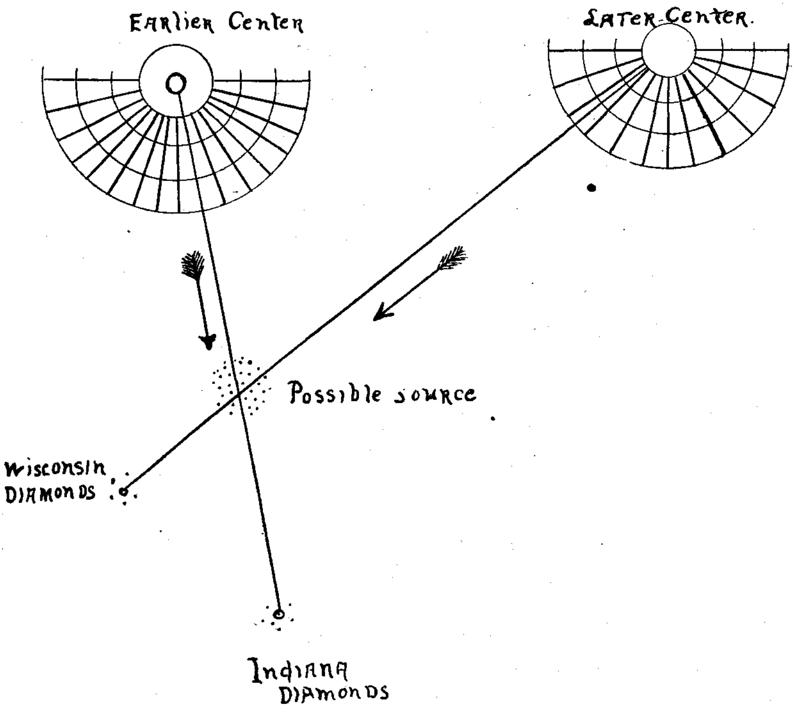


Fig. 3. Diagram illustrating possible source of Wisconsin and Indiana diamonds.

From him I have received a letter embodying the following views concerning the original home of the diamonds: "The fact seems pretty well established that the center of ice dispersion shifted gradually from west to east during the glacial period, or at the successive invasions. The last phase of glaciation in Indiana belongs to a time when the main center of dispersion was from a point on the Laurentide Mountains, far to the northeast.

"It is this last phase that gave the main expression to our top layers of drift. It seems to me probable that the gold and diamond bearing drift of Brown and Morgan counties was deposited at a time when the main center of dispersion was directly north, or nearly so, from Indiana, and if that is the case, it is not unlikely that the same source which supplied the diamonds of Wisconsin at a late stage of glaciation, supplied those of Indiana at an earlier stage.

"The accompanying diagram is a little too definite; for we can not tell with much accuracy just where the centers of dispersion were or just what deviations the ice-travel may have taken, so that the locus of the probable source is more indefinite than the diagram suggests.

"I have been led to this conclusion by the fact, as I remember it, that the gold-bearing gravels referred to are at the extreme margin of the drift and close to, if not indentified with, drift that is older than that designated as 'Wisconsin'—this fact coupled with the shift of the center of dispersion.

"Another possibility is that the Indiana diamonds came from some small unknown eruptive tract in the Saginaw Valley or carboniferous area of Michigan. But no such area is known at the present time.

"A fine diamond was found in a creek bed a few miles south of the city of Cleveland many years ago. It was taken to Boston lapidaries and cut and sold for $40,000. It would seem hardly likely that that one came from the same source as those of Indiana and Wisconsin by glacial transportation alone, unless we are to derive the Indiana diamonds from the Erie glacier lobe. Then the Cleveland stone might be attributed to the same source, but this would not include the Wisconsin stones."

Mr. Frank Leverett, one of the most prominent glacial geologists connected with the U. S. Geological Survey, has written me his views regarding the source of the Indiana diamonds, as follows: "It will be a difficult matter to determine the source of the diamonds through an examination of the glacial drift. There appears to be good evidence of movement from two widely different parts of Canada toward the region in central Indiana in which diamonds have been found. One movement, presumably the earlier, passed through the copper region of the upper peninsula of Michigan in a course east of south, carrying the copper across the southern peninsula of Michigan into Indiana and western Ohio. Another movement passed west of south from the region north of Georgian Bay across the southern peninsula of Michigan and northern Indiana into the region where the diamonds have been found, carrying boulders of red jasper conglomerate from ledges which outcrop north of Georgian Bay. I know of no means at present for determining with certainty which of these ice movements brought in the diamonds.

"If there is but one source for the diamonds, a study of their distribution in the drift may throw them outside of the range of one of the two movements to which I have just referred. For example, should the diamonds in the future be found so far to the northwest as to be out of the reach of the ice movement from the region north of Georgian Bay, then they would be referable to the movement which passed through the Lake Superior copper region. It seems important, however, to make sure that the diamonds have been derived from but one source, and that question may remain unsettled for some years."

* * *

The above are the views of persons in every way competent to judge as to the original source of the diamonds and gold. With one accord, they pronounce them of glacial origin. They, for the most part, also believe that their original home was somewhere in the neighborhood of James Bay, British America. The Director of the Geological Survey of Canada has become interested in the subject and has begun the mapping of the Canadian Wilderness in this region, in order to determine more definitely the direction of the ice movement. It is not improbable that within the next quarter century a new El Dorado will be discovered among the igneous rocks of this far northern region, which will be as rich in gold and precious stones as any heretofore known to man.

THE GEOLOGY

OF

The Lower Carboniferous Area

OF

SOUTHERN INDIANA.

BY GEORGE HALL ASHLEY, PH. D.,

Assisted by

EDWARD M. KINDLE, PH. D.

LETTER OF TRANSMITTAL.

INDIANAPOLIS, IND., January 15, 1902.

Hon. W. S. Blatchley, State Geologist of Indiana:

Sir—I have the honor to hand you herewith my report on the geology of the area of the Lower Carboniferous rocks of southern Indiana. This work was planned, in accordance with your instructions, primarily as a continuation of the survey of the Bedford Oölitic Limestone made north of Orange County in 1896. Pursuant to your instructions, however, the other members of the Lower Carboniferous have been mapped, and examined, especially for any strata of economic value. The most valuable part of the report is believed to be given on the accompanying maps, which attempt to show the distribution of the different formations with as much or greater accuracy than has hitherto been attempted in this State. They also show graphically the character of the topography by profiles, and the structure of the strata as a whole. In addition a columnar section is added. In order to complete the work in the time allotted it was necessary to omit much work that would have been necessary for the mapping of the quaternary and the formation herein called the "Ohio River Formation," believed to be of Tertiary age. The field work occupied the season of 1900. The writer was assisted by Dr. Edward M. Kindle. The writer is entirely responsible for the maps and reports of Washington and Harrison counties. Dr. Kindle made a rapid survey of the area in Scott, Floyd and Clark counties, scrutinizing the map of the Knobstone recently made by the University of Indiana Geological Survey, and adding the outcrop of the Bedford stone and other matter of value. He then took up the work in Orange, Crawford and Perry counties, and traced the line of contact between the Mitchell and Huron formations. The upper line of the Huron was traced by him in this area in 1895 and 1898. He also made a study of the Mitchell and Huron in this area.

Very respectfully yours,

GEO. H. ASHLEY.

ABSTRACT OF REPORT.

GEOGRAPHY OF THE AREA.—The area under study lies in the central part of the south end of Indiana. Topographically it consists of a low rolling strip on the east, then rough broken country in the "Knobs," then a high central, rather level plateau, then a broad belt of hilly broken land on the west. The drainage is north into White River, west into Lost and Patoka rivers, and south into the Ohio River, by way of Blue and Little Blue rivers, Indian, Buck, Silver and smaller creeks.

STRATIGRAPHY.—Quaternary deposits of limited extent occur, as glacial drift in the northeast corner, and alluvial deposits along the rivers and streams. On the divides at the east exist remnants of a once extensive deposit of sand and gravel. Their age is not known, but it has been thought they are of the Tertiary age. They have been called the Ohio River formation. The practical necessities of mapping have made it necessary to draw the line between the main body of the Kaskaskia and what has been called the Mitchell, well up in the Kaskaskia. The Mitchell has been continued up to this line, and the strata above grouped as the Huron group. This group consists of alternating sandstones and limestones with much shale at the south, the whole having a thickness of from 100 to 150 feet. The Mitchell limestone next underlies the Huron. It is almost entirely limestone, with much chert, and has a thickness of from 350 to 400 feet. Under that is a massive stratum of limestone highly suitable for building purposes, known as the Bedford oölitic limestone. It ranges from a thickness of 90 feet at the north to a thickness of usually less than 15 feet as the Ohio River is approached. It would appear that the thin bed of oölitic stone on the south represented only part of what has been called the "Bedford" stone at the north, the rest of the bed having become so changed as to be classed with the Mitchell or Harrodsburg. Below the Bedford stone is the Harrodsburg limestone, with which is some shale. This has a thickness of about 60 feet. At the bottom of the Lower Carboniferous is the Knobstone, a series of shales and shaly sandstones, the latter predominating at the top.

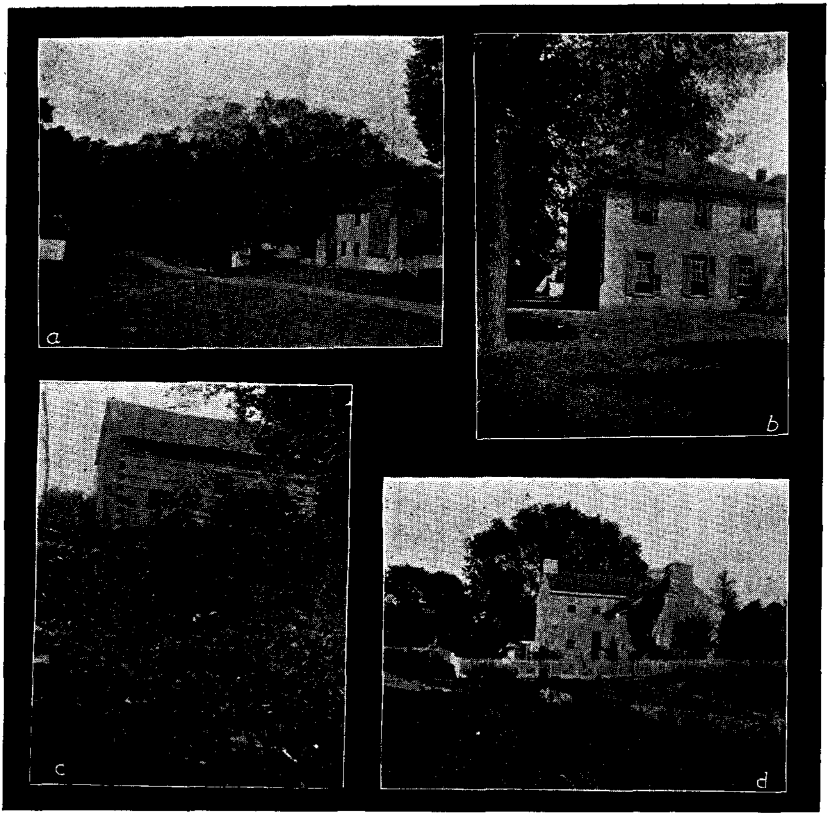
GENERAL STRUCTURE OF THE AREA.—In structure this area is a westward dipping monocline, with a dip of from 30 to 40 feet to the mile, about west by south.

ECONOMIC GEOLOGY.—First the soils of the area are briefly discussed. The Ohio River formation has yielded glass sand of excellent quality and contains an almost unlimited further amount. In the Huron are limestones that have proved suitable for glass manufacture, and for lime. In places the limestone has been used as marble with fair results. The lower sandstone has had extensive local use and has proved durable and especially suitable for bridge foundations and similar work. The Mitchell, in addition to the limestones that have proven suitable for rough masonry, or for road material, or for ballast, for which purposes much stone has been used and some exported, gives promise of yielding much stone of value for the manufacture of Portland and Roman cement. The stone best suited for the former is a very white, pure, coarsely oölitic limestone. It has a thickness of from five to 15 feet, and extends all through Orange and Crawford counties. The stone suitable for Roman cement is found nearer the bottom of the formation, and is an argillaceous limestone, that appears on analysis to be suitable for this purpose, and has been manufactured across the river in Kentucky, where it is claimed to make a high grade cement. Lithographic limestone occurs abundantly in this formation, but as yet has not been found sufficiently free from flaws to answer the purposes of engraving.

The Bedford Oölitic Limestone from the northwest corner of Washington County to Salem, has a thickness of about 65 feet and in general good quality, though tending to be a little more crystalline and a little harder than the stone further north. At Salem the stone appears to split up and in part to lose its oölitic character for one much more crystalline. A small thickness of truly oölitic rock continues, sometimes attaining a thickness of 25 or 35 feet, but in the main is from 5 to 15 feet thick. Most of this oölitic stone to the south is partly or largely crystalline, making it proportionally harder to work but correspondingly enduring and strong. Some of it, however, is of good oölitic grain. The use of the Bedford for the manufacture of lime and Portland cement calls for notice.

The Harrodsburg Limestone has some local use for road material, and locally for rough structural purposes. The Knobstone has furnished some sandstone for building, and some of the shales near the bottom have been successfully used for the manufacture of bricks.

Attention is also called to the possibilities of large water power, taking advantage of the large springs and the narrow, almost uninhabited, ravines. One hundred foot impounding dams could be used in places, giving large power all the year round.



SOME HISTORICAL POINTS IN HARRISON COUNTY.

a. The Constitution Elm, Corydon, Ind., under which much of the constitution of Indiana was written, the legislature having adjourned there on account of the heat.
b. The old State Capitol, at Corydon, Ind.
c. Goshen church, Boone Township, one of the few log churches in Indiana still used as a church.
d. "The Capitol Hotel," a stone house a mile east of Corydon, where many of the members of the Constitutional Legislature were guests.

GEOLOGY OF THE LOWER CARBONIFEROUS AREA OF SOUTHERN INDIANA.

BY GEORGE HALL ASHLEY.

GEOGRAPHY OF THE AREA.

LOCATION AND LIMITS OF AREA TREATED.—The present report covers an area in southern Indiana which includes all the area of outcrop of the rocks of Lower Carboniferous age between the Ohio River on the south and Lawrence County and the east fork of White River and Muscatatuck River on the north. As shown on the maps the eastern border runs through the center of Scott and Clark counties and the eastern edge of Floyd County to the Ohio at New Albany.

The western limit is very irregular and extends through eastern Dubois and Western Orange counties, reaching the Ohio in the vicinity of Rock Island, in Perry County. The area has an extreme width of about 65 miles from east to west and the same extent north and south.

Refer to maps for exact boundaries.

POLITICAL SUBDIVISIONS OF AREA.—The area includes all of Washington and Harrison counties, nearly all of Floyd County, the western part of Scott and Clark counties, nearly all of Orange County, the eastern part of Crawford and Perry counties, and parts of the western half of the two last named counties.

The boundaries of these counties as well as the boundaries and names of the townships into which they are divided are shown on the large maps.

TOPOGRAPHY.—ELEVATIONS.—The region ranges in elevation from about 340 to over 1,000 feet above mean sea-level. The lowest point is on the Ohio River where it leaves the region south of Perry County, and the highest is one of the high points in eastern Washington County. Exact elevations are not at hand to show whether the highest point would come in the divide around the headwaters of Blue River or whether any such elevation is exceeded by one of the high hills near Harristown.

The following table contains the elevations that have been determined:

	Feet Above Tide.
Birdseye	711
Borden	553
Boston	710
Chestnut Ridge	552
Corydon Junction	616
Crandall	650
DePauw	642
Edwardsville	799
Edwardsville, Knob at	901
English	503
Fort Ritner	522
Fredonia, Low water	348
Georgetown	710
Harristown	874
Lawrenceville, Low water	425
Leavenworth, Low water	349
Livonia	787
Maukport, Low water	351
Marengo	574
Memphis	489
Milltown	552
New Albany, Low water	367
Orangeville	635
Pekin	609
Paoli	611
Ramsey	707
Salem	717
Scottsburg	569
Sellersville	477
Smedley	878
Taswell	770
Tell City, Low water	337
Vienna	565

Topography.—An attempt has been made in the small map (Plate I), to give some general idea of the topography. A look at that map will show that there is a comparatively level strip of land extending from northeastern Orange County to the south end of Harrison County. This is from five to fifteen miles wide and will be found in the main to correspond to the area of outcrop of the Mitchell rocks. Extending around the north and east of this is a belt, known as the "Knobs," in which the streams cut down rapidly from the upland, then run off with a slight gradient through deep valleys with rather wide, flat bottoms and very steep almost precipitous sides. West of the broad flat belt mentioned rise a series of isolated knobs of Mitchell Limestone capped by Kaskaskia Sandstone. These increase in size going westward at the expense of the intervening level stretches until the topography along the western part of the area becomes a succession of high irregular ridges and deep narrow ravines.

The topography presents a series of types which may be studied more in detail.

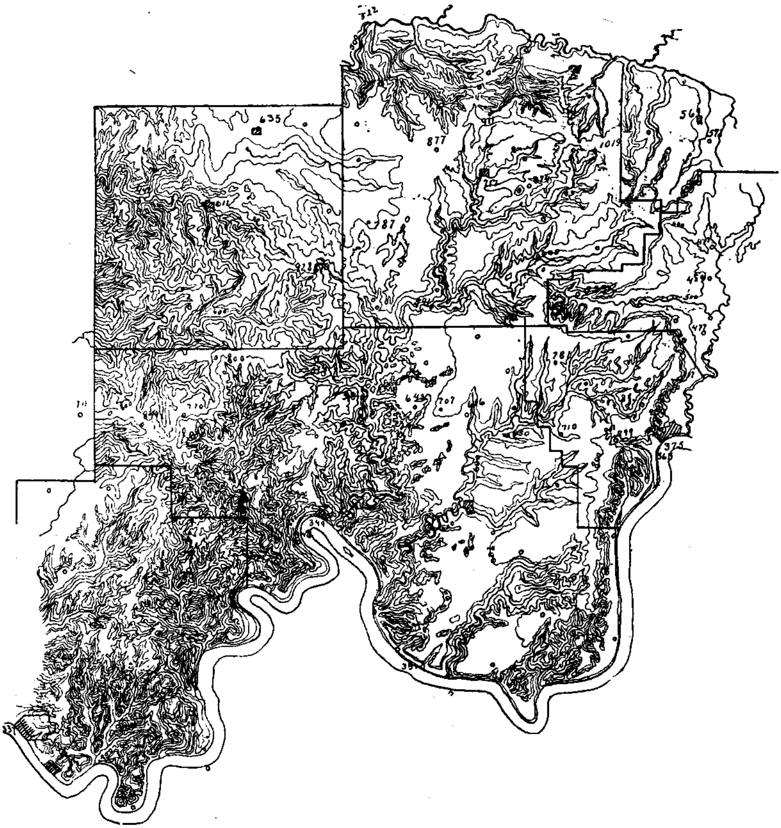
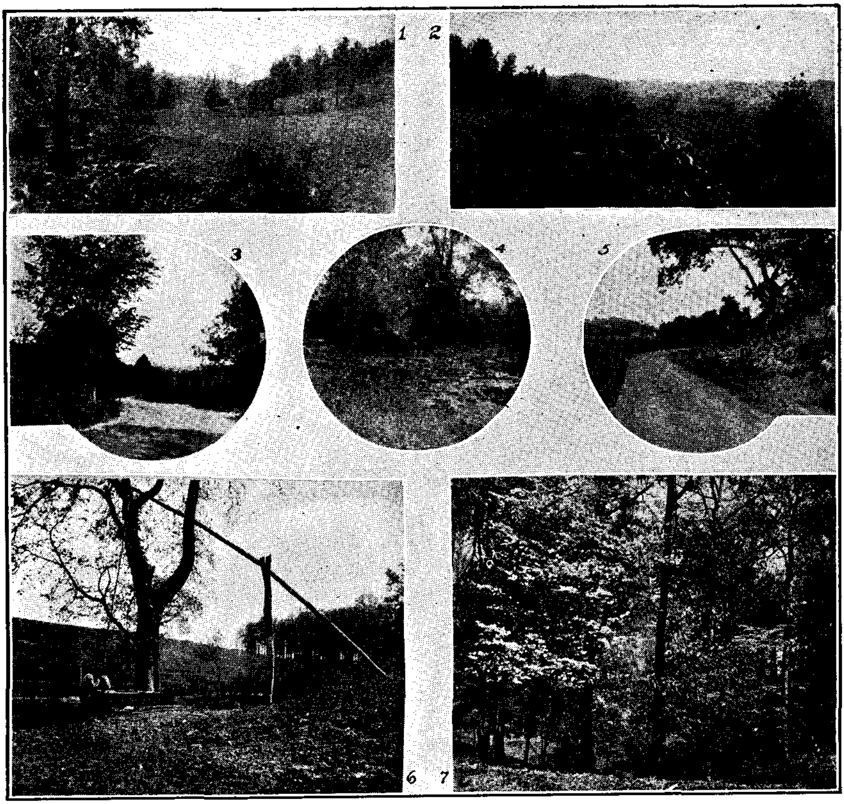


Plate I. Sketch map showing elevations, and the topography by 100-foot contours.

Lower Knobstone Type.—As will be shown further on the Knobstone with a thickness of about 400 feet is predominantly shaly in this region, especially toward the bottom. This characteristic dominates the topography in the area of its outcrop, and as a result the eastern edge of the area of the Lower Carboniferous rocks is a low, comparatively level, stretch of country, as is well displayed along the J., M. & I. Railroad. This area has a general descent to the west of less than 50 feet to the mile. The elevations along the eastern edge range from about 450 to 600 feet.

Knob Type.—Going westward, or southward from Muscatatuck River, the upper part of the Knobstone is approached. This has a larger proportion of sandstone and is capped by the hard limestones of the Harrodsburg. These withstand erosion much better than the lower members of the Knobstone and give rise to a belt of country of extremely broken character. The hard overlying limestones tend to form a high plateau sloping to the west with the dip of the rocks. The eastward and northward flowing streams have eaten through this overlying crust where it is thinning out along its edge, and once through that and the hard sandstones in the upper part of the Knobstone formation, they have cut rapidly through the soft underlying shales nearly to the base level of the region to the east. This sharp descent at their heads has allowed the streams to eat their way some distance from what tends to be the face of the plateau. The result is a series of valleys from 250 to 300 feet deep and from one to five miles long, separated by narrow divides. The divides tend to be flat-topped, evidently being uneroded prolongations of the plateau. As they extend out from the plateau they tend to become narrower and to have low saddles cut in the crest; and finally the ridge ends abruptly, making a bold headland, to which the name "knob" has been given. The character of one of the intervening valleys is shown by the accompanying profiles and half tones. (Fig. 1 and Plate II.) In the profile it will be noted that Twin Creek, which is taken as a type, starts from the fairly level plateau at an elevation of about 900 feet. Half a mile from the head, as indicated by the dotted line, it has descended 200 feet and presents a narrow V-shaped valley. At a distance of a mile from its head it is 50 feet lower, the lower valley being U-shaped with nearly perpendicular walls to a height of 80 to 90 feet, then the banks slope rapidly up nearly to the 900-foot level. A part of the bluff at this point is shown in Plate II. The descent is still rapid, in the next mile amounting to about 60 feet. This brings the stream down into the soft knobstone rocks, and from this point the descent is slight and the valley rapidly widens out with a flat bottom, though with very steep banks still. At six miles from the head it will be seen that the valley has a level floor nearly a mile wide. The appearance of the valley at this point is shown in Fig. 2 of Plate II. In the case of Twin Creek it crosses a fault a couple of miles above its mouth, beyond which point its valley is cut almost entirely in the hard overlying limestones, and the result is shown in

PLATE II.



VIEWS ILLUSTRATING THE TOPOGRAPHY OF THE AREA.

Fig. 1. View in branch southwest of McKinley Postoffice. Characteristic Knobstone valley.

Fig. 2. In valley of Twin Creek below junction with Rush Creek, showing wide flat valley bottom. The headlands across the valley do not come out distinctly in the picture.

Figs. 3 and 4. Views in Orange County. The valleys are cut in Mitchell limestone; the hills are capped with Huron sandstone.

Fig. 5. View in upper valley of Little Indian Creek, in Harrison County. Shows broad, rather shallow valley. The lower valley of Indian Creek, like that of Blue River, becomes narrow, deep and largely unsuited to cultivation.

Figs. 6 and 7. Views characteristic of the sinkhole area of the Mitchell limestone.

the lowest profile, the valley changing from a width of a mile to a few rods. Fig. 1 of Plate II is looking down a small branch of Buffalo Creek just above where it passes out from between the enflanking ridges. In the case of such streams as Delanys Creek, that occupy a rather broad basin, the side branches have the same characters as that just given, but the sides of the main valley become reduced to a series of parallel headlands with nearly perpendicular

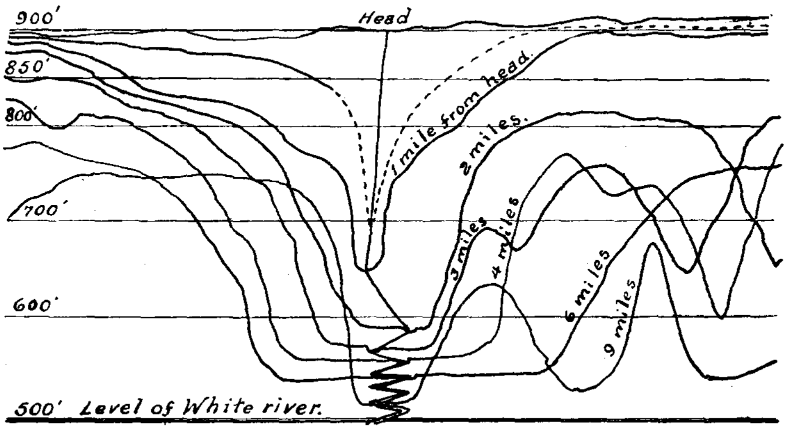


Fig. 1. Orthogram of Twin Creek.

Vertical scale: 1 inch = 200 feet.
Horizontal scale of valley profiles: 1 inch = ¼ mile.
Horizontal scale of stream profile: 1 inch = 4 miles.
The view shown in Fig. 2 of Plate II shows the character of the valley floor at the profile at six miles from the head, east of Mt. Carmel.*

faces 250 to 300 feet high, standing between the entering side valleys. Where the valley has a flat floor a mile wide, such a series of headlands make a striking appearance.

*A word of explanation may be needed in regard to the orthographic drawings presented with this report, as it is probable that this is a new use of the word orthogram, applied to a new method of representing topography. In a word, this method consists in projecting a series of equidistant profiles upon a vertical surface. This is strictly carried out only in the orthogram of Little Pigeon Creek. In that are represented a series of vertical profiles of one-half of the creek valley taken at points five miles apart. A modification of this may be necessary or desirable in some cases, where data is lacking for all the profiles, or where, on account of the length of the valley or topographic feature being studied, or for other reason, a limited number of profiles will best give the desired result. In such cases such profiles only may be given as are desired or as have been obtained. When this is done some means of indicating the relative distance apart of the profiles is necessary. In the cases presented, those of Twin Creek and Blue River, we have assumed a vertical profile of the stream bed to have been folded back and forth at equal horizontal distances, the horizontal scale in the cases given having been purposely taken very small as compared with the vertical. The zigzag line thus obtained is then projected on a vertical surface, and the vertical profiles are placed on this at the proper points. The vertical scale being stated or placed on the ortho-

Central Plateau Type.—Standing at the head of one of the streams just described a most striking contrast is presented. To the east or north the streams have cut down so sharply that a stone may be rolled down 100 to 150 feet in the head of a ravine, while on the other side in most places is a gently sloping plain into which the streams have cut only shallow channels as far as can be seen. We may first study the valleys of this region, of which the valley of Blue River has been selected as a type. As shown by the profiles, Fig. 2, this starts on the nearly level edge of the plateau at an elevation of about 900 feet. The first part of its course it occupies a broad valley with gentle slopes, almost entirely under cultivation, in striking contrast with the upper part of the streams, of which Twin Creek, was taken as a type. In the case of Blue River the creek cuts through into the soft Knobstone strata for a short distance, giving a flat valley bottom a quarter of a mile wide and rather steep banks for 30 to 40 feet. By the time Salem is reached the dip of the rocks, which is greater than the gradient of the stream, has carried the Knobstone under and the stream is again flowing over limestone. The low gradient above this point where it is flowing through the Knobstone is shown by the figure. Figs. 2 to 4 of Plate III are views in this valley a little southwest of Canton where it has cut through into the Knobstone as described, and Fig. 1 of Plate III shows the character of the flow of water. From Salem to its mouth Blue River continues as a rapid stream with a nearly uniform de-

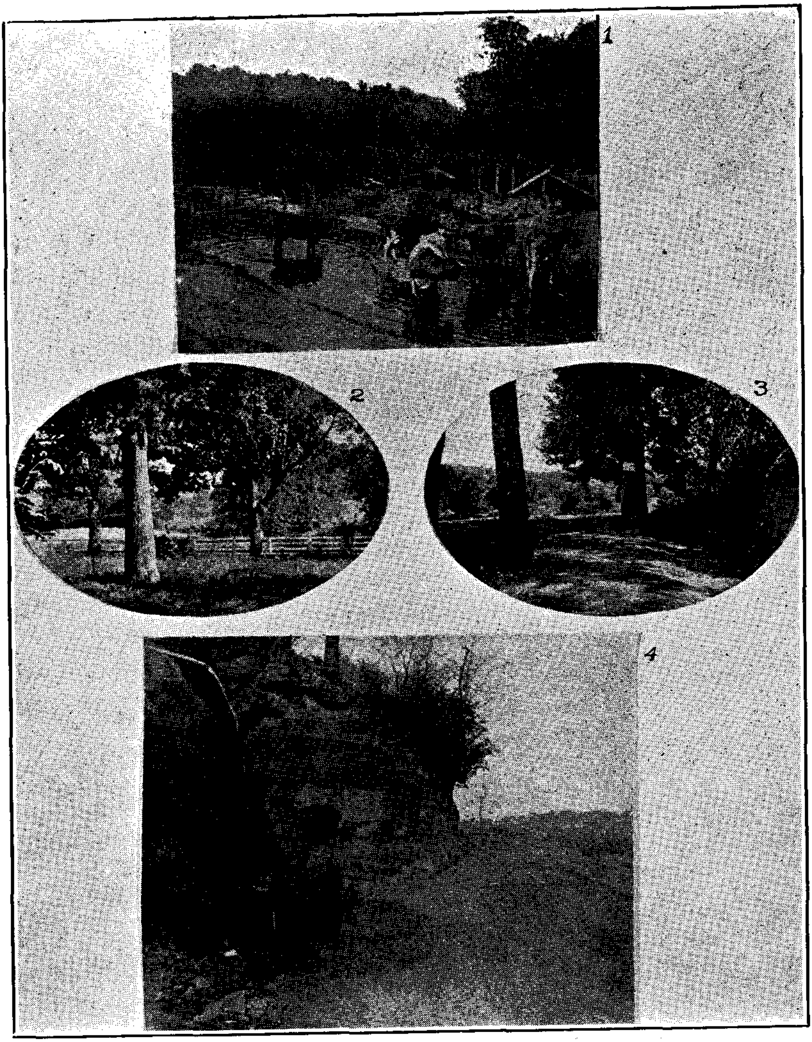
---

gram, as in the accompanying examples, may express not only the vertical value of the profiles, but the gradient of the river between the equidistant points chosen on the horizontal. Thus, in Fig. 1, the original profile of the bed of the stream (assumed, but of course not separately drawn) had a vertical scale of 200 feet to the inch, and a horizontal scale of four miles to the inch. This is supposed to have been folded at each mile, or at horizontal distances one-fourth inch apart.

Interpreting Fig. 1, it is seen that Twin Creek rises in a fairly level country, at an elevation of 900 feet. In its first mile, represented by the line running downward from the word "Head" and to the left, it descends to about 650 feet above sea level. The profile shows the shape of the valley at this point. The profile at one-half mile is shown by the dotted line. Successive shapes of the valley are shown at distances of 2, 3, 4, 6 and 9 miles from the head by the successive profiles, and at the same time is shown the change from a very high gradient in the first mile to a moderate and finally to a low gradient in the last miles.

In its unmodified form the orthogram, as thus described, is intended to give an outline view of the shape of a valley as viewed from the mouth, assuming the stream to have been straightened so as to give an uninterrupted view up its valley. While it is believed that there will be many to whom this method of practically vertical contours gives a clearer mental picture than the horizontal contours usually used, it is believed that its principal advantage will be where, as in this case, it is desired to make comparison of certain general features of two or more stream valleys and where the data is not at hand for making a contour map. It has the advantage over the hatchure method often used in such a case of giving definite and accurate information as far as it goes, and in a very condensed form. The relative or actual elevation of outcropping rocks can be readily shown on the profiles, thus serving in many cases to show the cause of minor topographic features. It seems possible to apply the same idea to hills or ridges of limited extent, associated with indicated structure.

PLATE III.



Views in the upper part of valley of Blue River, between Salem and Canton. The river here is flowing through a fine farming country, in a broad, shallow valley. The stream, as shown in Fig. 1, has a quiet flow, with few rapids and slight descent.

scent of about five feet to the mile, but its banks gradually increase in height and average steepness, as is indicated in the profiles. A few additional figures will help to make this character more real. Fig. 2 of Plate IV shows Blue River near Beck's Mill, at the point of the fifth profile. Figs. 3 and 4 of Plate IV give views at the succeeding profiles, near Sharp's Mill and just above Wyandotte. Fig. 1 of Plate IV shows the river at Fort Hill.

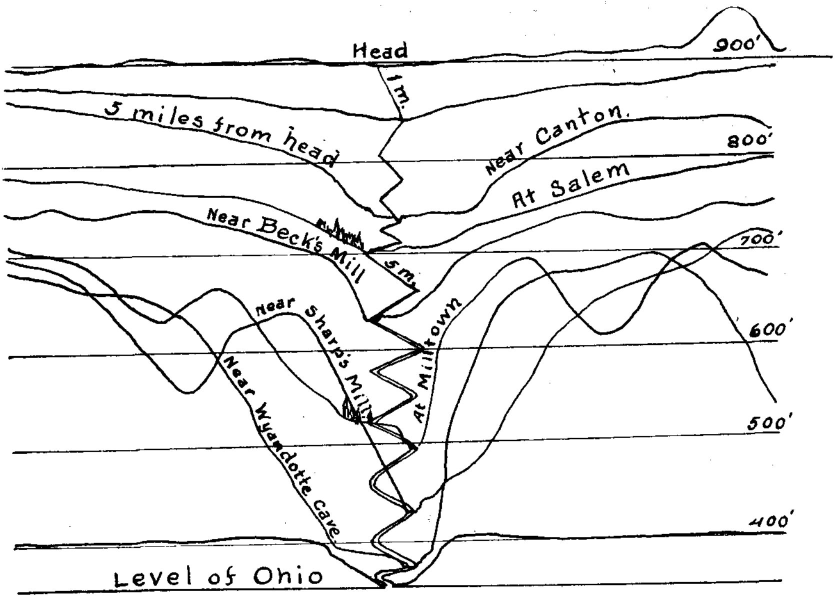


Fig. 2. Orthogram of Blue River.

Vertical scale: 1 inch = 200 feet
Horizontal scale of valley profiles: 1 inch = ¼ mile.
Horizontal scale of stream profile from head to Salem: 1 inch = 8 miles; from Salem to mouth: 1 inch = 20 miles.
Plates III and IV give views at points along the valley of Blue River.

Before attempting to interpret this type of valley topography it will be of interest to compare it with that found 50 miles further west. Fig. 3 gives a series of contours across the valley of Little Pigeon Creek taken five miles apart. In this case it will be noticed that almost the total descent of the stream is in the first five miles, amounting to about 100 feet in the first half mile, while the stream along its lower half has a fall of only a foot a mile or less. In this respect it would seem to resemble the streams of which Twin Creek was taken as a type, but examination shows some decided differences. Twin Creek has all along its course steep, precipitous banks. Pigeon

Creek has well rounded banks, nearly everywhere suitable for cultivation. Twin Creek has broad bottoms, but evidently carved out of the rock by erosion, the creek bed being everywhere in rock. Pigeon Creek's broad bottoms are evidently due to the filling of sunken valleys. The difference between the Pigeon Creek valley of erosion and the filled valley is well shown by comparing the valley just east of Ash Iron Springs, where the creek is at present running in a recently eroded channel, with the valley at other points. In brief, the area in which Pigeon Creek lies has evidently sunk below drainage level so that all the valleys have filled up until the streams have been raised so that they will run off again. At that point the sinking has been estimated at not less than 100 feet.

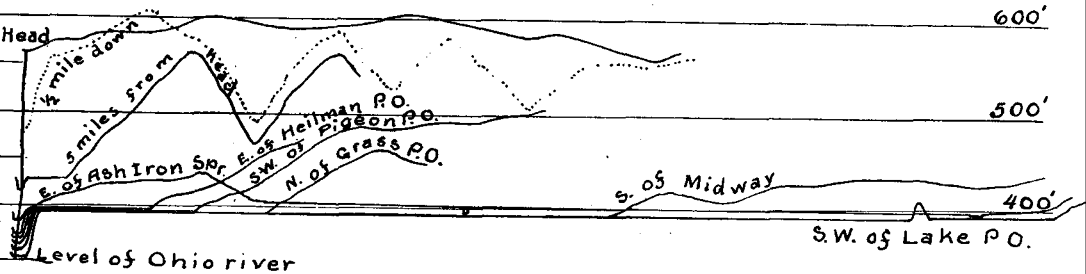
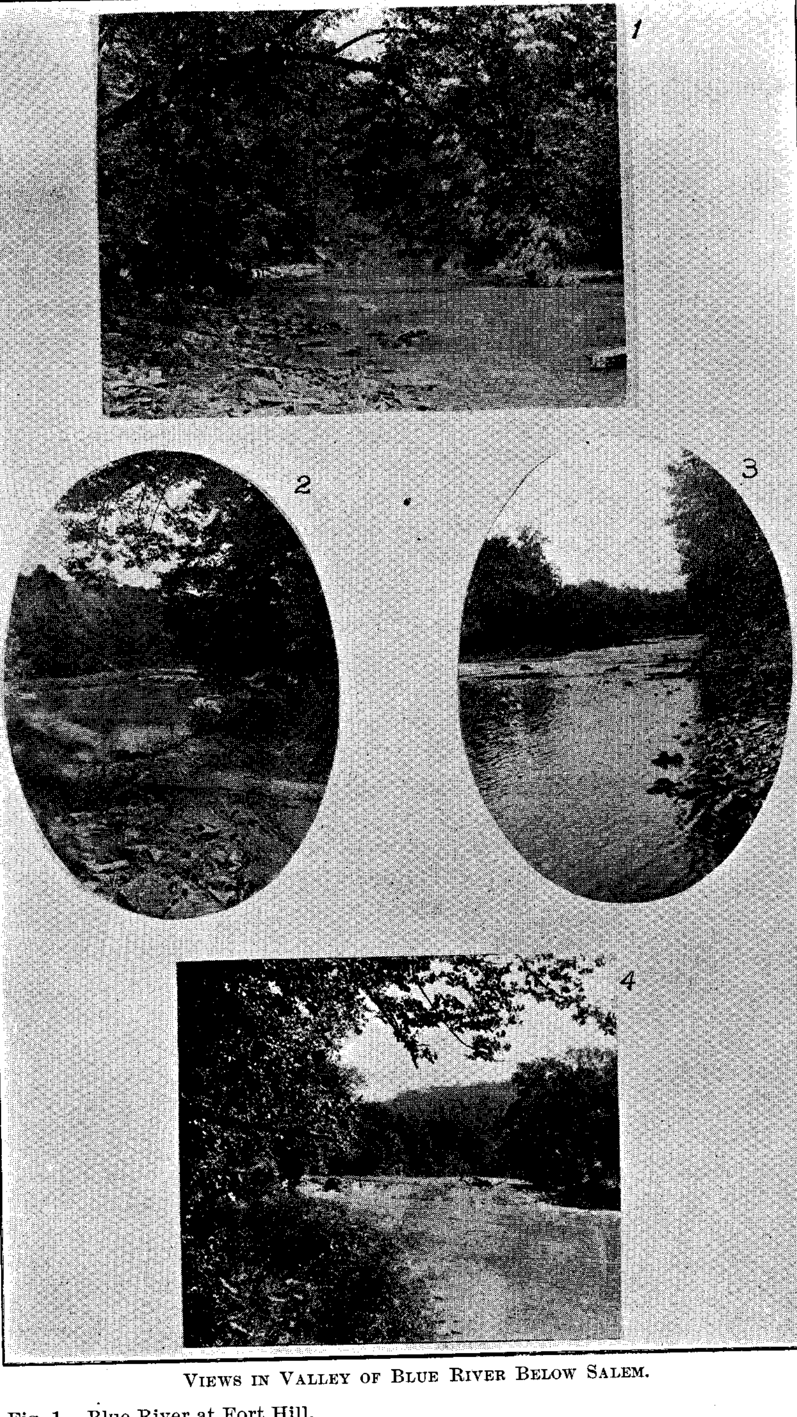


Fig. 3. Orthogram of valley of Little Pigeon Creek. Horizontal scale: 1 inch = ¼ mile.

Turning again to the region of Blue River, it is at once evident that that region has not suffered the same depression as has occurred to the west. On the contrary the evidence is quite strong that the Blue River region has recently been uplifted. For those not versed in geology a few words of explanation may help to make clearer the nature of the evidence. As is well known, if any region of land remains at one level for any length of time, erosion tends gradually to lower the valleys, then to widen them, reducing the height and steepness of the intervening hills, and if allowed to continue long enough, the land will become a flat base level, as it is called. If at any stage in the process, say when the area in question has been reduced to a gently rolling type of country, uplift takes place in part of it, it is evident that the streams that rise in the uplifted area will have their upper courses in shallow valleys with gently sloping banks just as before the uplift. When, however, the stream reaches the edge of the uplifted portion, where it slopes down to the portion not elevated, or where it runs into the channel of a large stream that has cut down below the general level of the plateau, it will become a rapid stream and one that will erode and deepen its channel rapidly.



VIEWS IN VALLEY OF BLUE RIVER BELOW SALEM.

Fig. 1. Blue River at Fort Hill.
Fig. 2. Blue River at ford near Beck's Mill.
Fig. 3. Blue River at Sharp's Mill Postoffice.
Fig. 4. Blue River at ford near Wyandotte Cave.

Below Salem, Blue River becomes more rapid, and the banks finally become toward the mouth from 300 to 400 feet high, and steep, leaving little or no bottom land, and making a narrow valley.

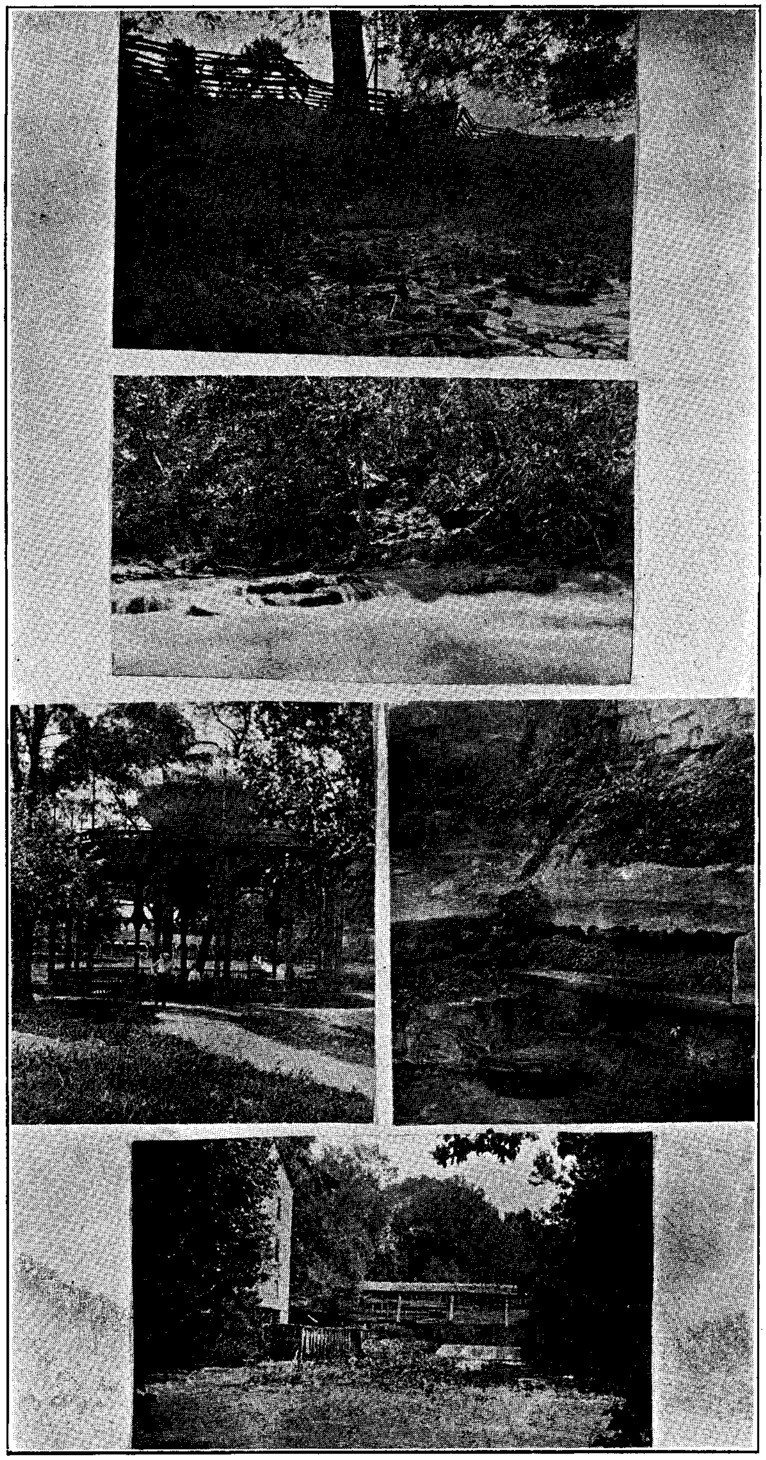
A gorge will thus be started at the edge of the plateau or at the mouth of the stream, which will rapidly tend to eat its way back into the plateau. With the process only partly completed we should have just such conditions as we find in the valley of Blue River, Indian Creek, Buck Creek and the other creeks of that region,—headwaters in shallow valleys with gently sloping banks, changing in their lower courses into rapid streams flowing through deep gorge like valleys. In the case of Twin Creek and the creeks flowing north and east, the soft and easily eroded nature of the Knobstone has allowed the erosion to proceed more rapidly so that the gorge has in many cases sunk its bottom down to drainage level, and the point of rapid descent has advanced from the mouth to the head waters on account of the shortness of the stream. Indeed in many cases it is evident that, due to their shortness, these northward and eastward flowing streams are cutting down the divides at the expense of the streams flowing the other way. A good illustration of this, "river stealing," as it is called, is seen about Borden. The valley in which Borden lies originally drained to the northwest, the divide being nearly as far east as Broom Hill. But the Muddy Fork of Silver Creek having cut down its side of the divide faster than the stream draining to the northwest, has captured all the drainage about Borden and it is only a question of time when it will extend up so as to tap the Mutton Fork of Blue River at Pekin and divert all the drainage above that point to Silver Creek.

Upland Types of Eastern Plateau.—In addition to the valley types already described, several features of the intervening divides remain to be noticed. First are the remnants of an old sea bottom or peneplane. It would appear that at some time not long ago, geologically speaking, the eastern part and possibly all of this area had been reduced to a nearly level plain and covered by the sea. Remnants of this old plain are still to be seen along the crest of the divide in eastern Harrison and Washington counties and western Floyd County. It is best preserved at the south, being over a mile wide east of Elizabeth. It may be doubted if any of the original flat surface still remains, but its influence is still evident in the nearly level divide, often from a half to a mile wide at points all the way from Buena Vista to Martinsburg. It is always accompanied by sands or gravelly deposits to be described later. North of Martinsburg the original level has disappeared, but a number of very high points, such as Spurgeon's Hill, must reach very nearly to the old surface, as remnants of the characteristic sandy deposits still cap them. These hills often rise as sharp conical knobs some miles from the divide and frequently

100 feet or more above the adjacent upland. At the south this plain appears to be between 800 and 900 feet above tide, while to the north some of the hills mentioned rise to 1,000 feet above tide. Whether the difference in elevation is due to unequal uplift or to the original slope of the sea bottom is not plain, probably both. The character of the deposits indicate that the original slope was from the north.

Descending to the west or southwest from the eastern edge of the plateau the country changes from a nearly flat to a gently rolling type in which the hills rise from 25 to 100 feet above the adjacent valleys, but with generally rather gentle slopes from hill to valley. A little further in the same direction finds the hills maintaining about their same height, while the valleys have steadily cut down, resulting in a much more broken type of topography. Still continuing westward the last type is replaced by large areas of sink-hole type. In these areas surface streams are wanting or as a rule are very short, and the surface presents the appearance of a nearly level plain, as viewed at a short distance; but at close range more or less completely dessicated by sink-holes. These may range from little round or oval depressions a rod or less wide and from a few feet to 40 or 50 feet deep up to a miniature drainage system, with little valleys often a mile or more long all converging at one point where the waters pass under ground. In places in this sink-hole area are to be found flat, often almost drainless tracts of prairie land. The level upland of this central region is believed to be the fairly well preserved remnant of gradation plains extending up the Big and Little Blue rivers, Indian Creek, etc. Similar gradation plains have been noted further east at slightly greater elevation. The plain rises from about 550 feet above tide, near the Ohio, to nearly or quite 900 feet above tide about the head waters of Big Blue River. The streams which are barely trenched in this gradation plain at their heads are 150 feet or more below it toward their mouths.

At the western edge of the sink-hole region it is everywhere encroached upon by hills and ridges capped with sandstone. These usually rise 100 to 150 feet above the general level to the east. They are sometimes found long distances east of the main body of rocks to which the sandstone belongs, and range from sharp conical sugar loaf hills, as Pilot Knob, near Corydon, to narrow-topped, steep-sided, ridges of extremely irregular shape. In Harrison County many of these knobs and ridges do not show any sandstone at present, or sometimes only a few scattered boulders can be found, but in either case they were capped with sandstone formerly, though it has now been removed by erosion.



1

2

3

4

5

TYPES OF SPRINGS IN THIS AREA.

Fig. 1. Spring near Blue River on road east from Beck's Mill. A common type in this area.
Fig. 2. Clifty Creek, below spring. A type of large springs associated with caves.
Fig. 3. No. 3 Spring at West Baden. Type of mineral spring not rising quite to surface.
Fig. 4. Pluto Spring. Freely flowing mineral spring.
Fig. 5. Stream from Harrison Spring. Small river rising to surface and flowing away. The drainage of a large area rises to the surface in such a spring. Photo taken in August, in dry season.

Type of the Western Upland.—The isolated hills and ridges last described become more numerous to the west and occupy larger and larger areas until the flat intervening areas are reduced to narrow V-shaped valleys, often 200 to 300 feet deep and sometimes hardly wide enough to allow the building of a road beside the stream.

DRAINAGE.—There is not as yet sufficient data at hand to enable making anything like a thorough study of the drainage of the area and its interpretation. It has already been stated that the present drainage appears to date from the elevation that followed the laying down of the Ohio River beds. Where this uplift had its center has not as yet been discovered. The difficulty is to differentiate that movement from those that followed in the Pleistocene. As the writer hopes to be able to make further studies along this line he will here only call attention to some of the most salient features of the drainage.

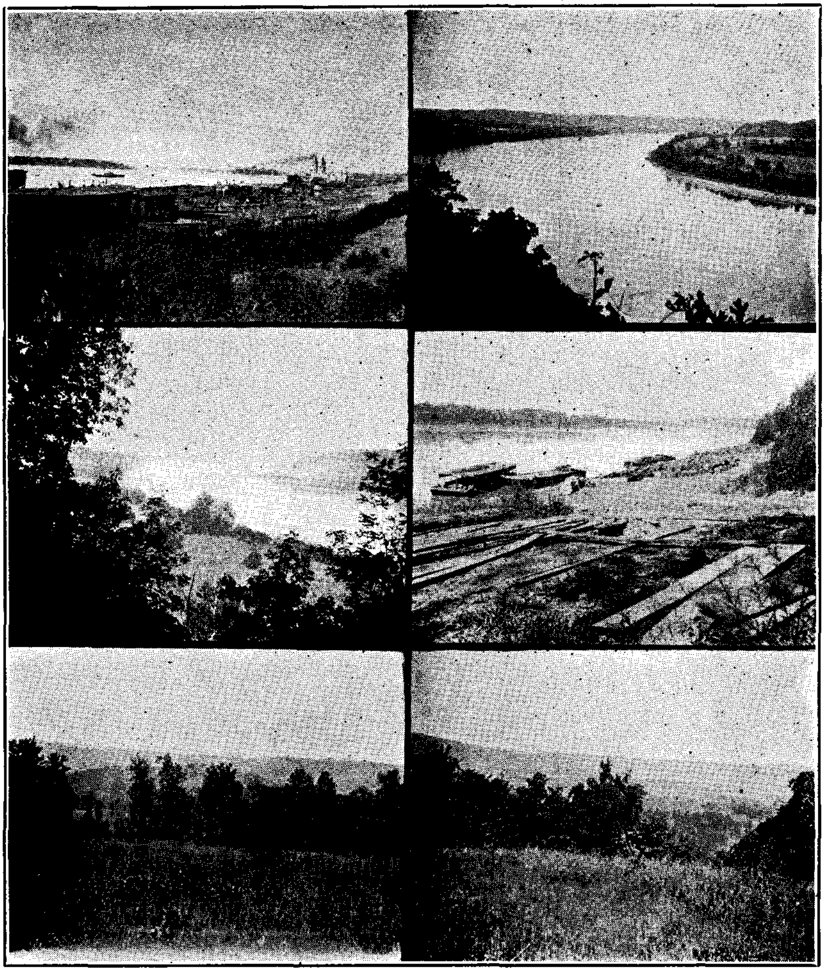
In general the drainage is to the southwest. Along the northern edge of the area the drainage is north and northwest into Muscatatuck and the East Fork of White River. Most of the eastern edge drains east and southeast into Silver Creek. From the edge of the central plateau the drainage is to the west and south into Blue River, Indian, Buck, and Mosquito creeks. Orange County drains to the west by Lost and Patoka rivers; Crawford County drains south in the main by way of Little Blue River; Perry County drains southeast by Oil and Poison creeks and southwest by Anderson River.

In the sink-hole region the drainage is almost entirely subterranean. The result is seen in the lack of surface streams, in the lack of stream valleys, and in the presence of caves and large springs. This region contains the well known Wyandotte and Marengo caves, besides a large number of other caves, mostly smaller, though many of them are of no small interest. (See the Twenty-first Annual Report of this Department.) This is a notable region for springs. The famous French Lick and West Baden springs occur in this region, also the well known sulphur springs at Sulphur Well Postoffice, in Crawford County, and at Corydon. Fig. 3 of Plate V, shows the No. 3 Spring at West Baden, and Fig. 4 shows the Pluto Spring at French Lick. Turning to non-mineral springs we find the region abounding with them of every size.

The top of the Knobstone is a notable spring horizon, especially where erosion has cut across this down the dip, in which case a succession of springs marks the horizon. The larger springs are mostly found further west, bordering the sink-hole region. A number of these are used to run mills or have been in the past. Of these may be mentioned: Clifty Mill, two mills in Twin Creeks, Beck's Mill, Organ Springs, in Washington County, and Harrison and Boone's Mills in Harrison County. Fig. 1, of Plate V, gives a spring such as is common all over the western part of the two counties mentioned. The spring figured is from near Beck's Mill. Fig. 2 of the same plate shows Clifty Creek a short distance below the springs; while Fig. 5 shows Harrison Spring Creek a quarter of a mile below the spring. This subject will be referred to again under the head of "Water Power." An interesting feature of the underground drainage of this region is the passing under ground for a greater or less distance of surface streams. The most notable case of this kind is Lost River. This stream, after rising in Washington County, flows a third of the distance across Orange County, then passes underground, in the so-called "Sink of Lost River." The River appears again at Orangeville at the "Rise of Lost River." It would appear that a large stream from the north enters Lost River in the underground part of its course. Parts of this channel may be explored from a boat. At times of high water the river occupies a channel upon the surface indicated by dotted lines on the map. It is of interest that this channel becomes filled from the lower end rather than from the upper end. Thus, for a short time the peculiar condition exists of the river flowing down stream through its underground channel and upstream in its aboveground channel. Indian Creek has an underground channel several miles long, starting a few miles below Corydon, as indicated on the map. In this case, however, the stream occupies its surface channel except at extreme low water, when the surface channel is practically abandoned, the underground channel at such times serving to carry the full volume of the stream. In several cases the roofs of these underground streams have fallen in for short distances. In some cases there are only a few yards between the points of appearance and disappearance of the stream, while in others the stream may be exposed for a quarter of a mile.

Many interesting problems present themselves for solution in connection with the drainage of this region, which will require further study. Thus, a comparison of the valley of White River along the north side of Washington County, or further up stream, with its valley a short distance above the mouth of Lost River will show a marked contrast, the valley being only a quarter of a mile wide in the latter region, as against several miles in the former region. How much of this difference is due to difference in the rock through which it flows and how much to earth movements and possible changes in channel? The Ohio River presents somewhat similar problems.

PLATE VI.



1 2

3 4

5 6

VIEWS ALONG OHIO RIVER SOUTH OF THIS AREA.

Fig. 1. At Louisville.
Fig. 2. Bend at Brown's Landing.
Fig. 3. East from Brown's Landing.
Fig. 4. At Tobacco Landing, near Laconia.
Figs. 5 and 6. Ohio Valley, near mouths of Blue River and Indian Creek, taken from high upland.

Plate VI gives a series of views extending from Louisville to Leavenworth. At Leavenworth the river, ten feet above low water, is 1,920 feet wide and the valley from bluff to bluff 3,960 feet wide. The river continues in this narrow gorge-like channel to Cannelton or beyond, but 20 miles further west it is found flowing in a valley four or five miles wide. In this case the difference in the width of the valley would seem to be mainly due to recent uplift at the east. A study of the course of the Ohio, as well as of the courses of Blue River, Indian Creek and others of the region, suggests very strongly that their present courses are largely a survival of their courses when flowing at the level of the upland or gradation plain then nearly at base level. Thus, take the horseshoe curve at Leavenworth, the two arms of the curve are separated by a high divide with bluffs as marked and precipitous as on the outside of the curve, indicating that the river has sunk its channel *in situ*. The same thing is very noticeable in following down Blue River where horseshoe curves abound, and in most cases the arms of the curve are separated by high divides.

GENERAL GEOLOGY OF THE AREA.

STRATIGRAPHY.—*General.*—The area to be studied has been limited to the area of outcrop of the Lower Carboniferous rocks. On the west they are overlain by the coal measures, as described in the Twenty-third Annual Report of this Department. On the east they are underlain by the New Albany black shale of Devonian age. Quaternary deposits occur in the Area in the form of alluvial deposits in the valleys, and glacial drift in the northeastern part of the area. There are also found deposits of limited extent associated with an old peneplane that evidently are younger than the Carboniferous and older than the Quaternary. They are thought to be of Tertiary age.

The Lower Carboniferous strata consist at the top of alternating limestones and sandstones with some shale for a thickness of from 100 to 200 feet. Below that comes from 400 to 500 feet of limestone with a few very thin beds of shale. One layer of this limestone appears to be of different origin than the most of the stone and can be traced more or less continuously over the course of its outcrop. It is, moreover, of the highest economic value. It has therefore been mapped by itself and will be considered under the name "Bedford Oölitic Limestone." It occurs from 50 to 100 feet from the bottom of the great limestone bed. The limestone below the Bed-

TABLE OF FORMATIONS, ETC.

Age.	Formations or Groups.	Correlations.	Character of Rocks.	Economic Materials.
Quaternary or Pleistocene.	Recent alluvial and lacustral deposits. Glacial drift.	Illinoian.	Gravel, sand. Till.	Road material.
Post Carboniferous (Tertiary?)	Ohio River.	Irvine formation of Campbell. ?	Sands, gravels.	Glass sand.
Coal Measures.	Mansfield.	Pottsdam.	Massive sandstone, shale, coal.	Building stone, coal.
Lower or Eocarboniferous. (Mississippi Series.)	Huron group.	Kaskaskia or Chester, of Illinois.	Archimedes limestone, upper sandstone, middle limestone, lower sandstones, shales.	Building (sand) stone. Marble. Lime.
	Mitchell limestone.		Lithographic limestone, Oölitic limestone (white). Hydraulic limestone, limestone and shale, cherty limestones.	Lithographic stone. ? Portland cement. Roman cement. Lime. Limestone for glass manufacturing. Limestone for rough masonry. Road material.
	Bedford oölitic limestone.	St. Louis, Warsaw.	Massive, even-grained, oölitic limestone.	Building stone. Portland cement. Lime. Road material.
	Harrodsburg limestone.	Burlington and Keokuk.	Hard limestone with chert and geodes, shale.	Road material. Limestone for rough masonry.
	Knobstone.	Waverly.	Sandstone, shaly sandstone, shale, thin limestone.	Building stone. Brick shale.
Devonian.	New Albany black shale.	Genesee.	Black shale (silicious).	Oil, tar, etc.

ford has received the name of "Harrodsburg." The limestone above the Bedford has been called the "Mitchell." Below the Harrodsburg limestone come about 400 feet of shales and shaly sandstones to which the name Knobstone has long been applied. The uppermost beds have been called the "Huron" group for reasons to be given below.

Quaternary Stratigraphy.—Deposits of Quaternary age divide themselves into upland deposits, river deposits from the country rock, from the Illinoian ice lobe, from the Wisconsin ice lobe, glacial drift of Illinoian age.

Mention has previously been made of the limited areas of prairie that occur in the central plateau. No detailed study of these was made but they had all the appearance of water deposits. It was judged that their origin was purely local in character, probably being due to the filling of some large sink-hole or area of former erosion with subterranean outlet, which had afterward become stopped up. In the eastern part of Harrison County are many stretches of flat country, some of which are undoubtedly due to recent deposition by water. Thus, Mr. Collett reports a well on the Conrad Bickell place in Section 1 (T. 4 S., R. 4 E.) as follows:

	Ft.	*In.*
Black soil	1	6
Yellow clay and gravel	15	0
Gravel and sand	8	0
Plastic blue clay	4	0
Sand to limestone	4	0
	32	6

This occurs in what are known as the "flat woods," which occupy a broad area in the eastern part of Harrison County. On the theory that this belt was formerly a gradation plain, these deposits may be described as flood plain deposits.

The deposits along the stream bottoms, except the Ohio, White and Muscatatuck rivers, consist of material derived from the country rock. The narrow valleys of the streams flowing south or west give little room for extensive river deposits, and the rapid character of the streams makes little tendency to form bottoms. The streams to the north and east have broad valleys, but they are in the main valleys of erosion and not of deposition.

Turning to the rivers on the north and south boundary of the area, we find that they take their rise in drift-covered areas, and as a result the alluvial deposits along them contain a large percentage of granitoid and other rocks derived from Canada. Along the Ohio, and the Muscatatuck nearly to its mouth, the alluvial matter consists largely of valley Illinoian, while the alluvial of White River across the northern border of Washington County is a mixture of Illinoian and Wisconsin drift.

The unmodified drift of this area belongs to the Illinoian ice lobe. No attempt was made to trace the boundary of the drift with accuracy. The western limit of the deposit in a general way may be said to cross the Muscatatuck River near the mouth of Elk Creek, in Washington County, and extends southeast to the Ohio River. A large boulder composed principally of hornblende and augite was found beside the road just south of the center of Section 1 (T. 2 N., R. 5 E.). As this is high up on the central plateau, its position beside a road seemed to make the chances strong that it had reached its present position through human agencies. At the southeast corner of Section 32 (T. 3 N., R. 5 E.), a boulder of quartzite 15 inches long was found, but its association with some other quartz and chert pebbles indicated that it might belong to the Ohio River formation rather than the drift.

Ohio River Formation.—Along the divide between the streams flowing east into the Ohio or Silver Creek and the streams flowing west or south are found more or less extensive deposits of sand and gravel, or locally, conglomerate. These sands are the ones that have been extensively dug for the manufacture of glass at New Albany. At the south these deposits have a thickness of from 20 to 30 feet or a little over; to the north they thin out. The thickness given is not the original thickness, which it is more than possible was greater at the north than at the south. In the area being studied these deposits reach their greatest development along the divide east of Buena Vista and Elizabeth. At the old DePauw bank, formerly worked for glass sand, it appears as a deposit of coarse-grained, yellow sand, in large part consolidated into a soft sandstone. On the surface level south and west of the quarry are to be found many boulders of hard brown sandstone that appear to belong to the same deposit. Considering the length of time since active work was carried on here it would appear that the sandstone when freshly exposed must have been much more solid than at present, for as a rule exposure to the atmosphere tends to make it disintegrate rapidly into a sand. The sandstone shows a slight degree of bedding, with false bedding showing abundantly. At or near the bottom of these deposits, here and at other mines in the region, it is reported that considerable quantities of kaolin have been found, ranging from white through yellow, red and blue to green. It was sometimes semi-crystalline. It is said that occasionally streaks of black magnetic sand carrying fine gold dust was found in the bottom layers.

The deposits of the Ohio River formation were formerly worked on the flat summit of the ridge east of Martinsburg on the border between Washington and Clark counties. Here the deposit shows seven or eight feet of brown sand, then from 12 to 16 feet of sand that varies from white to brown, much of it being white with bands of brown following the lines of cross-bedding. Under the glass this sand, as at all places examined, shows grains of clear transparent quartz, often stained with iron. In the southwest quarter of Section 11 (T. 1 N., R. 4 E.), similar deposits of sand cap the divide, but associated with the sand is a hard, ferruginous conglomerate. North of the middle fork of Blue River this formation is only found on the tops of the very highest points, and then usually in such a condition as to suggest that none of what remains is strictly in place, being merely fragments of the formation not as yet carried away. These deposits show less sand and unconsolidated material, but instead, are largely conglomerate. In the southwest corner of Section 19 (T. 2 N., R. 5 E.), on a high point east of the road, the deposit consists of scattered boulders of hard ferruginous sandstone. No gravel was seen here. The road between Sections 17 and 18 climbs over the top of a sugar-loaf-shaped hill, 100 feet higher than the surrounding land, which is capped with boulders, some of which are sandstone and some conglomerate. A somewhat similar high hill at the turn of the road at the center of Section 5 of same township, has on the top and slope many blocks of conglomerate up to 2½ feet across. As in all these cases, the conglomerate consists of a matrix of coarse-grained, brown, ferruginous sandstone, like the sand mined further south, in which are imbedded larger masses ranging from small pebbles of quartzite to pieces of limestone a foot square and several inches thick. Some of this conglomerate is fairly soft, breaking readily under the hammer, while other pieces are very hard, requiring many blows of a light hammer to produce fracturing.

Just north of Millport postoffice, in Washington County, the road cuts through a bed of water-worn gravel composed mostly of chocolate-colored chert, pieces of quartzite, and brown and yellow hard sandstone. The pebbles range in size from three inches down. This would seem to belong to the Ohio River formation, but it does not occupy the highest part of the ridge. As it is probably 300 feet or over above the river it would not seem to belong with any of the river deposits. Similar deposits have been found on the highest hills of Martin and Perry counties.

In the bluffs of the Ohio, just north of Enterprise, in Spencer County, at an elevation of 400 feet above sea level occurs a deposit of gravel, of quartz, quartzite and chert, strikingly similar to that found near Millport postoffice, and in general to the beds of the Ohio River formation, as developed in Washington County. It is overlain by loess and thus evidently antedates that formation. It is about 100 feet above low water in the river. The composition of this gravel suggests that it likewise is a part of the Ohio River formation. But its position does not agree with that of the deposits farther east. However, recalling the abundant evidences of recent submergence in the Spencer County area and of elevation in the Harrison County region, it is evident that the possibility of their being the same must be admitted, if not the probability. Much field work must be done in the intermediate territory before satisfactory answers can be made to the questions that suggest themselves. In the meanwhile there seems to be a growing mass of evidence that the region occupied by the present valley of the Ohio River has been base-leveled in pre-glacial times, that sea deposits of limited thickness but of probably wide extent were deposited over the area, that differential elevation has since taken place and the present valleys of the Ohio and its tributaries in Indiana and Kentucky have since been carved out. The lack of any named geographical feature immediately associated with these deposits in the area under study, and the possible wide distribution of the formation in the Ohio River Valley led to the selection of the name used in this report.

Some conglomerates along Middle Creek, in Boone County, Kentucky, from descriptions given by Dr. Geo. Sutton, in 1876, and Mr. E. T. Cox, in 1878, were for a time thought to correspond with the deposits here named Ohio River. However, they have recently been examined by Mr. Frank Leverett, who reports finding about one per cent. of rocks of Canadian derivation, and other evidence, such as their freshness, etc., that has led him to classify them as glacial till, possibly modified by water.*

The suggestion has been made that these deposits correspond with the Irvine formation, described by Mr. M. R. Campbell.†

Upper Carboniferous Coal Measures.—These deposits have been described in the Twenty-third Annual Report of this Department, to which the reader is referred for further information.

---

* U. S. Geological Survey, Monograph XLI, p. 266.
† Geological Atlas of U. S. folio 46, Richmond, Ky., 1898.

LOWER CARBONIFEROUS.

THE HURON GROUP.—The strata at the top of the Lower Carboniferous in Indiana have hitherto been described under the names of Chester or Kaskaskia. The two terms were originally applied to practically the same group of rocks by Messrs. Hall and Worthen independently, one from a study of the series of rocks along the Kaskaskia River, and the other from the study of the same rocks at Chester, Illinois, at the mouth of the Kaskaskia River. The determination that certain strata in Indiana were of the same age as the Chester, or Kaskaskia, of Illinois was, as usual, done through a study of the fossils. The upper limit of the group was easily determined as the bottom of the Coal Measures. In the valley of the east fork of White River the top of this group of rocks seems to be a limestone showing an abundance of Archimedes, and other forms of the Chester group further west. North of Greene County this limestone runs out and finally the lower strata, as well, thin out. South of Orange County again great trouble has been experienced in determining the line between the Coal Measures and what has been called the Chester, mainly on account of the unconformity between the two apparently becoming more marked. In Perry County the worked coal is in places apparently only 10 or 15 feet above a limestone recognized as of Chester age, while only a short distance off it is 135 feet above any such limestone. So that while a limestone has been taken as the top strata of the Lower Carboniferous in that region, it is evident that, if there is any such unconformity as is indicated by the above figures, different limestones have been used in mapping. While the existence of an unconformity in that region is considered well proven, it has been thought possible that much of the difference between the worked coal and the limestone indicated above is due to faulting. Not enough work has yet been done to satisfactorily settle the question. It will from this be evident that the top of what has been called the Kaskaskia is not a single recognizable stratum, but, starting in the north with the lower sandstones or limestones of the group, becomes successively higher sandstones and limestones to the south, with much uncertainty as to the correlation of the upper members in the Ohio Valley. No effort has been made in recent years to trace or even determine the lower limit of the Kaskaskia in Indiana until the field work of the present study. Considerable work was done on that line some years ago by Mr. Collett and others. How far from satisfactory these results were may be judged when it is stated that sandstones that at one point

Mr. Collett places only 20 feet above the bottom of the Chester, at other points within a few miles he placed in the Coal Measures; in one of the latter cases the bottom of the Chester is given as 127 feet below the sandstone. (The sandstone can be easily traced continuously from the locality of one of his sections to the others.)

In his report on Harrison County,—Eighth, Ninth, and Tenth Annual Reports, Geological Survey of Indiana, p. 303,—Mr. Collett gives the following generalized section of the Chester group:

	Feet.
Kaskaskia limestone	5 to 20
Chester sandstone	35 to 70
Thin-bedded lithographic limestone	40 to 20
Carboniferous shale (bone coal)	1 to 0

In a general section of Crawford County, p. 425 of the same report, Mr. Collett gives the following section:

	Feet.
Kaskaskia limestone, upper bed	2 to 10
Black pyritous shale (marl?)	1 to 25
Kaskaskia limestone, lower bed	5 to 20
Massive sandstone, passing into shales and flagstone	20 to 98
Argillaceous limestone in bands	10 to 26
Coal bone	trace to 1
Siliceous limestone and argillite	2

Mr. Gorby gives the following generalized section of the Chester group in his report on Washington County, Fifteenth Report, p. 124:

	Ft.	*In.*
Chester sandstone	10 to 100	0
Coal, semicannel		6
Thinly bedded gray limestone	5 to 20	0
Heavy bedded lithographic limestone	10 to 40	0

In Orange County Messrs. Elrod and McIntire found the following general section, Seventh Annual Report, p. 207:

	Ft.	*In.*
Chester limestone	17	0
Chester sandstone	105	0
Chester limestone	25	0
Chester sandstones.		
Heavy bedded or shaly, red or blue	5	3
Coal		4
Sandstone or shale	30	0
Limestone, massive and heavy bedded	50	0
Chester chert	1	0
Limestone, locally lithographic	40	0

In the Washington and Harrison county sections only the bottom of the Chester is given, the top not occurring in those counties.

The above sections have had their limits determined by an examination of the contained fossils and a comparison with the fossils of the Chester in the original locality. In these sections a heavy bedded sandstone is recognized in each near the bottom, underlain by from 20 to nearly 100 feet of limestone. An examination of the same sections as originally published shows that in each case the top of the next division below, the St. Louis group, is a limestone, and limestone continues on down with more or less variation for 100 to 200 feet or even more. Thus, the bottom of the Chester, as determined from the life forms, has been found to occur in the center of several hundred feet of limestone with no constant lithologic features to mark the line. An examination of the local sections given by the above geologists shows a still greater lack of constant, lithologic features to mark the line between the two groups; in fact, in many or most of those sections little or no attempt was made to indicate exactly where the line came. If this line can not be drawn at the few places where the exposures warrant publishing sections, how useless to attempt to draw it over the hundreds of miles of its outcrop in the region involved.

In view of these facts it became evident that if any lines were to be shown on the maps between the bottom of the Coal Measures and the Bedford Oölitic limestone some other horizon would have to be chosen than the bottom of the Chester, as determined by the fossils. A study of the conditions in the field showed that the bottom of the lowest, heavy sandstone, could be followed with some approach to certainty. As this was the nearest horizon to the bottom of the Chester available it was chosen for the purpose of mapping. Having done that, it was necessary to refer to the group of rocks between this line and the bottom of the Coal Measures, and as this line in places appears to be half way up in the Chester group it was evident that the use of the words Chester or Kaskaskia would not be correct, and at Mr. Hopkins' suggestion the name "Huron" has been adopted, on account of the complete and fine exposure of the rocks of this group at that point in Lawrence County. It has been further agreed since the term "Mitchell" was applied to a lithologic group of rocks, that though the top of the Mitchell was originally defined as the bottom of the Kaskaskia, in view of the impossibility of mapping the bottom of the Kaskaskia, for the reasons given above, the rocks included in the term Mitchell should be continued up to this line at the bottom of the sandstone. This rather full exposition of our reasons for adopting a new term has been given because of certain criticisms that have been made of the present survey on account of the introduction of new names in the past. It may be added further that in this matter we are confronted with a condition, not a theory, and that in meeting the condition we have tried to follow the methods now in use in all the better State and government surveys.

From what has preceded it is seen that the Huron is, in the main, an alternating series of thick-bedded sandstones and limestones, with smaller amounts of shale and one or two coal horizons, in which the coal seldom reaches a thickness of more than four inches. At the top is a noticeable unconformity with the overlying Coal Measures. See the Twenty-third Annual Report of this Department, for a discussion of this unconformity, with figures. As stated above, the Huron appears to have been laid down in a retreating sea. That is, when the lowest or earlier beds were being laid down the shore was in northern Indiana, and as the succeeding beds were laid down the shore gradually shifted south so that the upper beds were limited to the south part of the field. The group has a thickness of from 100 to 150 feet or more in the region being studied. The following sections, obtained by Mr. Kindle, give some idea of the stratigraphy:

Section at Foote's Spring, southwest quarter of the southwest quarter of Section 11 (T. 1 N., R. 2 W.):

	Ft.	*In.*
Slope with Mansfield fragments	18	0
Huron.		
Upper Kaskaskia limestone	15	0
Upper Kaskaskia sandstone	35	0
Middle Kaskaskia limestone	16	0
Lower Kaskaskia sandstone	30	0
Mitchell.		
Lower Kaskaskia limestone, etc	6	0+

In contrast with this simple section may be given two sections from Leavenworth. The first is from the wagon road leading up to the State road:

	Ft.	*In.*
Massive buff sandstone, rather soft	4	0
Covered, with sandstone debris	6	0
Light gray clay, nearly free of sand	1	0
Covered	2	0
Soft, shelly sandstone	1	4
Bluish drab, sandy clay shale	6	0
Dark blue clay shale	5	0
Green, slightly sandy clay shale, with limonite concretions	6	0

	Ft.	In.
Blue clay shale	6	0
Sandy blue shale	0	6
Coarse, brown, cross-bedded sandstone	3	6
Blue clay shale	5	0
Crystalline, gray to bluish, limestone	8	0
Bluish drab to green, clay shale with dark red patches, iron ore toward base	5	0
Shelly, gray sandstone and shale	3	0
Blue clay shale	6	0
Brownish crystalline limestone, splitting into thin layers ... 3 to	4	0
Brown calcareous, sandy shale and limestone	1	0
Blue clay shale (Level of cross roads)	4	10
Hard, fine-grained, crystalline, blue limestone	1	4
Blue clay shale, interbedded with coarsely crystalline limestone	3	10
Fine-grained, bluish gray, lithographic to sub-crystalline limestone	5	0
Bluish gray clay shale	2	8
Thin bedded and shelly sandstone	5	0
Sandy, blue shale with mica and traces of plants	5	0
Gray to brownish, coarsely crystalline limestone. .3 to	4	0
Gray sub-crystalline limestone, in 2 to 4-foot strata	16	0
Blue clay shale	1	0
Very soft, buff sandstone, bedding irregular to Mitchell. (See page 81)	8	0

Another section made above the reservoir gave:

Blue and greenish clay shale	30	0
Hard, bluish to gray, crystalline limestone	10	0
Covered	5	0
Drab sandy shale	2	0
Covered (clay shale?)	8	0
Gray, coarsely crystalline. limestone	2	0
Covered	1	0
Sub-crystalline to oölitic, gray to brown limestone, with some sand	3	0
Covered	2	0
Hard, brownish buff sandstone	1	10
Shelly sandstone	1	8
Bluish, sandy shale	4	0
Covered (clay shale?)	5	0
Gray, crystalline to sub-crystalline limestone	18	0
Buffish, irregularly bedded sandstone	8	0
Mitchell.		

The following section was obtained at Fredonia:

	Ft.	In.
Massive, thin-bedded sandstone	9	0
Covered	8	0
Gray crystalline limestone	4	0
Gray oölitic limestone	15	0
Massive buff sandstone	8	0
Drab colored, shelly sandstone, merging into massive sandstone	10	0
Dark blue clay shale	3	0
Shelly sandstone	7	0
Blue clay shale	1	0
Brownish crystalline limestone .....15 in. to	2	0
Bluish crystalline limestone	6	0
Blue clay shale	4	0
Shelly drab sandstone	1	0
Covered	3	0
Gray limestone	5	0
Covered	3	0
Buff sandstone	3	0
Covered	3	0
Blue clay shale	3	0
Mitchell limestone	10	0+

Near the head of the middle fork of Indian Hollow, Section 1 (4 S., 1 E.), the following section was obtained:

	Ft.	In.
Covered from level of wagon road	6	0
Shelly buff sandstone	5	0
Blue clay shale	3	0
Crystalline gray limestone	6	0
Covered	4	0
Bluish clay shale	0	6
Impure drab shelly limestone	1	2
Dark blue clay shale	7	0
Greenish clay shale	1	0
Covered	6	0
Sandy shale and shelly sandstone	5	0
Drab-colored clay shale	2	0
Thin-bedded to shelly sandstone	4	0
Brownish to buff, hard sandstone, in two to five foot strata	15	0
Gray sub-crystalline limestone	12	0
Covered	10	0
Shelly gray limestone	2	0
Buff earthy limestone	4	0
Covered	20	0
Gray limestone	3	0
Covered	4	0

	Ft.	In.
Sub-crystalline limestone	6	0
Covered	3	6
Hard, brownish sandstone, with sigillaria	1	6
Shelly buff sandstone	1	0
Mitchell, light gray sub-oölitic limestone	10	0

At the east the base of the Huron is represented by a considerable thickness of sandstone at the bottom. Thus in Section 5 (4 S., 3 E.), the section from the top of the hill shows:

	Ft.	In.
Sandy soil	20	0
Red ferruginous, coarse-grained sandstone	18	0
Gray and red limestone	12	0
Red and blue shales and sandstone	40	0

At the Rothrock Cliff in Section 34 (3 S., 2 E.), this shale and sandstone shows as follows:

	Ft.	In.
Laminated clay shale	14	0
Massive, gritty sandstone	8	0
Soft ferruginous sandstone	11	0

The limestone shows further up the hill but back from the cliff with no connected section between.

In tracing the line at the bottom of the Huron it was found that the lowest bed of sandstone, often only a foot and a half thick, was quite commonly filled with sigillaria, and was conveniently referred to as the sigillaria sandstone.

The distribution of the Huron is shown on the maps.

THE MITCHELL LIMESTONE.—A glance at the maps will show that the eastern and western limits of the Mitchell are generally 10 to 15 miles apart, and in no place less than about three miles apart in this area; therefore, at no point was it possible to obtain a single complete section. Furthermore, on account of the generally level character of the country where the Mitchell outcrops and the absence of valleys, due to the underground character of the drainage, extensive exposures of the Mitchell rocks are not common, in fact not common enough to permit saying whether certain somewhat similar beds were at the same horizon or not. And as no well records were found that were considered reliable in their determination of the variations in the limestone the result was that no complete section of the Mitchell was obtained. The best exposures of Mitchell rocks were found along the Ohio River. Perhaps the best estimate of the thickness of the Mitchell was made at Corydon. The top of the

Mitchell is found in Pilot Knob at 265 feet above the creek, according to the barometer. The bottom of the Mitchell is last seen at the quarry, four miles east of Pilot Knob. The average dip of the strata along the Air Line Railway, a few miles north, is found to be approximately 33 feet to the mile. If the same dip holds between the foot of Pilot Knob and the quarry, the bottom of the Mitchell should be 100 or 125 feet below the stream at the foot of the knob, allowing for the descent of the stream, or between 350 and 400 feet below the top of the Mitchell in the knob. In a well at Corydon the Bedford stone was not recognized. It was, however, 230 feet to the Knobstone. Allowing 100 feet for the thickness of the Harrodsburg and Bedford, it leaves 130 feet as the depth to the Bedford. It may, therefore, be assumed that in the region of Corydon at least, the thickness of the Mitchell is between 350 and 400 feet.

The following sections from this region and one section from Lawrence County will give some idea of the stratigraphy:

Mr. Siebenthal reports this section in Section 13 (7 N., 2 W.):

	Ft.	*In.*
Drab lithographic limestone	20	0
Chert breccia, rotten, lithographic groundmass	8	0
Bluish drab, fine-grained, fetid limestone	10	0
Lithographic limestone	4	0
Drab, calcareous, clay shale	9	0
Drab, rotten, magnesian limestone, with chert inclusions	29	0
Bluish, vermicular, shaly limestone	2	0
Drab calcareous shale	4	0
Rotten and shaly, lithographic limestone	5	0
Lithographic limestone	2	0
Rotten lithographic limestone	5	0
Drab calcareous shale	7	0
Fine-grained, bluish gray limestone, with conchoidal fracture	5	0
Calcareous clay shale	2	0
Gray limestone, in 8-inch beds	5	0
Fossiliferous, shaly limestone	14	0
Concealed	6	0
Fossiliferous, coarse-grained limestone	2	0
Bedford oölitic limestone	0	0

There is here presented a thickness of 139 feet. How near it reaches to the top of the Mitchell is not known. Apparently the Mitchell is much thinner to the north.

The following section, taken at the perpendicular bluff beside the railroad, a mile north of Corydon, shows the variable tendency of the Mitchell:

	Ft.	In.
Buff to drab and pink, shaly limestone	8	0
Outcrop of same rock, showing only clay to which the limestone has weathered, buff, yellow and red	3	0
Hard, light drab limestone	0	1½
Light brown to nearly black, fissile shale	0	6-8
Solid, dark blue limestone	3	0
Light brown shale and limestone	1	0
Light brown to blue shaly, hard limestone	2	6
Light brown, fissile shale	0	6
Light drab limestone, with plates of chert	4	6
Soft, dark drab shale	0	6
Drab limestone	5	0
Drab limestone, softer than last, to railroad track (12-15 ft. above creek)	2	0

The following section was obtained at the Eichol Quarry on the northeast side of Blue River, opposite Milltown:

	Ft.	In.
Slope, mostly hidden, appears to be mostly brown sandstone (Huron)	24	0
Mitchell.		
Semi-crystalline, semi-oölitic, fossiliferous limestone (trilobite tails abundant)	4	0
Gray oölitic limestone, pentremite bed at top	1	3
Yellowish-brown, sub-crystalline limestone	3	0
Brownish-gray, crystalline limestone	1	0
Hidden (same as last?)	9	0
Light drab, lithographic limestone	3	0
Gray, crystalline limestone	20	0
Hidden to top of quarry face	25	0
Light drab and light brown, lithographic limestone	7	0
Light bluish-drab, calcareous shale	1	3
Light drab, lithographic limestone, slightly cross-bedded, with thin lines of coarse sand grains, especially toward the top	12	0
Light gray limestone	9	0
White to dark gray, oölitic limestone, oölitic structure not distinct	13	0
Hard blue, sub-crystalline, sub-oölitic limestone (crow-feet)	6	8
Bluish-green shale	0	2
Light gray, granular limestone, one notable crow-foot near the middle accompanied with some green matter	5	0

	Ft.	In.
Shale parting	0	1
Interlayered, gray crystalline and oölitic limestone	3	9
Lithographic limestone, in thin layers, with shale partings	2	0
Drab lithographic limestone with calcareous bands and nodules	3	6
Gray crystalline limestone	0	2-6
Lithographic limestone, with numerous flint bands and nodules	7	0
To river, about	10	0

Mr. Collett gives several sections covering about the same strata as the last section. Three of these from the southwest part of Harrison County are given below:

Section at Stockslager's Quarry, Section 21 (5 S., 3 E.). (Eighth Annual Report, p. 403):

	Ft.	In.
To top of hill	70	0
Huron.		
Massive sandstone	6	0
Mitchell.		
Sandy limestone	30	0
Cherty shale	10	0
Shaly limestone	40	0
Gray fossiliferous limestone	5	0
Snow white oölitic limestone	8	0
Banded limestone	8	0
Massive gray limestone	10	0
Cherty shale, with bands of limestone	80	0
Flint balls	10	0
Shaly limestone	30	0

Section at John Brown's Mill, Section 10 (4 S., 2 E.):

Huron.	Ft.	In.
Sandstone	100	0
Mitchell.		
Limestone, etc	22	0
Shaly clay (marl?)	18	0
Shaly limestone	15	0
Shaly clay	11	0
Shaly limestone	35	0
Flinty limestone	30	0
Gray limestone	40	0
Hard limestone	15	0
White oölitic limestone	4	0
Cherty limestone	12	0
Oölitic limestone, fractured	6	0

Section at Kendall's Landing, Section 16 (4 S., 2 E., p. 405):

	Ft.	In.
To top of hill	33	0
Huron.		
Shale and sandstone	17	0
Thin-bedded sandstone	40	0
Massive coarse grained sandstone	7	0
Soft coarse grained sandstone	5	0
Calcareous shale and soft sandstone	20	0
"Keil"	5	0
Mitchell.		
Massive crystalline limestone	30	0
Shale	15	0
Gray and red, laminated limestone	11	0
Fissile, shaly limestone	25	0
Massive gray limestone	25	0
Flinty, shaly limestone	26	0
White oölitic limestone	4	0
Shaly limestone with plates of chert	40	0
Cherty limestone, partly covered	75	0

A part of the section obtained at Leavenworth by Mr. Kindle was given in the discussion of the Huron group. The following section is a continuation of that into the Mitchell. It begins where the other leaves off:

	Ft.	In.
Sub-crystalline to oölitic, gray limestone	6	0
Shelly limestone and shale	1 to	6
Bluish-gray to buff, lithographic limestone	7	6
Buff calcareous shale	0	10
Gray lithographic limestone, in solid ledge	3	2
Clay band	0	0½
Gray lithographic limestone	1	8
Blue and buff clay shale, interbedded	0	8
Hard sub-crystalline limestone	2	0
Buffish to drab colored, granular, soft limestone, with much chert	2	0
Bluish-gray sub-lithographic to sub-oölitic limestone, some chert	4	0
Gray to buff lithographic limestone	7	0
White or light gray, sub-lithographic, sub-oölitic limestone	4	0
Shelly gray limestone	1 to	6
Bluish calcareous shale	0	1-6
Gray oölitic limestone	4	6
Very soft, weathered, buff, saccharoidal, magnesian limestone	6	0
Buff to drab, rather soft, saccharoidal, magnesian limestone	8	0

	Ft.	In.
Clay band and crow-foot seam	0	1-3
Light gray to drab, coarsely crystalline limestone	3-4	0
Bluish-gray, saccharoidal limestone	1 to	8
White oölitic limestone, very pure	4	5
Drab sandy limestone	0	10

For comparison with the bottom of Mr. Siebenthal's section, the following short section of the bottom of the Mitchell is given, taken from the most southern outcrop of the Mitchell in the State, in Section 23 (6 S., 4 E.):

	Ft.	In.
Shaly limestone (Hydraulic)	3	0+
Coarsely fossiliferous, crystalline limestone, some oölitic grain	10	0
Light drab clay shale	15	0
Bluish limestone, like crystalline part of Bedford	10	0
Bedford oölitic stone	7	0

Notwithstanding the thickness of the Mitchell, only one layer was recognized as doubtfully, but possibly persistent. Oölitic structure is fairly common in the formation, but at a large number of points there was found an oölitic bed of unusual purity and whiteness. It ranged from 13 feet in thickness down, generally being from four to 10 feet thick. In different sections it is found from 60 to 185 feet below the top of the Mitchell. It was not definitely determined whether this very white limestone was all at one horizon or not. The recurrence of oölitic limestones of much the same structure, if not the same degree of purity, threw much doubt over the persistence of the very white layer and suggests that such layers are only local facies of the oölitic limestone so common in the Mitchell.

Another facies of the Mitchell that occurs abundantly but is not apparently confined to any horizon, is a fine-grained limestone eminently suited to the purposes of lithographing, provided rock can be found sufficiently free of crevices filled with calcite. As yet no such commercial stone has been found. But in its structure this limestone is clearly a lithographic stone. It appears to be most abundant near or at the very top of the Mitchell, but seems to occur at all horizons down almost to the bottom of the formation.

A third facies of interest, especially from the economic side, is the presence in this series of a shaly limestone that from tests made appears to indicate a suitable stone for the manufacture of hydraulic cement. This runs from 10 to 20 feet in thickness and is found not far from the bottom of the Mitchell. Different sections give its distance above the Bedford stone at from 15 to 70 feet. It is often spoken of as the "hydraulic limestone." It was stated above that many layers of the Mitchell tend to be oölitic. This oölitic limestone is quite distinct from the Bedford oölitic limestone. At first sight the grains are larger, more closely resembling fish roe than the Bedford stone. Closer examination reveals that this oölitic limestone is the result of chemical segregation of the calcite around centers resulting in building up the minute round grains, the grains usually being distinctly visible to the naked eye. The Bedford stone on the other hand has been found to consist of innumerable microscopic shells of the foraminifera, one of the single-celled protoza. This will be discussed more fully further on.

Having noted these three facies of the Mitchell the sections given are sufficient to show that the formation as a whole consists of a variable series of limestones and shales, the limestones greatly predominating.

The general geographic distribution of the Mitchell is shown on the maps.

The Bedford Oölitic Limestone.—This limestone has been so fully treated in the report of Messrs. Hopkins and Siebenthal, 21st Annual Report, that in this report we may concern ourselves mainly with its character and distribution in this area, referring the reader to the report just mentioned for fuller information as to the physical and chemical properties of the stone. In general the Bedford stone is a solid bed of limestone without bedding and usually without fossils of noticeable size. It is very uniform in grain, soft when first taken from the quarry, but rapidly hardening under the weather. It has been found under the microscope that the grains are composed of the microscopic shells of one-celled foraminifera. This grain is easily seen with a magnifying glass and frequently with the naked eye. The grain is much smaller than the white oölitic limestone of the Mitchell. In color the stone ranges from a creamy white to a dark drab, most commonly being between a buff and a light drab. The bed in this region is from 90 feet in thickness down. The thickest stone comes in the northwest corner of the area. A thickness of about 60 feet is maintained along the outcrop to Salem. Then the thickness decreases rapidly to 10 feet or less, sometimes running down to 3 or 4 feet, or even disappearing altogether, and on the other hand occasionally thickening up to 35 feet or more.

In some places the bed seems to have broken up into two or more strata. Thus at the Salem Lime and Stone Quarry is found the following:

	Ft.	In.
Grayish buff limestone	2	6
Grayish buff oölitic limestone	7	0
Grayish buff limestone	12	0
Grayish buff oölitic limestone	30	0

In this case, on microscopic examination, no difference was detected in the two layers of oölitic stone.

In the northwest quarter of Section 27 (2 S., 4 E.), occurs the following section:

	Ft.	In.
Soft shale	10	0
Oölitic limestone, grain medium fine, regular, close	5	0
Limestone, dark blue, oölitic in spots	8	0
Coarse-grained, slightly crystalline, oölitic limestone	5	0
Sub-crystalline limestone, slightly oölitic locally	3	0
Limestone, half oölitic and half crystalline	4	0

In this case, and the same thing is probably true at Salem, the apparent dividing into beds seems to be due to parts of the bed having lost the oölitic character.

The Bedford limestone in this region presents four marked facies. First, there is the characteristic oölitic facies. In this the stone appears as a granular limestone, the grains being almost microscopic shells of foraminifera, with sometimes bryozoa, and occasionally minute gasteropods, all being cemented together by calcite.

In the second facies, the stone is porous, due to the grains having all been dissolved out. Over most of the southeast quarter of Township 2 north, 4 east, all the rock seen on the surface is of this character. To what depth this weathering extends was not ascertained.

In a third facies the calcite is replaced by crystallized quartz, so that the rock which, when held at arm's-length, appears to have the characteristic structure, is seen, on close inspection, to be made up of minute quartz crystals. This facies was found most abundantly around New Philadelphia.

In the fourth facies the rock tends to grade over into a crystalline limestone, probably due to the solution and subsequent deposition of the calcite in the rock. This tendency becomes more and more pronounced in going southward, so that in many places in Harrison County it was not possible to recognize the horizon of the Bedford stone.

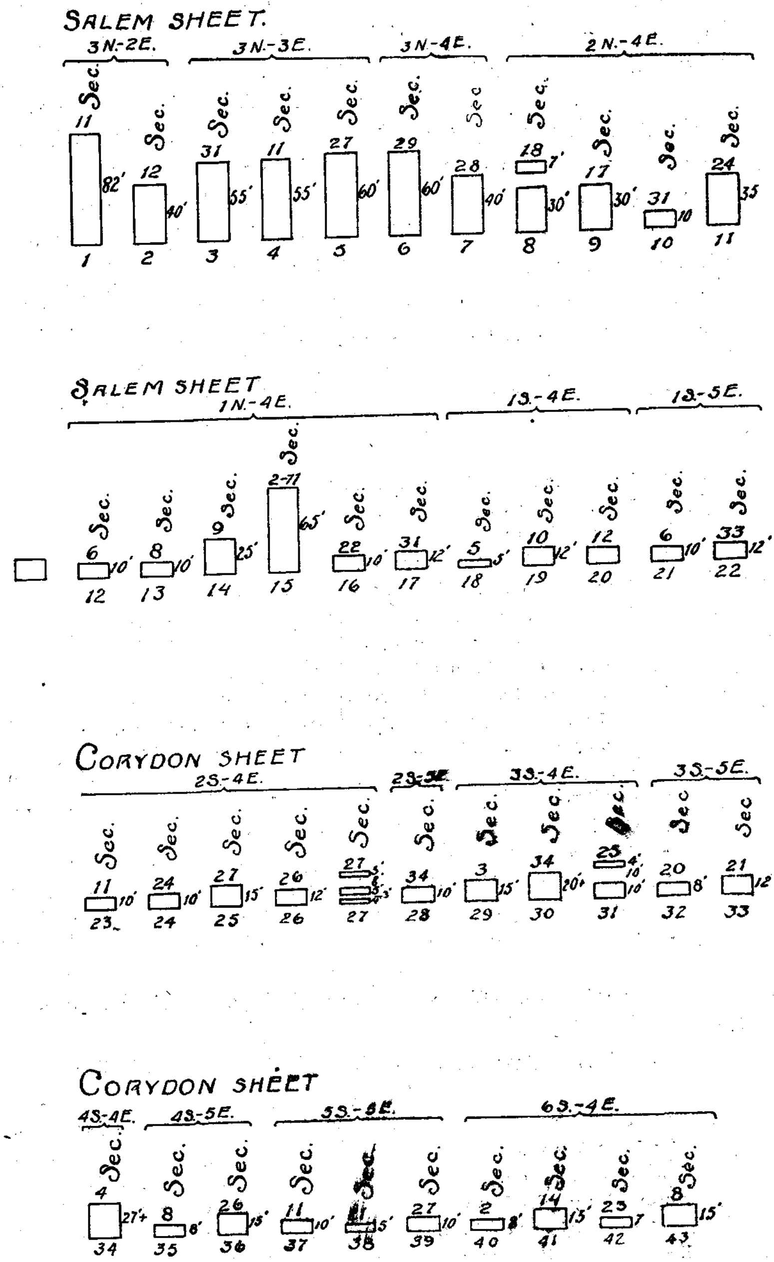


Plate VII. Sections of the Bedford oölitic limestone.

The distribution of the Bedford oölitic stone is shown on the map, and on account of its commercial value will be considered in some detail under the head of Economic Geology.

HARRODSBURG LIMESTONE.—The Harrodsburg limestones, named from the excellent exposure of these rocks at Harrodsburg, in Lawrence County, consists of a series of limestones with thin beds of shale, with sandy limestones in places just at the bottom, where it meets the Knobstone. The thickness of the series is from 35 to 100 feet or a little less, the average being about 65 feet in this area.

Fig. 4, from the face of the quarry just west of Salem, below the cemetery, gives an idea of the stratigraphy and of the variation to which the individual beds are subject. In the figure the numbers referring to the different strata correspond to the following section:

		Ft.	*In.*
1.	Soil, red .... 2 ft. to	3	0
2.	Bedford oölitic limestone	5	0
	Harrodsburg.		
3.	Light drab limestone, with crow-feet............	5	0
4.	Yellow to light drab limestone, with crow-feet....	6	0
5.	Light to dark blue limestone, crow-feet, fossiliferous, bryozoa common, top layer crinoidal, numerous cavities with calcite crystals........	6	0
6.	Gray, fine-grained limestone, composed largely of finely comminuted crinoid stems and shell fragments. One persistent crow-foot, several smaller ones	6	0
7.	Soft, blue shale	0	0-6
8.	Gray to drab limestone, similar to No. 6..........	3	0
9.	Shale like No. 7, only more persistent............	0	6
10.	Limestone, like Nos. 6 and 8....................	4	0
11.	Blue shale	1	to 6
12.	Blue, shaly limestone, fuel of geodes...........	2	0+

Two sections from Harrison County will show the character of the series in that region.

Section of Harrodsburg at Stoner's Hill, Section 11 (5 S., 5 E.):

	Ft.	*In.*
Cherty limestone	45	0
Shale, with geodes	11	0
Black, white and blue flint, in bands of one or two feet, with clay partings	14	0
Red, encrinital limestone	8	0

Section at Eversol Cliff, Section 13 (5 S., 5 E.):

	Ft.	In.
Crinoidal limestone	39	0
Clay shale and geodes	7	0
Blue, fossiliferous limestone	3	0
Sandy shale, with geodes	14	0
Flint in bands of six to twenty inches, with shale partings	12	0

The presence of geodes in these strata is quite characteristic of the Harrodsburg beds.

In places there appears to be a slight unconformity at the top of the Harrodsburg, as indicated in Fig. 2, of Plate VIII, showing the contact between the Harrodsburg and Bedford stone in the railroad cut at Spurgeon Hill, in Washington County. At other places the top of the Harrodsburg is a limestone full of bryozoa, resembling closely the Bedford stone at points where it is largely made up of bryozoan remains. The Harrodsburg limestones are often hard and well suited for road purposes.

The geodes of the Harrodsburg predominate in the lower strata, and range from two feet in diameter down to the size of peas. Fossils are abundant in these strata, many of them being of large size.

The Knobstone.—In the Knobstone the same difficulty is met with as in the case of the Mitchell, from the fact that the outcrop of the formation has a width of from two to fifteen miles, with no completely connected sections across it. The Knobstone has a thickness of about 400 feet, as shown by drillings, for, due to the character of the strata of which it is composed, it can be recognized with considerable certainty in deep drillings. In the well at Corydon the Knobstone has a thickness of 422 feet. In the Brandenburg Well, the Knobstone has a thickness of 380 feet. In a well at Mifflin, Crawford County, the Knobstone is reported to have a thickness of 490 feet. Some of the exposures in the bluffs along the eastern edge of the knobs show exposures of up to nearly 350 feet, with the bottom still some distance to the east.

In general the Knobstone consists of shale and shaly sandstones. At least two thin beds of limestone occur, one at the bottom, very persistent; the other, near the top, does not seem to be persistent. The shales predominate at the bottom of the formation and at the south; most of the sandstone being found toward the top of the formation, while to the north the proportion of sandstone greatly increases. At the bottom of the formation is the thin limestone mentioned, known as the Rockford Goniatite limestone. It runs from 10 inches to two feet in thickness, with an average of about 18 inches. It tends to be a bluish-gray on a fresh surface and a dull brown where weathered. It usually contains large quantities of crinoid stems. Above this limestone comes from 100 to 250 feet of greenish-colored, marly shale. The lower 100 to 125 feet of this was called the New Providence shale by Mr. Borden. This lower shale contains many thin bands of carbonate of iron, averaging from four to six inches in thickness.

The upper 200 feet of the Knobstone is composed of a variable deposit of shales and sandstone, the latter usually quite shaly. At the south shales predominate, while to the north these upper beds become almost entirely sandstone, and even the lower shales are largely replaced with sandstone to the north of the area under study. From 30 to 120 feet below the top of the Knobstone there occurs at many horizons a thin limestone, as shown in the following sections:

Section east of Mt. Carmel, Section 7 (3 N., 3 E.):

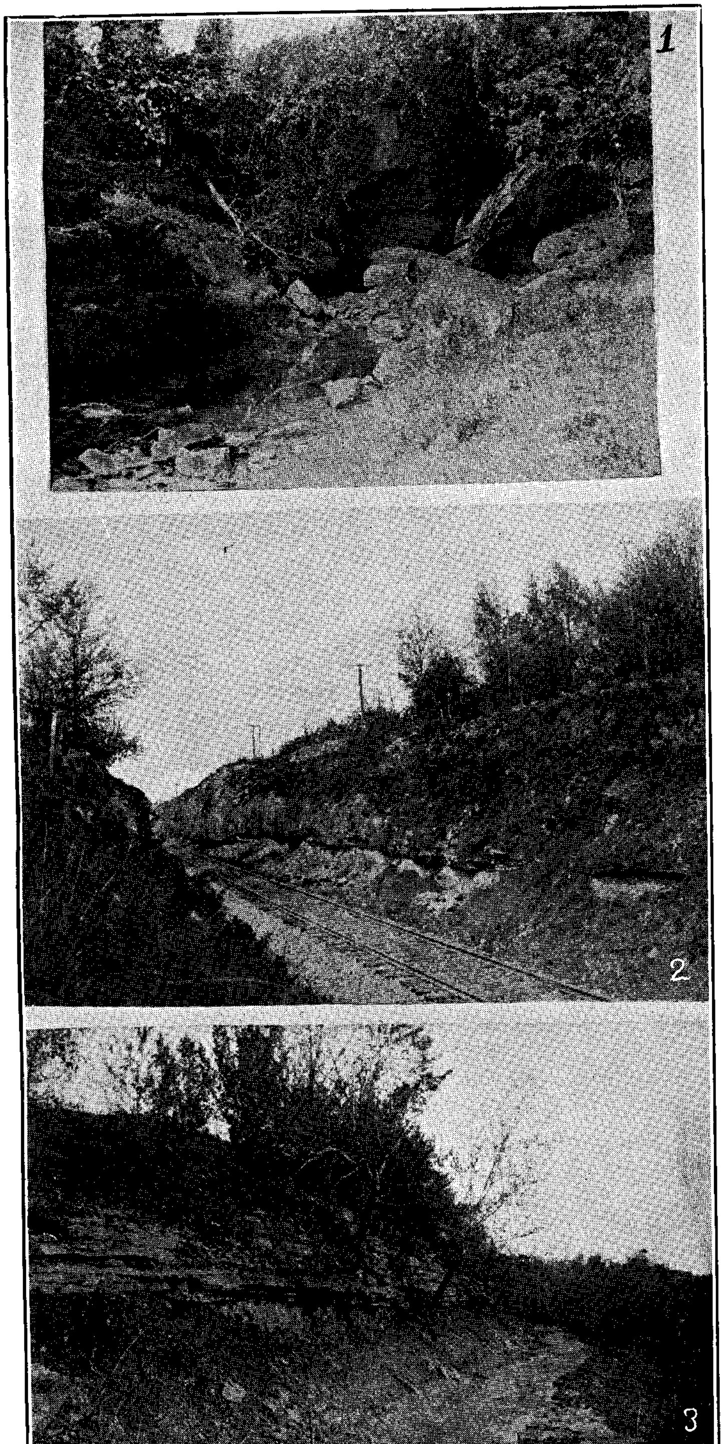
	Ft.	*In.*
Buff, shaly sandstone, soft	95	0
Hard, brown sandstone, with geodes	20	0
Light brown limestone	2	0
Yellow sandstone	20	0
Gray, fine-grained sandstone	30	0
Gray, shaly sandstone	30	0

At the center of Section 19 (3 N., 4 E.), the limestone is found 70 feet from the top of the Knobstone, the rock between being a gray, splintery, sandy shale. In the northeast corner of Section 27 (3 N., 3 E.), the limestone is four feet thick, ferruginous in character, and is 70 feet below the Harrodsburg limestone, the intermediate strata being shale and sandstone. In the northeast quarter of Section 27 (3 N., 4 E.), this limestone is a dark brown, crystalline limestone, three feet thick. It is here only 35 feet below the Harrodsburg limestone, with gray shale between. Below it comes massive light brown sandstone.

At the top, the Knobstone in places appears to grade over almost insensibly into the Harrodsburg limestone. Generally the line is quite distinct, as shown in Fig. 3 of Plate VII, but in other places the limestone becomes more and more sandy until it has become a true sandstone.

Mr. Kindle obtained the following section on the road up the knob from Locust Point Postoffice, Section 12 (4 S., 5 E.):

PLATE VIII.



VIEWS SHOWING BEDFORD STONE AND CONTACTS ABOVE AND BELOW HARRODSBURG LIMESTONE.

1. Bluff of Bedford Stone at upper end of open stretch of underground stream, in southeast 40 of Section 10 (3 N., 2 E.).
2. Railroad cut at Spurgeon Hill, showing famous locality for fossils of Bedford stone, and contact between Bedford stone and Harrodsburg limestone.
3. Contact between Harrodsburg limestone and Knobstone shale.

	Ft.	In.
Gray crinoidal limestone (Harrodsburg)	15	0
Knobstone.		
Shelly sandstone	2	6
Limestone	2	0
Shelly sandstone, with one or two limestone bands	6	0
Sandstone and chert	0	11
Yellowish sandstone, with geodes	3	0
Gray chert, with small geodes	1	8
Buff, soft, shelly sandstone	3	0
Massive sandstone, rather shelly	10	0
Shelly, bluish sandstone	6	0
Light gray, heavy bedded sandstone (building stone)	35	0
Crinoidal limestone	0	to 18
Shelly sandstone	10	0
Massive, drab colored sandstone	5	6
Covered	6	0
Buff to blue sandstone, with crinoid stems	2	0
Shelly, buff to drab sandstone where exposed, with fossils	50	0
Blue sandstone, containing iron which slacks on exposure, causing rock to crumble	65	0

THE NEW ALBANY BLACK SHALE.—This shale, which is here the highest member of the Devonian, is a black, bituminous shale about 100 feet thick. At Scottsburg this shale has a thickness of 120 feet. The black shale is very persistent and has been recognized in deep drillings all over Indiana. The outcrop of the black shale forms the eastern limit of the area to be studied in this report.

GENERAL STRUCTURE OF THE AREA.

In its general structure this area shows a uniform westward dip, being on the eastern side of the Illinois basin. The lack of an accurate topographic base or of a large number of railroad levels gave little opportunity for determining the dip with accuracy. Between Harristown and Salem the Bedford stone descends from about 900 to 740 feet, giving a dip of about 40 feet to the mile. Between the Edwardsville Tunnel and Crandall the Bedford stone descends 300 feet, or 33 feet to the mile. Between New Albany and Corydon the New Albany black shale descends from about 450 feet above tide to about 200 feet below tide (in Corydon Well) or, again, about 40 feet to the mile. These dips are not accurate nor inclusive enough to fully decide the average dip, but suggest an average between 30 and 40 feet to the mile. In the minor details of structure this area shares with other parts of the State in having much variation. In many places dips of one or two feet in the hundred can be seen in bluffs, and frequently in very small exposures the rocks have a very noticeable dip, often amounting to 50 or 100. Though the most of these had a dip to the west, the dip is variable.

The strike appears to be a little east of south. The top of the Knobstone is about 700 feet above tide at Salem, and reaches about the same elevation at Georgetown, about Section 15, east of Salem. But, as showing the variation to which it is subject, the top of the Knobstone in the Mutton Fork of Blue River on the line between Salem and Georgetown, instead of being about 700 feet above tide, is only about 600 feet above tide. Vienna, Henryville, Memphis and New Albany are all nearly in a north and south line, and all about on the edge of the bottom of the Knobstone, but the elevation along that line decreases from 570 feet at Vienna, to 478 and 489 feet approximately at Henryville and Memphis, and to about 450 feet at New Albany. Many evidences of local disturbances were found, including the finding of one large fault and probably of another.

The Mt. Carmel Fault.—North of the East Fork of White River there is a prominent strip of limestone, known as the "Heltonville Strip," that is found some distance east of the regular outcrops of the limestones of the Lower Carboniferous. This limestone strip is found in patches as far north as Section 10 (9 N., 1 E.), and from Limestone Hill, about eight miles southeast of Bloomington, it runs more or less continuously to White River at Fort Ritner. It has a width of from one-half to one and a half miles, and is bordered on each side by Knobstone. At Heltonville, the stone shows the facies of the Mitchell, Bedford and Harrodsburg limestones, the Bedford stone being extensively quarried here. Evidently this strip is a portion of the overlying limestone occupying a depression in the Knobstone. Mr. Siebenthal, who first studied this strip, concludes that "This depression may have resulted from a double fault or may be an old erosion channel. Some things seem to point to one as the origin and some to the other. The facts at hand incline us to the latter view."*

In the proceedings of the Indiana Academy of Science for 1897, Mr. J. A. Price gives the results of his study of this strip, including a study of the disturbance south of White River. Unfortunately he was not familiar with the slight differences characterizing the different horizons of the limestone. He concludes: "It is not possible

*21st Annual Report Department Geology and Natural Resources, of Indiana, p. 391.

from the data at hand, to say surely whether this limestone owes its existence to an unconformity or a fault."

Due to the change in the slope of the land after crossing White River, coming from the north, the outcrop of the Lower Carboniferous limestone turns and swings some distance to the east, south of White River. It is evident that if the limestone strip north of White River is due to a fault its effects should continue to the south rather than turn and follow the outcrop. A glance at the map in the region north of Campbellsburg is alone almost sufficient proof of the fault character of the disturbance. However, in the branches of Clifty Creek, south of Mt. Carmel, is even more conclusive evidence. In the first ravine just south of Mt. Carmel, as the fault is approached from below, the Bedford limestone is noted outcropping rather prominently and almost continuously on the north bank. This outcrop ends abruptly, then in the bed of the ravine a few rods farther up, the Harrodsburg is seen with a dip of about 40° to the west. Only a few yards above this the Knobstone is found in the bottom of the ravine and well up the bank. In the next ravine to the south the fault shows just east of the quarter section line. The Knobstone here is exposed for a thickness of 20 feet on the east of the fault; the top of the Bedford is just above creek level on the west of the fault. The fault can then be traced southward through a series of sink-holes that appear to follow its course.

At Mt. Carmel the down-throw appears to be 130 feet. Where last seen in Section 24, of the same township, it appears to have a down-throw of over 100 feet. The evidence in this region does not indicate a double fault, but simply a down-throw on the west side of the fault line. West of the fault line the down-throw strata rise rapidly as though to gain their normal elevation. Though no exposures showing this rise were found, it was shown in the greatly increased apparent thickness of the stone; for example, the Bedford stone when measured by barometer westward from the fault line, has an apparent thickness of 140 feet, though the bed was probably less than 90 feet thick. It shows again in the relative elevation of any bed near the fault and a mile or so to the west. Thus, in the center of Section 26 (4 N., 2 E.), the bottom of the Harrodsburg is only a few feet above Twin Creek, while a mile west the same horizon is 140 feet above White River.

A glance at the geology in Indian Creek north of Georgetown, in Floyd County, shows a peculiar condition, very suggestive of a fault, running northwest and southeast. In Section 19 (2 S., 5 E.), about

60 yards above where Indian Creek turns sharply to the east of south, the Harrodsburg outcrops in cliffs down to the level of the flood-plain of the creek, five or six feet above the creek level. Within a few feet of where this outcrop abruptly ends the Knobstone extends in outcrop for 60 feet up the bank. In this case the downthrow is to the east. Though less clear, there is evidence of a continuance of this probable fault in Section 11 (2 S., 4 E.). At the north side of this section the rocks seem to be Mitchell down to creek level, while near the center of the section the Bedford stone outcrops 40 to 50 feet above the creek bed. The evidence here is negative. While no Bedford stone could be found north of the north line of this section, the evidence that the few exposures were of Mitchell was not conclusive.

ECONOMIC GEOLOGY.

Materials of Value in Area.—Although the primary object of this study was to continue the work of tracing the outcrop of the Bedford stone, with a study of its thickness and character, in extending the plans to include the mapping of the other formations of the Lower Carboniferous, it was planned to also make a study of the economic materials included in those formations.

The economic materials, as far as observed, may be listed under the heading of the formation in which each is contained.

Quaternary.—Soils, surface clays for brick, etc.

Ohio River Formation.—Gravel for roads, sand for glass making.

Huron.—Whetstones, sandstone for structural purposes, limestones for building, marble.

Mitchell Limestone.—Oölitic limestone for Portland cement, hydraulic limestone for Roman cement, lithographic limestone, road building material, limestone for structural purposes.

Bedford Oölitic Limestone.—Building stone, limestone for Portland cement, road material.

Harrodsburg Limestone.—Road material.

Knobstone.—Brick shales, sandstone for structural purposes.

Quaternary Materials.—Until a detailed study of the soils of the State is taken up, little can be said about the soils of any locality. It is important to recognize that the soil at any point in Indiana is in most cases derived in one of a few ways. First, it may come from the decomposition of the indurated rock immediately underlying, as is the case with most of the soils of this region; second, it may consist of the surface of the deposits, often of considerable thickness, laid down during the glacial period by overland glaciers; third, it may be material associated with stream bottoms, recently deposited by running or standing water, and depending for its character on the character of the rocks or deposits from which it was derived.

The first, or residual soils, partake of the character of the underlying rock. If that rock be sandy, the soil will be sandy. If the underlying rock is a limestone, the soil above will be limy or calcareous; if the limestone is very pure, as in the case of the Bedford stone, in weathering the waters that weather it may, by dissolving the limestone, carry it all away, leaving almost no soil except such as may wash in from the adjacent areas. This probably accounts for the fact that the outcrop of the Bedford stone, though that stone is softer than the surrounding limestones, tends to present bare exposures. In general, however, limestones tend to carry a large per centage of clay or shale, so that when weathered the clay is left behind, most of the calcite of the limestone being removed in solution. Such limestones are characterized by a calcareous clay soil. Thus the Harrodsburg limestone in places around Salem has yielded a rich clay soil, often 25 feet deep. Any other insoluble substances in the limestone, such as sand, flint or geodes, will, of course, be left in the soil. Thus soil derived from the Harrodsburg limestone often contains large numbers of geodes, and over a large part of its extreme eastern outcrop in Clark and Floyd counties is represented by fragments of chert, and geodes that originally were in the solid limestone. In the area of the Mitchell, especially, this is noticeable, in large areas the ground being so strewn with chert fragments as to interfere with agriculture. These, of course, are the residuum left after the removal of the calcite of the Mitchell limestone that formerly existed above the present surface. In the case of hillsides or long slopes there is always a tendency for formations outcropping high up on a hill to influence the character of the soil derived from some other formation outcropping further down the hill. Otherwise a knowledge of the character of the soil derived from any given formation will apply anywhere that that formation has been the source of a residual soil. So that a geological map, especially one prepared not only to show the outcrops of the underlying indurated rocks, but also the glacial and other alluvial deposits of recent time, becomes at once the basis of a soil map or may serve as such a map itself. After such maps have been prepared it is only necessary to determine the character of the soil derived from each formation or recent deposit, and the map will show at once where soil of that kind may be found. Without such maps analyses and other tests of soils scattered over the State may be very misleading, for the next farm to the one examined may have soil derived from a different formation, and therefore of entirely different character and needing entirely different treatment.

From what has been said it will be seen how the maps accompanying this report may be made of value to those living in the region, or planning to settle in the region. In the first place, general repute will in every region assign unusual richness, or unusual adaptability to certain crops, to some farm, or part of a farm, or it may be to a group of farms, or it may even be to certain divisions of the township or county. Locate such rich or adapted area on the map and if it be found to overlie the outcrop of a given formation, it is highly probable that similar richness or adaptability will be found over much of the outcrop of that formation. In the same way in the experiments being tried with different types of fertilizers or correctives, a use of the map in connection with a study of actual results obtained by different people over a region may prove of great actual value. The line between, for example, the Harrodsburg limestone and the Knobstone is seldom one that can be detected in a farming area; and while a partial recognition of differences of soil either side of the line might have existed there is often a failure to recognize that the two soils are inherently different and require entirely different treatment, and are capable of yielding entirely different results in the way of success with differing crops. It is hoped later to make a complete study of all the types of soils in Indiana, as to their contents, their needs, their adaptability, etc. The State map and the series of maps upon which it is based, of which the last are published in this report, form the basis for an intelligent examination of the soils of the State and for a profitable application of the results of such an examination by the farmers all over the State.

Ohio River Formation.—From a commercial standpoint this formation is chiefly of interest as having proved a satisfactory source of sand for the making of glass. For many years these deposits supplied the glass factory at New Albany, of Mr. W. C. DePauw & Company. The discovery of natural gas in the northern part of the State led to the abandoning of these works and consequently of the quarrying of sand. Recently, I understand, a new company has been organized and has reopened the plant. When previously worked the sand was partly obtained from quarries near Martinsburg, whence it was hauled four miles to Borden (then New Providence) and shipped by rail to New Albany, a small amount going to Louisville and Cincinnati. Part of the sand was obtained from quarries east of Elizabeth. In 1873 the quarries near Borden yielded 250 carloads, of 65 barrels to the car. Weight of sand per barrel, 330 pounds. Cost, washed and delivered at Borden, per barrel, $1.00; delivered in Louisville, per barrel, $1.40. The sand as seen in the quarry ranges from a white to a brown, the latter color due to iron. By washing this iron is readily removed, leaving it in a very pure and white condition. The elevation and position of these deposits has prevented the running of a railway switch to them. However, their elevation would seem to make it certain that the deposits along the bluffs above the Ohio, especially, could be shipped by means of a gravity tramway, loaded cars descending being used to draw up the empties.

The distribution of these deposits is not fully shown on the maps. In general they may be stated to be found, or rather confined, to the high divide between the streams draining direct to the Ohio River and those draining westward to Blue River, Indian and Little Indian creeks, Buck and Mosquito creeks. It is probable that the areas mapped are the most important, but it is probable that examination would reveal remnants of this formation along all the least eroded parts of that divide.

As stated under the head of general geology, this deposit is up to 20 feet thick and covers several square miles, so that the deposit may be considered sufficient to supply a large demand for an almost indefinite period.

The use of deposits of this age for road building may be considered as very limited, for the reason that they are gravelly to any extent only to the north, and in that region the deposits are very limited and often rather inaccessible.

Huron Group.—As at present developed the only commercial stones obtained from this group are the coarse whetstones and grindstones quarried in the valley of French Lick Creek. These have been described and their location shown by map in the Twenty-first Annual Report of this Department, pp. 329 to 368. For details the reader is referred to that volume of the report. Suffice to say here that the fine-grained whetstones manufactured around French Lick come from the Mansfield sandstone, the lowest division of the Coal Measures. Coarse whetstones are made from thin layers in the upper sandstone of the Huron. While this sandstone is well developed along the upper course of Lost and Patoka rivers, and to the south, the only stone yet found suitable for whetstones has been along French Lick Creek. Most of the stone is not apt to be sufficiently white and free from iron to be used for whetstones. The stone that is used is a white, coarse-grained, friable stone resembling loaf sugar. It would seem quite probable that further search would reveal other areas of desirable rock. In 1901 and 1902 about 100,000 pounds of this coarse whetstone was put on the market from the Indiana quarries.

Grindstones are or have been made from the sandstone of this group for both local use and for shipment. Thirty years ago grindstones were made quite extensively in the northwest part of Orange County. They were made by hand and shipped to points in Indiana and adjacent States. The introduction of machinery in their manufacture elsewhere led to the decline of the industry here. The Indiana stone ranges in grit from medium coarseness to fine. The most of it is soft. It has been found well adapted to grinding carpenters', mechanics', and machinists' tools.

Grindstones have been cut from the sandstones of this group from many points, and from different horizons. A number of grindstones have been cut from the lower sandstone in the top of the cliff just east of Blue River at St. Cloud, Harrison County.

The use of Huron group rocks for building purposes is apt to be confined to a more or less strictly local use on account of the nearness of the Bedford Oölitic limestone, one of the best building stones in the United States. The sandstones have been extensively used for foundations of buildings and especially for bridge foundations for which latter use they are preferable to the Bedford stone. On account of the quality and quantity of the Bedford stone there is not likely to be any large commercial demand for these stones for some time. On the other hand, the comparative excellence of these stones and the ease with which they can be gotten out and worked into desired dimensions will probably exclude any other stone for local use. The two sandstone beds of the Huron appear to be very similar in character. They vary from a white to a dark brown in color, a light brown predominating. White or gray rock of quite uniform color is not uncommon. In most places the rock is soft when quarried, often being wedged up the natural thickness of the bed and trimmed to shape with a common axe. It hardens afterward. Some stones were seen near Central Postoffice, in Harrison County 16½ feet by three feet by one foot. These came from a quarry a mile southwest of Central. Others were obtained from this outcrop 26 feet long, by three by three feet. They were too large to be moved. A number of structures were examined in which these stones from various parts of the area had been used, and in every case the results seemed to indicate stone of good durability. The old county jail at Dover Hill, in Martin County, was built from the upper sandstone of the Huron, over fifty years ago, and the stone appears in good preservation still. A number of bridge foundations were examined and in general showed fairly satisfactory wearing qualities. In many of the old houses built 70 and 80 years ago the stone still shows the tool marks sharply. In places the sandstone occurs in thin beds of more or less convenient thickness for use; in more cases the beds are quite massive, often showing almost no bedding in a thickness of 40 feet or more. Bold perpendicular outcrops of from five to 20 feet are not uncommon, and along the Ohio bluffs of 40 or 50 feet are found.

The position of the lower sandstone is well indicated on the map as it always comes just west or inside of the line marking the bottom of the Huron group. The upper sandstone will be found in general near the line marking the upper boundary of the Huron group.

While nearly every hill that contains these sandstones may, in general, be considered a possible quarry site, not all of the stone is suitable for building. In places it is found that instead of becoming harder the stone crumbles into sand. Such rock as a rule, however, will not make prominent bluff-like outcrops and thus is not likely to attract the quarrymen. Again in places this massive sandstone in a short distance is sometimes found to grade into shale, as near Indian Hollow near Leavenworth.

The limestones of the Huron group have been used for making lime to some extent and seemingly with success. As a rule they are pure, but they tend to be hard and in view of the large quantities of waste Bedford stone to be found lying around all of the quarries, it does not seem probable that this use will ever extend beyond local needs.

The limestones of the Huron tend to be coarsely crystalline and of close grain. In many cases they take a good polish and would seem to answer the requirements of marble. Many gravestones have been cut out from these limestones, but as far as seen most of this limestone does not hold its polish well when exposed to the atmosphere. In color these marbles range from gray to a handsome mottled red. In places the limestone is coarsely fossiliferous, which shows up well in a polished face. The position of the lower limestone is shown in places by the use of the dotted line, above or within the line of the bottom of the Huron. On the whole the proportion of these limestones that may prove suitable for the purposes to which marble is put is probably very limited, and it has yet to be proven that it will satisfactorily meet the exacting demands of competition.

MITCHELL LIMESTONE.—*Oölitic Limestone for Portland Cement.*—Within the last few years an oölitic limestone at Milltown has attracted some attention as a possibly commercially valuable deposit. It is the same stone that has long been known from its exploitation at the Stockslager quarry in southwestern Harrison County. The latter has long been assumed to be the same as the Bedford oölitic limestone. The survey of this part of the State has shown that this limestone occupies a more or less constant horizon near the top of the Mitchell, that it is widely distributed through Orange, Crawford and Harrison counties, and, at its proper horizon, in Madison and Posey townships, in Washington County. In the first place, this limestone differs structurally from the Bedford stone. Instead of a grain composed of minute more or less globular shells, the grain of this limestone is composed of small spears, composed of concentric layers of calcite formed around a center. The resulting grains are somewhat larger than the grains in the Bedford stone, and by analysis this stone is somewhat purer than the Bedford stone. A recent analysis of this stone by Mr. Noyes of an average specimen, gave as follows:

Calcium carbonate ($CaCO_3$)	98.91
Magnesium carbonate ($MgCO_3$)	.63
Ferric oxide and alumina (Fe_2O_3 Al_2O_3)	.15
Insoluble in hydrochloric acid	.48
Total	100.17

An analysis of the Stockslager limestone, published in 1879 by this survey, gave as follows.

Water, dried at 212° F.	.50
Insoluble silicates	.31
Ferric oxide	.16
Alumina	.14
Lime	54.93
Magnesia	none.
Carbonic acid	43.17
Sulphuric acid	.25
Chloride of alkalies	.40
Combined waste and loss	.12
	100.00

Carbonate of lime, 98.10.

The strength of this stone, as determined by General Gilmore, gave crushing strength, 10,350 pounds; a cubic foot weighs 149.59 pounds; rate of absorption, 1 to 27.

As a rule this limestone is a very pure white wherever found. As a building stone it has not as yet proved a distinct success, as it is found to be too hard to work easily and seems to show a tendency to flake off from the edges of squared blocks. It can hardly be said that a fair test has been made of the stone, as all the quarrying yet done has been on a more or less weathered outcrop, and with the use of powder. However, its unusual purity has recently suggested its use for the manufacture of Portland cement. For this it seems eminently suited. No suitable clay was noted in close proximity to the deposits of this limestone. But it would seem quite probable that some of the beds of shale occurring in the Mitchell, though thin, might be found of suitable quality. Again, it is but a short distance west to the Coal Measure shales. The reader is referred to the Twenty-fifth Annual Report of this Department for fuller discussion of this subject. In its distribution, this stone will usually be found very close to the upper limit of the Mitchell. Considered from the standpoint of immediate availability the deposits along the railroad are the most valuable. These outcrops occur along the French Lick branch of the Monon Railway, especially a short distance west of Paoli. Also along the Southern Railway from Marengo to Milltown and in the hills east of Blue River to the tunnel east of DePauw. West of Paoli this stone is being used as ballast by the Monon Railway. A rock-crushing plant was being installed at the time this region was examined. Outcrops of this white stone are abundant over eastern Orange County, as far as to within a quarter of a mile of Millersburg. At Spring Mill the oölitic limestone shows an unusual thickness. The bluff at the spring above the mill shows the following section:

	Ft.	*In.*
White to light gray oölitic limestone	10	0
Gray oölitic to semi-oölitic limestone	6	0
Fine textured lithographic limestone, sub-oölitic or subcrystalline in places	18	0
Drab colored calcareous shale	4	0
Massive, gray, oölitic, sub-lithographic in places	14	0
Drab colored magnesian limestone "cement rock" 3 ft. to	5	0
White to gray oölitic limestone	10	0

In Crawford County this white oölitic limestone outcrops at Milltown as described above. It is only from two to four feet thick where it outcrops in the quarry at Marengo. A section of the face of the quarry at Marengo shows:

		Ft.	*In.*
Surface clay	1 to	5	0
Hard, gray, sub-oölitic limestone		4	6
Hard, light bluish-gray, sub-oölitic limestone		5	0
Gray, sub-oölitic to sub-lithographic limestone, in six to 36 inch strata		6	0
Buff limestone, hard to rather soft		4	6
Coarse, crystalline, gray limestone, oölitic in places		6	0
Dark gray, lithographic limestone	3 to	5	0
Pure white to light gray, oölitic limestone	2 to	4	0
Buff limestone, very hard to very soft		5	6
Dark, bluish-gray lithographic limestone, irregular in layers and texture		5	6

South of the railroad the white oölitic limestone outcrop is constantly noted near the top of the Mitchell, but it is seldom well enough exposed to reveal its thickness. Where the thickness can be determined it is found to run from about four to 10 feet. At Leavenworth it is only three feet thick. In the hills two or three miles west of Corydon this stone runs 10 feet thick. About Kellarsville it is six feet thick. At Frenchtown it is from four to eight feet thick. At the Stockslager Quarry in Section 21 (5 S., 3 E.), it is six feet thick. At Kendall's Landing it is four feet thick, and has a similar thickness in the valley of Potato Creek.

As shown by many of the sections semi-oölitic limestone or oölitic limestone of gray color is fairly abundant in the Mitchell, and much of it would undoubtedly fall but little behind the white oölitic limestone in purity. Thus, analysis of the different limestones from the face of the quarry at Milltown, gave an average of only a little over 2 per cent. of impurity, 1.19 per cent. being magnesium carbonate. In like manner the most of the lithographic limestone appears to be very pure. The Mitchell would therefore seem to have an abundance of pure limestone suited for the manufacture of Portland cement.

The position of the while oölitic limestone in Harrison County is in part indicated by a dotted line near, but within the upper boundary of the outcrop of the Mitchell.

Hydraulic Limestone in the Mitchell.—In the '70's and later, hydraulic cement was made from limestone quarried at Rock Haven, in Meade County, Kentucky, just across the Ohio River from the south point of Harrison County. No official reports of practical tests of this stone are at hand, but reports indicate that it was a stone of good quality, holding its own in competition with the Louisville and other cements. Indeed the reasons usually assigned for the closing of the works are not unfavorable to the quality of the stone. However that may be, the fact remains that limestone suitable for hydraulic cement is found at Rock Haven and presumably should be found on the Indiana side.

The Rock Haven stone gave the following analysis:*

Water expelled at 212° F	.75
Insoluble silicates	34.30
Soluble silicates	.20
Ferric oxide and alumina	1.90
Lime	30.80
Magnesia	.66
Carbonic acid	24.20
Sulphuric acid	1.80
Combined water, organic matter, traces of alkalies, etc.	5.39
Total	100.00

Analysis made of similar rock in Harrison County a few miles north gave about 7 per cent. less of the insoluble silicates, and from 10 to 12 per cent, more of calcium carbonate. Stone was seen at a number of places that was thought to be an hydraulic limestone. On the south slope of Spurgeon Hill some 25 or 30 feet above the Bedford stone, in the railway cut, is an outcrop of light drab, very fine grained limestone, that was judged to have hydraulic properties. The rock has a thickness of 10 feet or over. The upper part contains some calcite crystals, but the lower part is very even grained and free from impurities. As this is but a few rods from the railroad track, it is admirably situated as regards transportation facilities. The only other place where this rock will be found close to the Monon Railway is in Sections 11, 12 and 14 (2 N., 3 E.). Good looking stone was seen at many places in the heads of the streams north of Hitchcock, Smedley and Campbell stations. The stone in the head of Clifty Creek has been tested and is said to have shown an excellent quality of cement. No record of the tests could be found. At many of these points the large springs furnish abundant water power. The bed runs from 10 to 20 feet thick. A similar bed was noted at various points down Blue River and at Beck's Mill. These points are farther from the railway and so have not the immediate prospects of the places mentioned above. In general, this bed should be looked for between 25 and 50 feet above the top of the Bedford stone.

* Geological Survey of Indiana, 8-10th Annual Report, p. 73, 1878.

Lithographic Limestone.—Near the top of the Mitchell, but found at all horizons in it, are beds of massive gray, lithographic limestone. These have the fine texture and even grain peculiar to such rocks. These rocks are often well exposed, and have been examined at a great many points, but as yet no place has been found that seemed to promise stone of commercial value. Practically everywhere examined it is found to be cut up with minute seams of calcite in such a way as to prevent the obtaining of sizeable blocks free from such imperfection. Nevertheless we can not but hope that the future may disclose areas of this rock that will prove suitable for lithographic purposes.

"Glass Rock."—One of the uses to which this lithographic limestone has been successfully put has been in the manufacture of glass. At Glass Rock Station, on the French Lick branch of the Monon Railway this stone has been quarried and shipped. It has been quarried for the same purpose at other points along Lick Creek. This rock is apt to be found wherever there is an exposure of any thickness of the upper part of the Mitchell. Only the lighter colored beds are used.

Lime.—The many pure limestones of the Mitchell lend themselves admirably for the production of lime.

Lime is made on a commercial scale at Milltown. A section was given above of the quarry east of the river. As the section west of the river at the Speed Quarry differs somewhat from that, it may be given here. Section at Speed Quarry, Milltown:

		Ft.	*In.*
1.	Buff, weathered limestone	1	8
2.	Coarsely crystalline limestone, with numerous crinoid stems	2	0
3.	Pure white, oölitic limestone, with few fossils	4	0
4.	Light buff to drab lithographic limestone	5	0
5.	Greenish shale	0	4
6.	Gray, lithographic limestone	0	10
7.	Greenish-gray shale, intercalated with bands of lithographic limestone, two to eight inches thick 0 to	1	6
8.	Gray, lithographic limestone	7	0
9.	Soft, granular, buff, magnesian? limestone.. 3 to	4	0
10.	Lead gray, fine-grained, crystalline limestone, 3 to	4	0
11.	Pure white, oölitic limestone	5	0
12.	Calcareous shale 2 in. to	0	4
13.	Gray, oölitic to sub-oölitic limestone	4	6
14.	Limestone with black chert 1 in. to	0	8
15.	Drab colored, impure limestone	4	0

		Ft.	In.
16.	Bluish gray lithographic limestone......... 0 to	0	10
17.	Dark gray, sub-oölitic to sub-crystalline limestone.	8	0
18.	Very soft, drab colored, magnesium limestone....	6	0
19.	White oölitic limestone	6	0
20.	Gray limestone	16	0

The beds used for lime are Nos. 3, 11 and 17; Nos. 3 and 11 make a very pure, white lime; No. 17 makes a good lime, but of a darker color. The other beds of the quarry except Nos. 9 and 18, which are thrown out, are used for crushed stone. No. 18 is at present the floor of the quarry. It is intended to deepen the quarry so as to obtain Nos. 19 and 20. No. 11 is believed to correspond to the oölitic bed in the east bank of the river. The Speed plant has a capacity of 1,500 bushels a day. (See *a*, Plate IX.) Small kilns are to be found all over the area of outcrop of the Mitchell making lime for local purposes.

Crushed Rock.—At least four quarries are using limestone of the Mitchell for the purposes of ballast or for road building on a large scale. The Monon Railway has a large plant on the French Lick Branch west of Paoli, using the white oölitic limestone. At Milltown the Speed Quarry has a capacity of 200 cubic yards a day. The Eichol Quarry, on the east side of the river, ships from 14 to 20 cars of crushed stone a day, employing 66 hands. Another large quarry is situated at Marengo. The continued existence of these large quarries is the best of evidence of the suitability of this limestone for the purposes mentioned, at least as compared with competing materials in this general region. This part of the Mississippi Valley yields none of the traps and other igneous rocks that experiments seem to show have the highest resistance to abrasion, and the other qualities necessary in good road material.

ECONOMIC GEOLOGY OF BEDFORD OÖLITIC LIMESTONE.

As Building Stone.—In view of the complete exposition of the properties and adaptability of this stone for the purposes of building, as well as of the methods of quarrying, preparing and marketing the stone, given in the Twenty-first Annual Report of this Department, it seems best to refer the reader to that report for information on that line. Suffice to say here that due to the facts that the stone has a pleasing buff color, that it has in a high degree the requisite qualities of strength, endurance, resistance to weathering or heat, an even soft grain that facilitates its quarrying, preparation for the market, trimming or carving in place, its extensive exposure near the surface facilitating quarrying, and other desirable qualities have led to its having a most extensive use in this country. It combines the qualities of ease of quarrying and consequently of cheap production with many of the most desirable qualities of a stone for building purposes. The report mentioned gives lists of buildings built of this stone in 26 States and one territory, and the list could undoubtedly be much swelled. It was said at that time that 80 per cent. of the buildings going up in New York City were of this stone.

In the area of this study there are only two commercial quarries, and on account of high freight rates due to lack of competition, neither of these is at present producing stone. Both quarries show a good grade of stone, equal to the best in strength and durability. The general tendency of the stone of this area is to be a little more crystalline, and therefore a little harder to work than the stone around Bedford.

For Lime.—At the present time the most extensive use made of the Bedford stone of this region is for lime. The quarries at Salem are actively engaged in quarrying and burning this rock for lime. For this use the rock is quarried by blasting. The lime is said to be very white and of excellent quality.

For Portland Cement.—Attention has recently been called to this stone as especially suited for the manufacture of Portland cement. Its uniformity of composition, purity, ease of working, and the fact that large quantities of it are immediately available in the waste heaps at the present quarries, are some of the advantages to be claimed for it. In the Twenty-fifth Annual Report of this Department are given some of the results of recent tests made with a view to determining the value of cement made of this stone. Sufficient to say at this point that the following results were obtained:

Cold pat test: 7 days, sound; 28 days, sound.

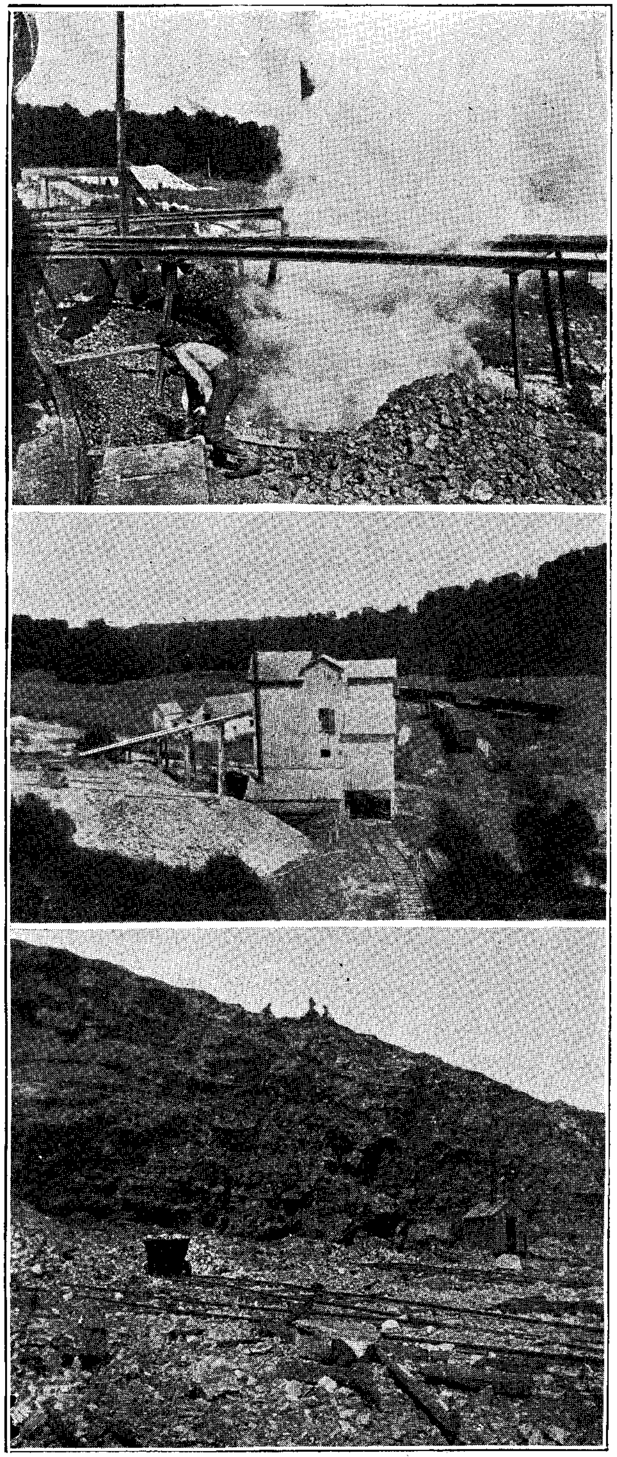
Hot test: 5 hours in steam, 19 hours in boiling water, sound.

Tensile strength, neat; 7 days, 713-740; 28 days, 870-935.

Tensile strength with three parts standard sand: 7 days, 415-490; 28 days, 536-585.

"These tests show the cement to be of the highest quality and at least equal to any Portland cement manufactured in this country or in Europe." The oölitic stone of this region undoubtedly will give as good results.

For Road Material.—This stone has been used locally for the building of roads. Such use was probably induced mainly because of prominent outcrops in the immediate neighborhood of the road being built. None of the roads of this stone in this region has been in use



a

b

ILLUSTRATING QUARRYING INDUSTRY AT MILLTOWN, INDIANA.

(From photos by E. M. Kindle.)

(a) Top of lime burner at J. B. Speed & Co.'s quarry.
(b) Rock crushing plant.
(c) Quarry on east side of Blue River; output used for railway ballast.

PLATE X.

OUTCROP OF OÖLITIC LIMESTONE ON BLUFF EAST OF TWIN CREEK, WASHINGTON COUNTY.

(Harrodsburg limestone in the foreground. Bedford white limestone at the top.)

long enough to fairly test its wearing qualities. Appearances would indicate, though, that it was inferior for this purpose to the harder stone of the Mitchell or Harrodsburg.

DISTRIBUTION AND CHARACTER OF BEDFORD OÖLITIC LIMESTONE.

IN TOWNSHIP 4 N., 2 E.—The Bedford stone occupies the top of the ridge in Sections 26, 27, 34 and 35. The fault cuts off the outcrop on the east. In the southeast quarter of Section 26, west of the fault, about 25 feet of Bedford stone tops the point of the ridge. It is about 120 feet above Twin Creek, the Harrodsburg here being 45 feet thick. In the region of No. 7 school, the Bedford gave an apparent thickness of 160 feet. This was due to the fact that the measurement was made where the stone had a very decided, though unseen, dip to the east, or toward the face of the fault. It is probable that the stone measures 90 feet or less. It is fairly fine grained.

IN TOWNSHIP 3 N., 2 E.—In this township the distribution of the different formations is much disturbed by the Mt. Carmel fault. Bedford stone is believed to cap the hill just north of Mt. Carmel. It makes the surface rock at the bend of the road southeast of Mt. Carmel. Small outcrops of Bedford stone occur on the east side of the fault in the line of sink-holes in Sections 12, 13 and 24. West of the fault the Bedford stone is found at elevations of from 100 to 130 feet below the same stone east of the fault. It outcrops up Clifty Creek to the mill, and makes up the surface over a broad area in the west part of Section 11. Measurements here gave the bed a thickness of 90 feet. There are several bold exposures in this area (see Fig. 1 of Plate VIII). The stone here is a buff, medium fine grain, and lies so that a large area could be worked to advantage. In the figure referred to just above, a stream comes from the mouth of a cave, runs in a narrow valley for about a quarter of a mile, then passes under ground again only to appear a quarter of a mile further down at the foot of a perpendicular face of Bedford stone 50 feet high. The stone of this bluff is a light brown, very coarse and irregularly grained. At a small quarry just west of Mt. Carmel the Bedford stone is coarse grained, buff, fossiliferous, with several crowfeet showing. Some weathered stone in this vicinity showed calcite geodes.

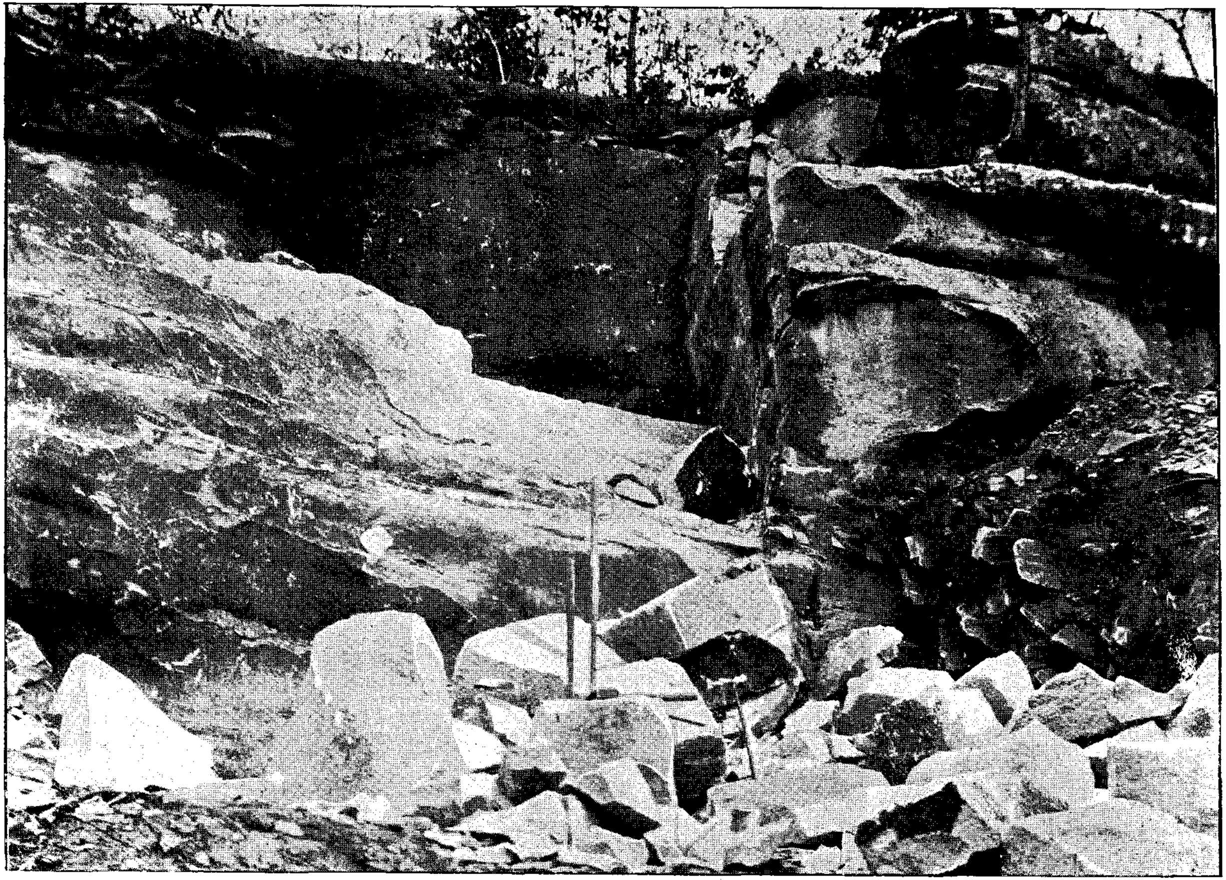
The Knobstone has an exposed thickness along the lower course of Clifty Creek of about 120 feet. The Harrodsburg is about 55 feet thick along Clifty Creek.

In Township 4 N., 3 E.—In this township the Bedford stone is confined to a very small area in Section 34. It is found there capping the ridge, but of too slight a thickness to probably pay for working.

In Township 3 N., 3 E.—Some of the best Bedford stone in the area occurs in this township. The stone occurs in the hills and valleys south of Rush Creek and capping the ridge north of Rush Creek. On the ridge last mentioned it caps all the highest parts of the ridge except in two small areas, where it is overlain by thin bodies of Mitchell. It is thus very easy of access for quarry purposes. In the northeast quarter of Section 11 the bed measured 55 feet by the barometer. At most points examined the stone appeared to be of a dark color. The grain tends to be good at the top, tending to become coarse and fossiliferous toward the bottom. The best grained stone was noted at the top of the bed near, but north of the center of Section 11, but the bottom of the stone a short distance west is coarse grained and full of gasteropods one-fourth inch or less in diameter. In places, as in the southeast quarter of Section 12, the stone lacks cement, tending to crumble easily.

In the valley of Twin Creek, the Bedford stone is in the bottom of the valley in Sections 31 and 32. A little stone has been taken out beside the road east of the center of Section 31. The stone is about 70 feet thick. The stone is of good color, medium grain as regards fineness and regularity. At the section line between Sections 31 and 32 the Bedford stone outcrops in a bold perpendicular bluff 25 feet high. The grain, though irregular, is of medium fineness. Just south of the section line between Sections 31 and 30, is an outcrop of Bedford stone that was examined by Mr. Hopkins after a study of the stone about Bedford and further north, so that for purposes of comparison with the stone being quarried in those regions his description of the stone at this point will be of interest and value. He says: "On Twin Creek, about two miles north of Smedley Station, on the Monon Railway, and seven or eight miles west from Salem is a promising outcrop of oölitic limestone. It is exposed on both sides of the creek in bold cliffs at or near the top of the bluff, in some places forming perpendicular or overhanging ledges. There are clean exposures of not less than 25 or 30 feet of oölitic stone, and the total thickness may be greater than that, as at no one place are both the top and bottom of the bed clearly exposed. (The writer made the total thickness 55 feet, and the bottom of the stone 40 feet above the creek.) A few small stylolite seams were observed, and there are a few joint seams, all of which appear to be regular.

Plate XI.



A Near View of Portion of the Bluff Shown on Plate X.

The weathered surface is in most places comparatively even and smooth.

"The bluff at on. place shows 25 to 30 feet of massive oölitic limestone overlain by 10 to 20 feet of coarse, partly oölitic laminated stone, overlain by eight to 10 feet of earthy, sandy limestone, overlain by blue limestone. The massive ledge has a fairly uniform texture of medium fineness and buff color. It appears to be a little more crystalline and harder than the stone further north.

"The Twin Creek Stone Land Company, of Salem, who own the greater part of this bluff on the east side of the creek, sent in samples for testing, the results of which show for the crushing strength:

Tested on natural bed, No. 1....	11,700 pounds per square inch.
Tested on natural bed, No. 2....	6,900 pounds per square inch.
Aested on natural bed, No. 3....	11,100 pounds per square inch.
Tested on edge, No. 4...........	8,900 pounds per square inch.

The average of all being 9,400; the average on the natural bed, 9,900; but as No. 2 was an imperfect sample, the side chipping off before breaking, the average for the good specimens on the natural bed would be 11,400, a result higher than that for any of the other specimens of oölitic limestone tested in the same lot, with one exception. The absorption shows about equal to the average oölitic limestone in this respect, one in 31. Its specific gravity is a little higher than any of the other limestones tested. The chemical analysis shows it to be a very pure carbonate of lime, closely resembling the oölitic stone from other localities in this respect."

The analysis given shows 98.16 per cent. carbonate of lime.*

Plates X and XI are taken from Mr. Hopkins' report, illustrating this exposure.

In Section 19 the stone where noted was of a brown color, uniform and rather fine grained. In Section 18 the grain as noted was a buff, and irregular. In Section 17 in places the stone has scattered all through it hollow oölitic grains. West of Rush Creek Postoffice the Bedford stone covers the top of a broad ridge in Sections 9 and 16. The stone is a buff, fine-grained stone, and appears to be of good thickness, probably over 50 feet in the higher part of the ridge. On the whole this was judged to be one of the best localities noted for quarrying the stone. In part of this area the grain was judged to be as fine as any noticed in the county and elsewhere; though coarser, it was quite regular.

*21st Annual Report Department Geology and Natural Resources, p. 395.

At a quarry for crushed stone in the northeast quarter of Section 27, the Bedford stone is blue in color, and coarse and irregular in grain. Several crow-feet showed in the quarry face. About the center of the section line between Sections 26 and 27, a little quarrying has been done for road use. The stone is here about 150 feet above the branch, and measured 60 to 70 feet thick. It is buff in color. The grain is large and slightly irregular. The stone here makes bold cliffs 20 feet high along the crest of the bluff. Going up this branch into Section 35, the grade of the stream gradually brings the Bedford stone to creek level. Most of the stone in this section is blue, with coarse and irregular grain. Some of the stone seen on the summit of the ridge a mile southeast of Rush Creek Postoffice was of fair grain and a light gray in color. In Section 24 the oölitic stone caps a large area of hill. It appears to be of good color but of irregular grain.

In Township 3 N., 4 E.—In this township the Bedford stone is confined almost entirely to the western half. South of Kossuth Postoffice, the Mitchell occupies the top of the ridge; north of that postoffice the Bedford limestone caps the ridge nearly to the township line. In Section 5 the oölitic stone is too thin to work. In Sections 8 and 9 it becomes thicker, its full thickness in places, the grain being irregular, buff at the top, blue at the bottom.

At Kossuth Postoffice the stone is a fairly fine-grained, buff stone. It outcrops prominently just southeast of the postoffice. In Sections 18 and 19 some fine-grained stone was noted, though it is inclined to be irregular. In Sections 21 and 29 the stone varies, some of it being of fine grain, while other stone near by is quite irregular in grain. The stone has a thickness of 60 feet. In general the finest stone is at the top in this neighborhood. In Section 28 the stone is from 40 to 60 feet or over thick, 40 feet being measured just southwest of the center of the section. At the latter point the stone is of good color and of fairly uniform and fine grain. Farther east, around No. 12 school, the grain tends to be coarse and irregular. The Bedford stone is well exposed in the northeast quarter of Section 32. The stone, which is mostly rather coarse-grained, is buff at the top and blue below. The stone here is some 30 feet below the top of the ridge.

In Township 2 N., 3 E.—Practically all of this township is underlain by Bedford stone, but it is only along the very eastern edge that it reaches outcrop in the valleys there. A little stone has been quarried at the Richardson Quarry in the southeast quarter of Section 13. About 10 feet of Bedford stone is exposed here. From nothing to eight feet of the dark overlying Mitchell has been removed in stripping. The stone can best be discussed in connection with the next township east.

IN TOWNSHIP 2 N., 4 E.—The drainage divides the outcrop of the Bedford stone into several distinct areas here. The first is the area west of Brock Creek and north of Blue River. The bottom of the stone is only about 10 feet above Blue River where the river turns south. Near Salem it is between 40 and 50 feet above the river. In Section 5 it is only about 15 feet above Brock Creek. The top of the bed reaches to the top of the ridge in places. The stone in this area is, as a rule, not very characteristic, so that considerable difficulty was found in drawing the lines of boundary. In places the grain is coarse and irregular. In others the grain is extremely fine, so much so as to leave much doubt as to its oölitic character. The best stone seen in this area was in the west half of Section 5. The stone here was blue but even grained. East of Brock Creek the country is gently rolling, and while the Bedford stone outcrops over a considerable area, it is weathered to such a depth as to leave almost no exposures and to make it doubtful if the stone could be profitably worked even if it should prove to be of desirable quality and of sufficient thickness.

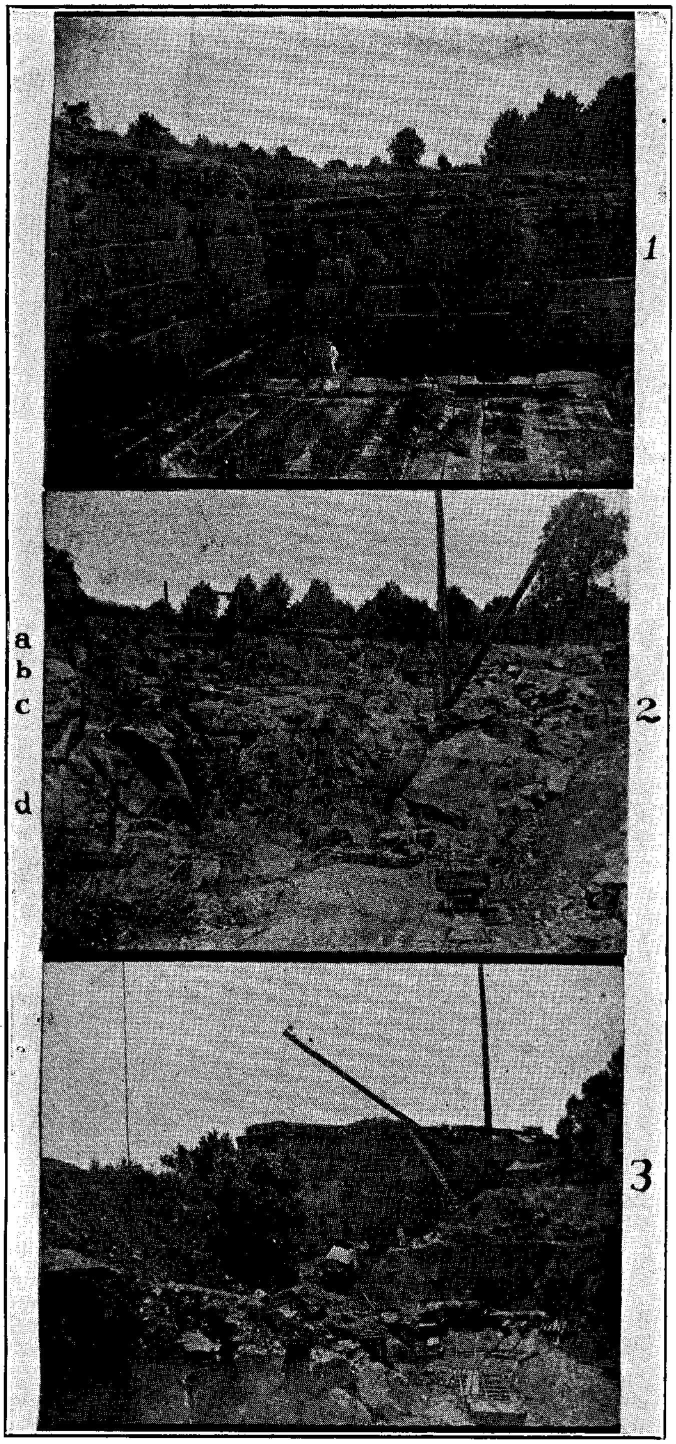
West of Blue River this stone outcrops along a narrow band along the western edge of the township. It has been worked extensively just where the river turns south, by the Salem Lime and Stone Company. This quarry is south of the Monon Railway, with which it is connected with a switch. As shown under the general geology of the Bedford stone, the oölitic stone here occurs in two beds, the upper seven feet thick, the lower 26 feet thick at the north end of the quarry and 30 feet thick at the south. The two beds are 12 feet apart. The stone is mainly a buff, of medium fine and uniform grain. In places cross-bedding is noticed. At present (June, 1900) no dimension stone is being quarried, all the stone being used for lime and obtained by blasting. The stone has been quarried for about a quarter of a mile along its outcrop in the face of the hill. These quarries have supplied a large amount of stone, which has been used in many important buildings, especially in Louisville and the South. Thus in Louisville might be mentioned the City Hall, Galt House, City Hospital, Broadway M. E. Church, First Christian Church, German Methodist Church, German Evangelical Church, Temple Adas Israel, Hamilton Block, J. T. Thompson & Company Block, Falls City Bank, Pendennis Club House. The State Capitol Building of Georgia, at Atlanta, and the State Capitol Building of New

Jersey, at Trenton, are of this stone. Among other buildings of stone from these quarries may be mentioned the Cincinnati Courthouse, the New Orleans Cotton Exchange, and the fine courthouse at Salem. This stone was among those tested by Gen. Q. A. Gilmore and gave him 11,750, 10,000 and 12,000 pounds resistance to the square inch. Tests made for the State House Commissioners of Georgia, of fresh stone, gave 8,975 pounds to the square inch.

Chemical analysis of this stone showed 96.04 per cent. of carbonate of lime. The stone withstood a temperature of 1,200° F., without injury. Its rate of absorption was found to be one to 42.

Going south from the quarry the Bedford stone is exposed at points about 10 feet above Blue River through Section 19. Just south of the north section line of Section 30 is a bold cliff exposure of Bedford stone, 29 feet thick. The stone is blue or brown in color, of uniform and medium fine grain. South of this the stone appears to decrease in thickness, and west of the center of Section 30 it is very coarsely fossiliferous. In Section 31 the Bedford stone is only 10 feet thick as far as could be found, and varies from 15 or 20 feet to 40 feet above the river. The grain is fine, but the color dark.

South and east of Blue River the stone is variously developed. South of Salem the stone runs from a fairly typical oölitic stone to a semi-crystalline stone, in some places very little of the typical oölitic stone appearing, so that it was found difficult to draw the limiting lines. Just south of the center of Section 26 is a little fairly fine-grained stone, but grading up into a sub-crystalline, hard, blue stone. Ten feet above that is a bluish-gray stone, somewhat resembling the Bedford in appearance, but still more crystalline than the last. The same conditions are found just southeast of Salem, most of the stone being brown, and ranging from a fairly fine grain to a crystalline stone. At Poynter's Hill, at the intersection of two roads near the center of Section 26, the Bedford stone is a brown, porous stone, in some cases the cement is gone, in others the grains are gone. In the northeast quarter of the northeast quarter of Section 21 the Bedford appears to be only about 10 feet thick. A quarter of a mile east it is from 15 to 30 feet thick, of good color, fairly fine grain, but irregular. All the oölitic limestone seen in Section 23 was of the porous weathered type. This weathered porous limestone is often quite fossiliferous, notably at Poynter's Hill. Approaching Harristown, the Bedford stone is well exposed in Spurgeon's Hill where cut by the railway a quarter of a mile south of the station. See Fig. 2 of Plate VIII. It was from the rock thrown out of this cut that the fossils were found in such abundance and in



VIEWS AT SALEM QUARRY.

1. In part of old quarry.
2. In present quarry. a. Stripping. b. Seven-foot bed of oölitic limestone. c. Twelve-foot bed of buff limestone, not oölitic. d. Main bed (30 feet thick) oölitic limestone.
3. Lime-kilns.

such perfection as to make Spurgeon's Hill known to students of fossils all over. The rock thrown out is no longer accessible, so that only a limited number of specimens can now be picked up as they gradually weather out of the rock. At the bottom of the cut is six feet of gray, sandy, calcareous shale, containing lenticular masses of limestone up to 10 feet long. The contact of this shale with the limestone above is quite irregular. Above the shale is 35 feet of oölitic limestone. It is buff or gray in color, with very coarse grain at the bottom, which becomes finer toward the top. Much of the oölitic grain is so coarse that it can readily be distinguished at a distance of several feet from the face of the bluff. The stone here contains many fossils, in places seeming to contain little else. Gasteropods and pentrimites predominate. An unusual thing found here are numerous masses of calcite crystals, some of the masses being up to a foot in diameter. In the northeast corner of Section 24 the oölitic stone is fairly fine in grain, a gray or buff. The rocks appear to be disturbed by faulting, or in some way, a half mile east of Harristown. Oölitic rock underlies the top of the hill in the center of Section 13 and forms a small outlier in Section 12.

In the south part of Section 29 the Bedford stone appears to be only 12 or 15 feet thick. In the northwest part of Section 33 the stone is about 25 feet thick, of dark to light gray color, very fine-grained rock, though somewhat irregular. The grain is not as good at the top as below. Under this bed is a 15-foot bed of crystalline limestone that is partly oölitic. It is dark in color. At the center of Section 33 the grain is coarse, but even, a light brown, with many dark brown grains scattered through it. Bedford stone occupies the crest of the ridge in the northeast corner of Section 33. At the bottom of the bed it is of good grain and fair color, but gets more crystalline above.

In Township 3 N., 5 E.—The Bedford stone in this township is confined to a small area in Sections 32 and 33. In places the weathered, porous facies are found, but in most cases the stone is not a characteristic oölitic grain. The Mitchell is exposed at one point, but lack of exposures made it impossible to determine the thickness of the oölitic rock, or its general character.

In Township 2 N., 5 E.—The Bedford stone in this township is confined to the ridge between the Middle Fork of Blue River and the headwaters of the North Fork. No outcrop of the oölitic stone was seen in Sections 4 and 5, though the surface is strewn in many places with the porous, weathered stone. Most of the stone seen in Sections 7 and 8 were weathered surface fragments. Some stone seen in the south part of Sections 7 and 8 is a rather coarse-grained, fairly regular, blue stone. At other places the stone shows only a skeleton of minute quartz crystals. In Sections 17 and 18 the most of the stone seen was of large concretionary grain, gray in color, and in places quite uniform in structure. In places in these sections the stone outcrops as huge blocks over the surface. Near the top of the high knob over which the road runs between the two sections is more of the stone showing only a skeleton of minute quartz grains. In the center of Section 19 the oölitic stone shows an outcrop of 25 or 30 feet near the top of the hill. At the top of the bed the stone is very white, concretionary in structure. The grain is fairly fine, and quite uniform, but toward the bottom is dotted with dark crystals of calcite.

In Township 1 N., 3 E.—The Bedford stone underlies all of this township, but is exposed only in the valley of Mill Creek and Blue River, and there, as a rule, only at or very near the water level. Where Blue River enters the township the Bedford stone extends for 15 feet above the water. The stone here is very fine-grained. At all the outcrops seen in Sections 1 and 12 about the same conditions are found, the stone extending from water level to about 15 feet up the bank; fine-grained at the top, but becoming coarser below, and in places softer and more porous. The stone is buff in color.

There appears to be a disturbance of some kind in the northeast corner of Section 11. There appears to be a sharp southward dip and in a short distance, what was taken to be the hydraulic limestone in the Mitchell, is found at the water's edge. At Beck's Mill the Bedford stone shows an exposed thickness of 36 feet. Lack of outcrops prevented connecting this point structurally with the stone in the river bed in Section 12. On the south side of Mill Creek the bluff exposures seem to indicate that the oölitic stone at Beck's Mill is the upper of two beds, of which the lower bed becomes exposed at a six-foot fall in the creek near the mouth. Near the ford of the river below the mouth of Mill Creek, the lower bed, which seems to have the more typical oölitic structure is exposed only just at the water's edge and for two or three feet up. The upper bed here, believed to be the same bed as at Beck's Mill, has been reduced to a thickness of six or seven feet. Between the two is first 10 feet of light brown shaly limestone, then over that 10 feet of irregular grained limestone. Whether the two oölitic beds and their intermediate strata represent the single 60-foot bed in the north part of this county or not can not be definitely stated, but many things indicate that such is the case. If so, it is evident that the thin bedded Bedford stone mapped from Salem south to the Ohio River is in most cases only part of the bed mapped north of Salem, the other parts not being absent, but so changed in character as not to be recognized.

Near the center of Section 14 the stone is found for about 10 feet above the water, with a coarse and irregular grain, and showing some crow-feet. At the center of Section 23 the stone outcrops for 20 feet above the river. The grain here is not very characteristic. At the center of Section 26 Bedford stone is exposed in a perpendicular bluff to a height of 40 feet. The grain is fairly good at the top but becomes coarse at the bottom. At Organ Springs Mill about 10 feet of Bedford stone of fine and uniform grain is exposed. A little further south fully 20 feet are exposed in nearly perpendicular bluffs.

IN TOWNSHIP 1 N., 4 E.—The Bedford stone underlies most of this township. Starting in the northwest corner, the stone is well exposed on the south side of Blue River near the center of Section 6, in a perpendicular bluff 15 feet high, starting about 15 feet above the water. The stone ranges from buff to blue, and from medium fine to coarse in grain, with a tendency to show a large percentage of blue crystals. Along the Middle Fork of Blue River, between Sections 5 and 8, the stone must be about 75 feet above the water, and apparently only 10 to 15 feet thick. It is gray in color, fossiliferous, and generally irregular in grain, though some fine grain was seen. In Section 4 is found some stone that is sub-pisolitic in structure, resembling the white oölitic limestone found in the Mitchell. The color is gray. Some of the stone in this section is fine-grained and darker. The stone seen in Section 9 was of fair quality, blue in color, with a rather coarse, irregular grain.

In Sections 2 and 11 the Bedford stone presented the most promising outcrop seen in the south part of the county. The stone appeared to be 30 feet thick, blue, uniform, medium fine in grain, on the whole, excellent stone except for color. The stone seen in Section 14 was of buff color, and irregular grain, but with more or less quartz in it. Small outcrops in Section 15, northern half, indicated a soft blue stone of good grain. The stone seen in Section 16 was of fair grain. In Section 22 the stone seen was buff, coarse and irregular in grain. At the center of Section 33 the grain of the stone seen was coarse and irregular. Good exposures in Section 31 showed stone at least 12 feet thick, light brown in color, with a medium fine, uniform grain. Over most of this township the outcrop shows only weathered fragments on the surface, these often showing the characteristic fossils.

In Township 1 S., 4 E.—Along the valley of Dutch Creek, the only outcrops of stone seen were small, giving little idea as to the thickness of the bed or the general character of the stone. The stone seen was all of fair grain. Appearances indicated that the bed here was quite thin. Up the Bear Creek Branch of Blue River extending south of Martinsburg, several exposures of the stone showed a thickness of uniformly 12 feet, at most points only a few feet above the water and having about the same rise to the east as the stream bed. At the center of Section 10 the stone is buff, coarse and uneven in grain. In the southeast corner of Section 10 the grain is more even and of medium fineness. South of Martinsburg the stone runs from buff to blue, and in the main is coarse and irregular in grain, and more or less crystalline.

In Township 1 S., 5 E.—(In Washington County.) The outcrop of Bedford stone in the county is confined to Section 6. The only stone seen there had a thickness of six to eight feet and a grain hardly recognizable as Bedford, crystalline and powdery.

Bedford Stone in Floyd County.

The outcrop is shown on the map. The Bedford stone has been quarried a little in the west edge of Greenville. The blocks seen show a good quality of buff to gray stone, though rather hard. The Bedford stone is believed to cap the ridge between Indian and Richland creeks, though little stone was seen that could be identified as such. Some typical Bedford stone was seen on the west side of Richland Creek, with a thickness of at least eight or nine feet and probably more. North of Georgetown the stone seen was irregular in character, earthy and with shelly bands, making it of little value. Just south of Edwardsville the Bedford stone is eight feet thick and a buff to gray close-grained stone. In Section 12, a mile south of Edwardsville, the Bedford stone is quite typical in appearance, uniform though rather coarse in grain. It runs from five to 10 feet thick. Three miles south of east of Lanesville, in the northwest quarter of Section 26, the Bedford stone attains a thickness of 15 or 20 feet. It is buff or gray in color.

BEDFORD STONE IN HARRISON COUNTY.

IN TOWNSHIP 2 S., 4 E.—There is some evidence of a fault in the northeast part of Section 11. Above this, Bradford Creek appears to be flowing in the Mitchell, but near the middle of Section 11, the Bedford stone is found 40 or 50 feet above the creek bed. The stone here is a soft, sub-crystalline stone of medium grain and gray color except the crystalline part which is dark. The stone has a thickness of 15 or 20 feet. In the northeast quarter of Section 24 the stone is 10 feet thick, coarse but uniform in grain. At one point it has a dip to the west of 5°. In the northeast quarter of Section 27 the stone appears to show three oölitic strata, as given under the general geology of the Bedford stone. In the southeast quarter of Section 26 the stone is 20 feet thick and lies 40 to 50 feet above Indian Creek. The stone is gray, irregular and varies from fine to coarse grained. In the southeast quarter of Section 27 the stone is a buff with the grain generally coarse and irregular. The upper 15 feet is oölitic in the main, then come several feet of rock that are only partly oölitic. South of the center of Section 34, the stone is light gray, oölitic, uniform in places, in others quite irregular. In the southeast corner of this section is a small quarry. The quarry face shows about 18 feet of stone with from one to four feet of stripping, the latter mostly limestone. The Bedford stone here is coarse grained, fossiliferous, and irregular in grain. In the southwest quarter of Section 33 the stone is well exposed, coming just below the level of the railroad bridge over Indian Creek. Further west it shows as a perpendicular bluff 10 to 12 feet high gradually running down to creek level.

IN TOWNSHIP 3 S., 4 E.—South of Crandall the Bedford stone is about 15 feet thick. At the bottom it is gray, fairly oölitic, grain coarse, irregular, open. In the center of the bed the stone is of medium fineness and uniform; at the top it is coarser though still uniform, not close textured.

In the valley of Little Indian Creek, there is some excellent stone around Kings Cave Postoffice in Section 34. At the "Cave" there is a bluff of 20 feet of stone extending down to the creek bottom. As a whole the grain appears as good or in some places better than at the quarry half a mile down stream. At the bridge at the east side of this section the stone is quite crystalline, hardly distinguishable from the rock above, which is similar in color, but finer in grain, and from the rock below, which is darker, more crystalline, and coarser grained. The rocks here have a dip of from 5° to 10° S., 35°

W. From this point up to Breckenridge the stone shows a similar lack of characteristic oölitic structure, and appears to have a thickness of about 15 feet. At Breckenridge are better exposures, the stone showing a thickness of 11 feet. It is coarse and irregular in grain, largely made up of small fossils, which in places weather out very much in the same way as at Spurgeon's and Poynter's hills in Washington County; the fossils are the same as at those points. The underlying stone here has some resemblance to Bedford but is darker and almost entirely crystalline. East of this in Section 25 there appear to be two beds of oölitic stone separated by about 10 feet of laminated crystalline limestone. The upper bed is only three or four feet thick. On the south side of the creek in this section no strictly oölitic stone could be found. A slightly oölitic tendency in the stone about 20 feet above the creek was taken to indicate the horizon of the Bedford stone.

IN TOWNSHIP 3 S., 5 E.—At the north side of Section 30 a six-foot ledge of coarse grained blue Bedford stone outcrops from 20 to 25 feet above the creek. No characteristic Bedford stone could be found in Section 19, the line being drawn at the top of a bed believed to correspond to the bed just below the Bedford at Breckenridge. To the south and west of Lanesville, though good exposures exist, the horizon of the Bedford stone could not be certainly recognized. As in all such cases the apparent lack of the stone is probably due not to its absence but to its character becoming so changed as not to be distinguishable from the over and underlying stone. North and especially east of Lanesville, the stone sets in with a fairly characteristic grain and runs to the county line. At the schoolhouse just east of town it appears to be only eight feet thick, but in Section 21 thickens up to 12 or 15 feet, and makes a series of fairly bold outcrops on the hillside, from 10 to 15 feet above the creek. The grain is coarse and fossiliferous.

IN TOWNSHIP 4 S., 4 E.—Outcrops in this township are confined to the point where Buck Creek enters the township and to a small area along Little Indian Creek in Sections 3 and 4. In Section 4, however, is located the only extensive quarry south of Salem. This is near the northeast corner of the section. The stone here has been quarried to a depth of 27 feet. It lies at creek level, the top of the stone being only about 15 feet above the creek, so that the stone in the bottom of the quarry is some 10 feet or more below creek level. The stripping at present amounts to 11 feet. Of this the lower eight feet is gray to black limestone in beds one to two feet thick. Above that is clay and decomposed limestone for a thickness of three feet.

The color is buff at the top as usual, and blue at the bottom. The grain is close and runs from medium fine to coarse. Much of the stone tends to show dark bands, like cross-bedded lines, that on examination prove to contain a large percentage of dark brown crystals of calcite. In places fossils make the grain open and very coarse. No stylolites were seen. There appears to be a noticeable non-conformity at the top of the Bedford stone. The quarry is equipped with single and double channelers, cranes, a single bladed saw for trimming, etc.

IN TOWNSHIP 4 S., 5 E.—The outcrops of Bedford stone in this township are confined to the valley of Buck Creek, in the northwest part of the township, and to the bluffs of the Ohio along the eastern edge of the township. Along Buck Creek the stone seen ran from five to 10 feet thick. The grain is uniform, fine and in places characteristic, though in most places it tends to be nearly half crystalline. The Bedford stone at Bridgeford, Locust Point Postoffice, is dark, full of cavities, and partly silicified. At the center of Section 24 it is five feet thick, a hard, even textured, gray oölitic limestone. The section here shows:

	Ft.	*In.*
Hard blue, close-grained limestone	10	0
Buff, magnesian to gray limestone	15	0
Bedford limestone, as above	5	0
Thin-bedded, blue limestone	5	0
Massive blue to gray limestone	8	0
Hard gray limestone	15	0
Sandstone (Knobstone)	0	0

At the center of Section 26 the Bedford stone shows a thickness of 15 feet. It is light drab or gray, the grain is close, fairly fine, only slightly crystalline, and the crystals fine. In places the grain is almost entirely oölitic. No crow-feet were seen. It has been worked a little for road use. The overlying stone is a shaly limestone and shale. The underlying stone is a dark blue limestone.

IN TOWNSHIP 5 S., 4 E.—The outcrop of Bedford stone in this township is confined to the valley of a branch of Mosquito Creek, in Sections 25, 26 and 35. The stone here, as far as seen, is less than 10 feet thick. The stone ranges from a true oölitic limestone to a crystalline limestone. Most of the grain seen was fine and regular.

IN TOWNSHIP 5 S., 5 E.—In Section 11 the Bedford stone has a thickness of about 10 feet. The grain is coarse and irregular. In the center of Section 27 the Bedford stone is fairly well exposed, and shows a coarse, oölitic structure, mostly bryozoa. The thickness is over 10 feet.

Over the Bedford stone here is the following section:

	Ft.	In.
Shale and shaly limestone	7	0
Shale	5	0
Shaly limestone	6	0
Shale	8	0
Blue limestone and chert	4	0
Bedford limestone	10	0

A mile up the creek from Buena Vista (Convenience Postoffice) there is a five-foot bed of typical oölitic limestone five feet above the creek, with a three-foot, semi-oölitic bed four feet above; the two being separated by a shaly limestone and shale. At Buena Vista the Bedford stone shows a thickness of eight feet and is not very characteristically developed. The grain in most cases though uniform and fairly fine is almost entirely crystalline.

In Township 6 S., 5 E., no typical Bedford stone was found and the line in the main is drawn on the map from the shales and other rocks accompanying the Bedford. The following section, by Mr. Kindle, in the northwest quarter of Section 5 will give an idea of the stratigraphy in this region:

	Ft.	In.
Red clay	10	0
Hard, bluish-gray limestone	12	0
Soft, buff, magnesian limestone	10	0
Bluish, calcareous shale, with an abundance of bryozoa	8	0
Blue limestone	2	0
Covered	?	0
Bluish, shelly, magnesian limestone	2	0
Massive, even-grained, gray limestone	7	0
Covered, limestone fragments	14	0
Hard, blue limestone	12	0
Shelly, buff sandstone	4	6
Crinoidal limestone	0	10
Blue, sandy shale	5	0
Limestone	0	5
Shelly, sandstone, with small geodes	3	0
Cherty limestone	0	8
Shelly, blue to buff sandstone	6	0
Sandy, drab colored shale	10	0
Cherty, hard limestone 0 to	1	8
Sandy shale and sandstone	7	0
Crinoidal limestone	3	0

In Township 6 S., 4 E.—In Section 2 the Bedford stone is about eight feet thick and only slightly oölitic. It is 35 to 40 feet above drainage. Above it is 12 to 15 feet of gray shale, with one or two thin, fossiliferous bands; over that is 20 feet or more of shaly limestone. On the road up from Brown's Landing in Section 14, at a height of 85 feet above low water in the river, is a massive outcrop of limestone 38 feet thick. The lower 15 feet of this is semi-oölitic and appears to correspond to the Bedford stone. There is a marked crow-foot at the top of this, above which is compact fine limestone with thin shale partings toward the top. In Section 23 the Bedford stone comes just at or above the bottom land of the river. It is six or eight feet thick, of medium fine, sub-crystalline grain. In the southwest quarter of Section 4 the stone appears to be only three or four feet thick, dark blue, only partly oölitic. A little typically oölitic stone was found on the surface. Just below Tobacco Landing the Bedford stone is about 15 feet thick, and occurs about 70 feet above low water in the river. It is about 45 feet above the narrow river bottoms. The stone here is a dark gray or bluish in color, fairly even in grain, but coarse. The stone is in part typically oölitic, but principally crystalline, the crystals in places being large—1-16 of an inch in diameter and down. Masses as large as small houses have fallen down from the face of the cliff. Over the bed is a perpendicular cliff from 50 to 100 feet high. In Section 6 the Bedford stone approaches the level of the bottom land. Only five feet showed oölitic structure here.

ECONOMIC MATERIALS OF THE HARRODSBURG LIMESTONE.

In the presence of the overlying limestones, which as a rule are rather purer and freer from chert, the limestones of the Harrodsburg have little to offer of economic value except in the way of road material or for ballast, or as a rock yielding a fine deep soil by its decomposition. It has been extensively quarried for use as ballast in the western part of the town of Salem, and on a small scale it has been used for building roads at many points over the area of its outcrop. The quarry at Salem has not been operated in several years, the stripping having become quite extensive at the last. There is apt to be a larger proportion of clay in this limestone, rendering it less suited to use for making lime. On the other hand, in places it weathers into a deep, rich soil. East of Salem in places this soil was found of depths up to 17 feet or more.

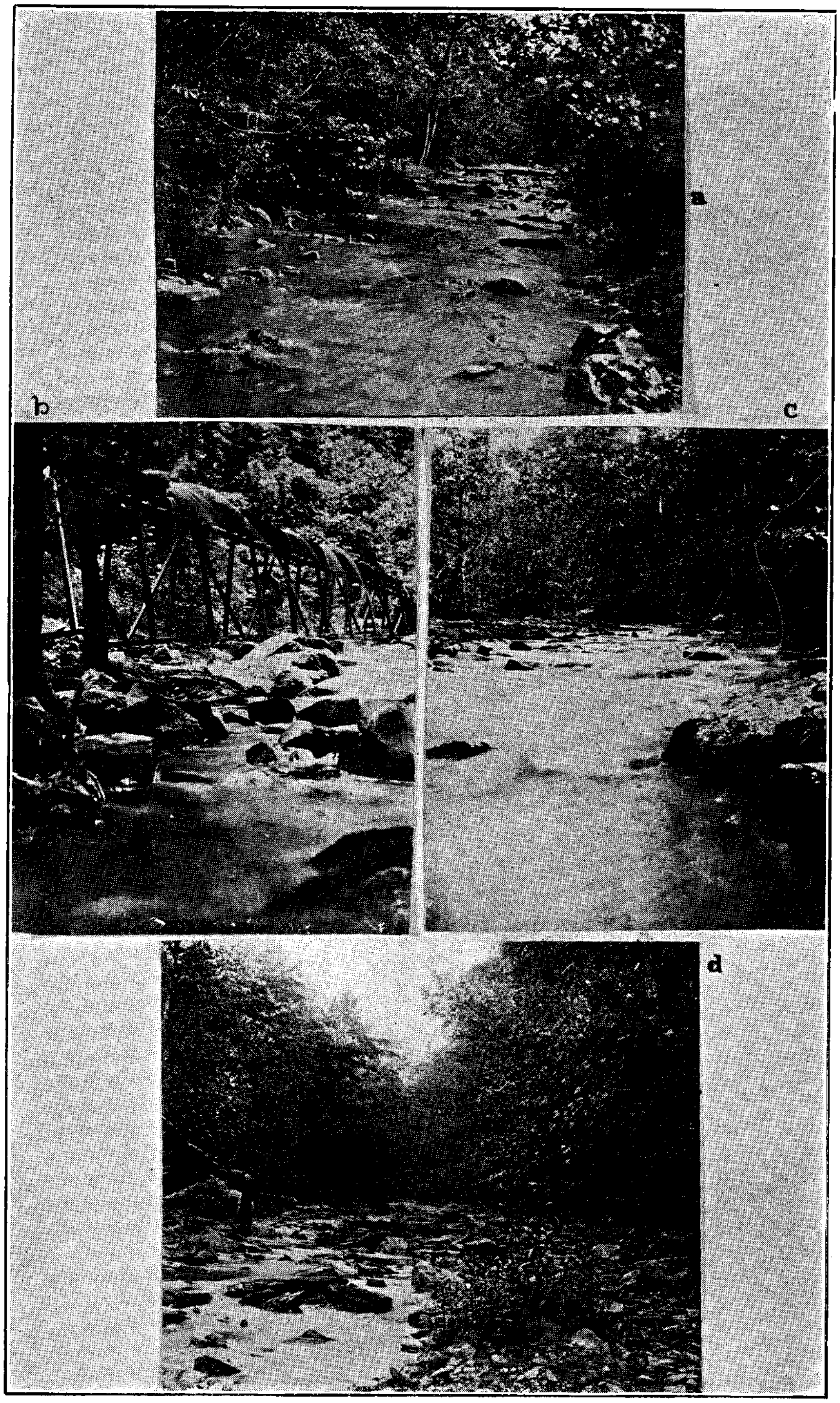
ECONOMIC GEOLOGY OF THE KNOBSTONE.

Considering the thickness of rocks involved the Knobstone presents a very limited amount of material of commercial value. The upper beds in this area consist of shaly sandstones and sandy shales that have little value for structural or other purposes. At present, development is confined to a very limited use of sandstone from a quarry just east of Mooresville, and to a slight use of the shales of the lower part of the section. The Mooresville sandstone has a thickness at the quarry of 12 feet; it is a massive, dove-colored stone, dark blue when first quarried. It is a soft stone when first obtained but hardens on exposure and makes a durable stone. It is used to some extent in New Albany. This stone has been prepared for market by the Acme Stone Company of New Albany. The Hoosier Brick Company is working the Knobstone shale two miles west of New Albany on the Southern Railway. The shale is a tough, blue shale, with an exposed thickness of 40 feet. It contains very little fine sand. The product is light red brick of good color and good quality. Some lenticular concretions of ironstone occur in the shale, but they are not numerous. The factory is well equipped, having a capacity of 25,000 brick a day. Shale from near this point is used by Bannon and Company, of Louisville, in their brick and tile plant.

The limestone sometimes found near the top of the Knobstone has been used some for local road work. Thus a quarry for this purpose has been opened in the southeast quarter of the southeast quarter of Section 29 (2 S., 6 E.). It is said to reach a thickness of 11 feet, though eight feet was the greatest thickness observed. The stone from this quarry has been used on the New Albany and Vincennes Turnpike.

WATER POWER.

With the perfecting of long distance transmission of power by electricity, the question of the utilization of the water power resources of this area becomes one of great importance. Over a large part of this region the underground drainage lends itself well to power production. Three methods of utilizing the water power of the interior of this region present themselves. First. The building of impounding dams at suitable points; second, the fluming of waters downstream a suitable distance; third, the sealing of the mouths of spring caves. To take an example: The position for an impounding dam on Twin Creek would seem to be at the north side of Section 31 (3 N., 3 E.). The valley here is very narrow, with almost perpen-



ILLUSTRATING SOME OF THE WATER POWER RESOURCES OF THIS AREA.

a, b and c. Views in valley of Clifty Creek, north of Campbellsburg, showing descent and volume of water in July.

d. Twin Creek, near north side of Section 31, 3 N., 3 E., showing volume of water in June. The narrow part of the valley is below this. See Plate X.

dicular banks to a height of nearly, if not quite, 100 feet. A dam at this point 100 feet high would impound a fairly good-sized body of water, reaching at least a mile up each of the three main forks. The value of the land inundated would be slight, as practically none of it is at present under cultivation, or in fact cultivatable, and is almost uninhabitable. Fig. d of Plate XIII shows the flow of water in June above the point suggested for the impounding dam. The power house placed at the foot of the dam could secure a maximum head of 100 feet. This head could be increased by carrying the water further down stream, but at considerable additional expense.

Clifty Creek rises in two large springs, while another large spring adds its waters in Section 11. As shown in Plate XIII the fall of Clifty Creek is quite rapid, for the first mile or two. To get the full benefit of the fall the dam should be in Section 2. However, there is no suitable place there.

Probably the best results could be obtained by a dam a short distance below the present mill, say, across from the Lover's Leap, and another in the side valley below the spring in Section 11. Plants could be established at each of these points. It is probable also that the fall is sufficient to warrant fluming the streams after leaving the power houses, and from the side ravines to some point in Section 2, where a third power plant could be established. It is possible that the mouths of the three caves could be successfully sealed, and at a much smaller expense than the building of impounding dams.

This condition of large springs with narrow valleys below is found in a number of places in the knobs, and in the valley of Blue River. In such cases it would seem as though high impounding dams could advantageously be placed at a number of points so as to secure large power. In most of these cases it would probably be best to build impounding dams near the spring where the valley is narrow and then flume the water down stream some distance to secure fall. Along Blue River, especially along the western bank, are a number of large springs, as at Beck's Mill, Organ Springs, and at many other points are springs that result from the drainage of large tracts of land. Many of these springs are at present used in a small way. In most cases it would seem as though they could be made to yield many times as much power as at present. This could be accomplished in many cases by leading the water a mile or two down stream. High impounding dams would usually accomplish the same result more easily and with the added advantage of securing a larger supply of water. Blue River itself is used at a number of places for water power, but in most cases no attempt is made to secure a fall of more than a few feet, five to 10 at most. (See Plate IV.) Many places were seen where it was thought that impounding dams could be built from 20 to 40 feet high. The river has a fall of 89 feet between Milltown and its mouth, or about seven and one-half feet to the mile. Indian Creek likewise, along its lower course presents many places where high impounding dams could be built, storing up the spring waters for use during summer. The streams of western Orange County and at Spring Mill also suggest possibilities of greatly increased water power.

With the limited data at hand this paragraph can only hope to be suggestive of the possibilities of this subject. In almost every case suitable stone can be had on the spot where needed. This subject can hardly be passed over without reference to what must have occurred to many, the utilization of the fall of the Ohio River at New Albany. The Ohio has a fall here of some 22 feet. During a large part of the year boats use the canal rather than descend the falls, an impossible feat in the summer months. It would seem, then, as though all the water not needed by the canal in summer might be utilized for power, while in the spring there would be water enough for the boats and for water power purposes as well.

THE ORTHOPTERA OF INDIANA.

An Illustrated Descriptive Catalogue of the Species Known to Occur in the State, With Bibliography, Synonymy and Descriptions of New Species.

BY W. S. BLATCHLEY,
Indianapolis, Ind.

INTRODUCTORY.

One August evening in 1901 I was seated in the lobby of the St. George Hotel, at Evansville, Indiana, when a large "lubberly locust"—*Melanoplus differentialis* Thos.—attracted by the light, flew into the room. Several of the guests, men of intelligence, saw me pick it up, and immediately surrounded me and asked me what it was. I told them that it was a locust or grasshopper, and that fifty or more species of the same family of insects occur in Indiana. All seemed much surprised and a number of them made the statement that they thought there was but one kind of grasshopper in the State. Such is the opinion of most persons who pay little or no attention to the forms of animal and plant life which surround them. Verily, the most common things about us are those of which we know the least.

For eighteen years I have been more or less interested in that group of insects known as the *Orthoptera*. During that time I have collected them in the different parts of the State which I have visited and have made many notes upon their habits and their distribution. This information I have concluded to bring together into a form suitable for the use of the student in the public schools of the State, or for the boys and girls on the farms, who daily come in contact with some of these interesting insects. While the information which they will gain from the study of such a group may not be of great monetary value, i. e., may not add many "almighty dollars" to the future wealth of the student, it will add to his powers of observation, upon which much of his future knowledge will depend. It may serve to bring him in closer contact with nature, and teach him something of the mutual relationships existing between all of her objects, himself included.

The first thing which any one asks concerning a bird, an insect or a stone, is "What is it?" It must have a name—a handle—to hold it by, while we talk of its habits, the benefits or injuries which it does, the means for its protection or extermination. Each of the insects treated in this paper has a double Latin name by which it is or may be known to students of the Orthoptera in all parts of the world. In order that the student may determine this name for himself, "keys" or "tables of determination" have been inserted, which, if carefully followed and compared with the different characters of the insect in hand, will lead up to its scientific name. The common name by which it is generally known is also added, but the common name varies greatly in different localities.

While collecting has not been done in all the different counties of the State, enough of them have been visited to make the collection upon which the paper is based a representative one. Those localities in which collecting has been done are marked with small **X's** on the accompanying outline county map of the State.

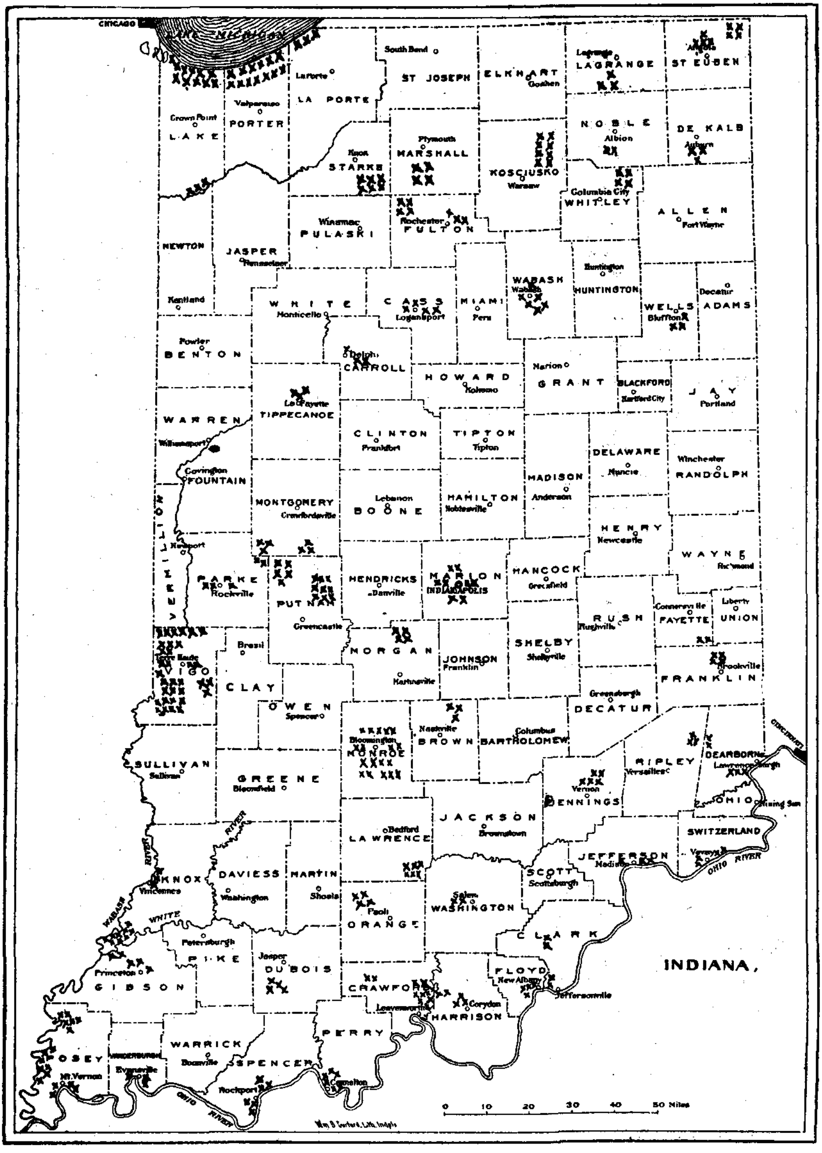


Fig. 1. Sketch map of Indiana showing localities in which collections of Orthoptera have been made.

Acknowledgments.—During my study of the Orthoptera and in the preparation of the present paper I have been greatly aided by that nestor of orthopterological students, Mr. S. H. Scudder, of Cambridge, Massachusetts. To him, more than to all others combined, is due our present knowledge of the classification and distribution of North American Orthoptera. Always willing to answer questions and ever interested in any new form which was discovered, his counsel has been to me both inspiring and helpful. His many works upon the subject have been freely used in preparing the present paper. Profs. Lawrence Bruner, of Lincoln, Nebraska, and A. P. Morse, of Wellesley, Massachusetts, who, next to Mr. Scudder, are the leading authorities on the group, have also rendered me much aid in comparing and verifying specimens sent to them for examination. Only a person situated as I have been, far from any great reference collection, can duly appreciate such kindness as they have shown. To Dr. J. L. Hancock, of Chicago, and Mr. A. N. Caudell, of Washington, D. C., I am also indebted for favors shown; the former having passed in review the collection of Tettiginæ made in the State. Other acknowledgments are made in the body of the paper.

Illustrations.—The illustrations used have, for the most part, been taken from the late Prof. Otto Lugger's "Third Annual Report of the Entomologist of the State Experiment Station of the University of Minnesota;" permission to use them having been kindly granted by the present State Entomologist, Prof. F. L. Washburn. A number of original drawings have, however, been made expressly for the paper, by S. Fred Prince, of Lincoln, Nebraska, and Miss Lillian Howenstein, of the U. S. Department of Agriculture. The Secretary of the Smithsonian Institution has also kindly granted the use of the figures illustrating the abdominal appendages of the *Melanopli,* which are from Mr. Scudder's "Revision of the Orthopteron Group, Melanopli," published in Vol. XX, of the Proceedings of the U. S. National Museum.

THE EXTERNAL ANATOMY OF A LOCUST.

Before taking up the description and classification of the insects treated in this paper, it is thought best to describe briefly the external parts of a typical member of the order Orthoptera. The beginner may thus the more readily grasp the name and location of the parts used in classification, as well as the meaning of many of the technical terms which, of necessity, have to be used in such a paper.

If we compare the body of a locust or grasshopper with that of any vertebrate animal, as a fish, bird or squirrel, we find at once great

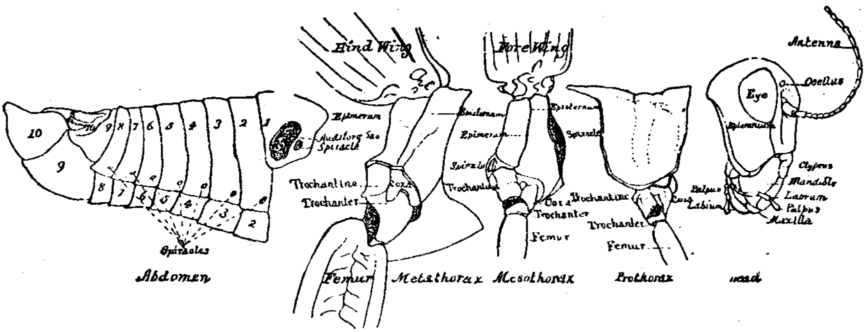


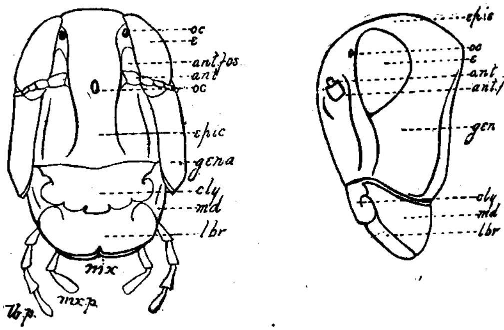
Fig. 2. Body of a locust, side view, showing the thorax separated from the head and abdomen, and divided into its three segments.
(After Packard.)

and important differences. The vertebrate is an animal with an inner bony skeleton, two pairs of jointed limbs or appendages, and breathes by means of lungs or gills, according as it dwells in air or water. The insect is an animal which has no inner skeleton or bones whatever, but only a hard crust on the surface which surrounds the muscles and vital organs. This crust is composed of separate rings, 17 in number, placed end to end. These rings, as well as the legs and wings attached to them, are composed of a cuticle or skin hardened by a substance called "chitin," which is secreted or exuded by the cells which compose the cuticle. Chitin itself is insoluble and is not composed of cells, but consists of fine, irregular plates. It hardens the cuticle and thus aids the latter in protecting the delicate vital organs within, and also in forming a framework to which the muscles of movement may be attached. Between the joints the cuticle is devoid of chitin and is thin, delicate, and flexible, thus allowing the necessary freedom of motion.

The adults of insects, and in most cases, the young, have six true legs, and the former usually, though not always, have wings. Moreover, insects breathe by a system of tubes called tracheæ, which branch and ramify through every portion of the body, and which open externally in about ten places on each side of the body, instead of at the front end. A locust could, therefore, be held with its head beneath the water for an hour, without drowning it. In the true insects, the rings of the body are grouped in three regions; the head, the thorax, and the abdomen. In general, it may be said that the head contains or bears the organs of sense and of prehension and mastication of the food; the thorax the organs of locomotion; and the abdomen those of reproduction.

The Head.

The head of the locust is composed of four or more segments or rings, solidly fused together into a capsule or hard box of chitin, known as the "*epicranium,*" which contains the brain and associated ganglia, and the mouth. It bears or gives support to the antennæ, mouth parts, eyes and ocelli; also internally to the muscles moving the mandibles or jaws. The broad basal portion of the epicranium back of the eyes is known as the "occiput;" the narrower portion be-



a

Fig. 3. (a) Front view of the head of a locust
(b) Lateral view of the head of a locust.
(After Lugger.)

tween the eyes, the "vertex," while the long frontal portion as far down as the prominent transverse suture is the "front" or "face."

The short plate *(cly)*, below or in front of the epicranium, is the *"clypeus."* Below this and hinged to its front edge is a movable flap known as the *"labrum (lbr)* or upper lip, to which are attached a pair of jointed *"labial palpi."* This forms the roof or covering of the front part of the mouth, within which are the large, black-tipped, toothed jaws or *"mandibles" (md)*, which are so attached to the epicranium as to move only in and out or to and from a median line. Beneath the labrum and arched over the tongue will also be found a

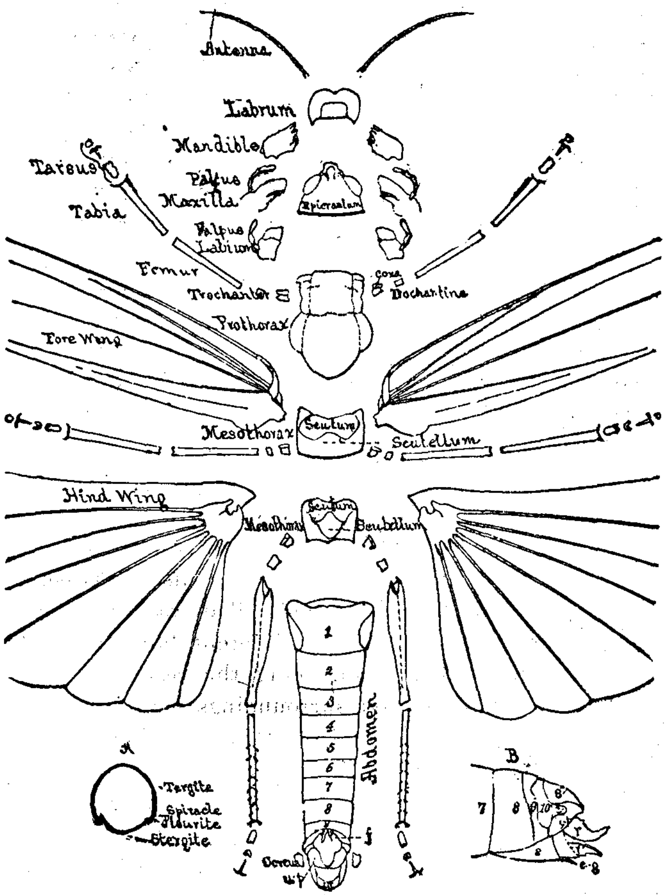


Fig. 4. External anatomy of a locust, showing the head and thorax disjointed. (After Packard.)

pair of accessory jaws, the *"maxillæ" (mx)*, each of which is composed of three pieces, the most important, used in classification, being the jointed *"maxillary palpus."*

Above the clypeus, is a ridge extending upward along the median line of the face to the vertex. This is the *"frontal costa;"* and its characters are often used in classification. In one species it may be sulcate or grooved; in another, flat. Its edges, or *"carinæ"* may be parallel the full length or may diverge or converge. Its width and prominence are also often mentioned.

The region on the side of the head, behind the eye, and above the base of the mandibles is the cheek or *"gena" (gen.)*. To its inner wall is attached the large muscle which moves the mandible.

The eyes of a locust are five in number; two large compound ones, and three small, simple ones. The compound eyes are present in all Orthoptera. In the locust they vary in shape, but for the most part are oval, and are located on the upper portion of the sides of the head. Each is made up of many thousands of six-sided facets or lenses, in each of which a single filament of the optic nerve ends. The simple eyes or *"ocelli" (oc.)* are absent in some Orthoptera, as the *Locustidæ*, but are present in the locust. Two of them are situated just above the base of the antennæ close to the inner margins of the compound eyes; while the third is located near the middle of the frontal costa. Their position varies in the different families of Orthoptera. These ocelli are thought to be inherited from the obscure eyes of the worm-like ancestry of the locust, while the many facetted compound eyes of insects and crustaceans have been evolved to satisfy the needs of the more recent existence of these groups.

The *antennæ (ant.)* of the locust are simple, many jointed appendages, located on the face between the eyes and articulating with the head by a ball and socket joint. They are principally organs of touch, but are also supposed to contain the nerves of smell. They vary much in length and form among the different families of Orthoptera, the variation being the result of adaptation to their peculiar surroundings and habits. For instance, in those Locustidæ which dwell in caves they are very much longer than in those members of the same genus which dwell above ground. Characters pertaining to their form, length, and point of union with the head, are much used in classification. Such terms as "filiform," "clavate," "setaceous," etc., relating to their form, are defined in the accompanying glossary.

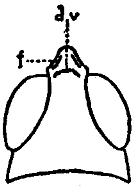


Fig. 5. Showing fastigium, disk and foveola of vertex.
(After Lugger.)

Characters pertaining to the vertex, or that part of the epicranium between the eyes, are much used in separating the different species of Orthoptera. The central portion of the vertex, known as the *"disk,"* *(dv.)* or "scutellum," *(sv.)* is often depressed, or separated from the remainder. Its bounding walls are termed "*lateral carinæ*" and often a "*median carina*" divides it into two parts. The front portion, or apex, often called the "*fastigium,*" is variable in form, and its characters are also much used. On the outer side of, and a little below the front half of each lateral carina of the vertex, there is, in many Orthoptera, a little space or concavity bounded by elevated ridges. These spaces are the "*lateral foveolæ,*" *(f.)* and their variations in size and form also afford characters much used in classification.

The Thorax and Its Appendages.

The middle region of the body is called the "*thorax.*" To study its parts aright, the wings and legs attached to it should be removed; when it will be seen to consist of three rings or segments. These are known as the "*prothorax,*" "*mesothorax*" and "*metathorax.*" Within these rings are located the muscles for moving the wings and legs; as well as some of the digestive organs.

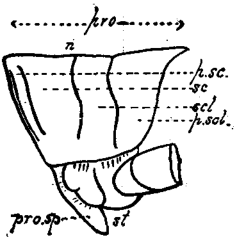


Fig. 6. Lateral view of the prothorax of a locust. (After Lugger.)

The Prothorax of the locust (Fig. 6) has its sides and dorsal surface covered by a large, sun-bonnet shaped piece known as the "pronotum" *(pro.)*. This varies much in shape and size in the different families of Orthoptera. Its upper surface is called the "disk," and its sides, the "lateral lobes." Raised lines known as "*lateral carinæ*" usually separate the disk from the sides, while a third line, the "*median carina,*" runs lengthwise through the middle of the disk. This may be "high" or "low," "crested," "arched," "distinct," "aborted," etc. It is usually cut by one or more notches formed by shallow grooves or "*sulci*" which cross the disk of the pronotum and extend down its sides. The hindmost of these sulci, or grooves, divides the disk of the pronotum into two parts known as the "*prozona*" *(pz.)* and "*metazona*" *(mz.)*. The fore and hind margins of the disk of pronotum may be "truncate," "rounded," "angled," "notched," etc. The surface of the disk is often smooth, but sometimes "wrinkled" and may be "rugose" or roughened with numerous tubercles.

The under or "ventral" side of the prothorax is a narrow, somewhat movable piece called the prosternum. On its center it often bears a tooth or spine *(pro sp.)*, the presence or absence, and shape of which form characters used in classification. Near the outer ends of the prosternum are shallow sockets in which are attached the front pair of legs.

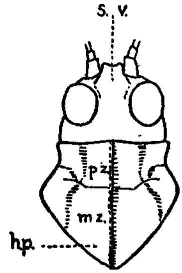


Fig. 7. Showing "prozona" and "metazona" of pronotum, and "scutellum" of vertex. (After Lugger.)

THE MESOTHORAX and METATHORAX, the second and third segments of the thorax, are, in the locust, rather firmly united with the basal abdominal segment of the abdomen to form a firm walled box; though in the *Blattidæ* they are distinct. The upper portion of these segments is, in many Orthoptera, partly or wholly covered by the pronotum. To the mesothorax are attached the first or outer pair of wings and the second or middle pair of legs. To the metathorax are joined the inner wings and the third or hind pair of legs. The under or ventral portion of these segments are called respectively

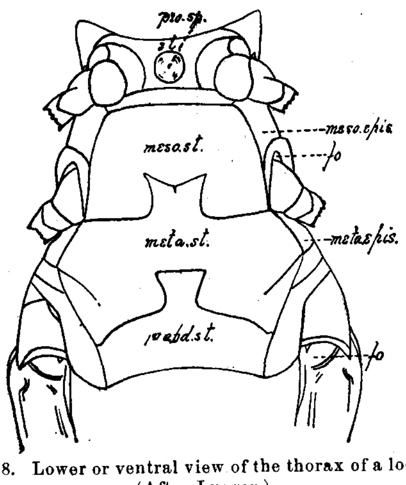


Fig. 8. Lower or ventral view of the thorax of a locust. (After Lugger.)

the "mesosternum" and "metasternum." The former, in the locust, is composed of a front transverse portion, with two nearly rectangular lobes projecting backward. Between these lobes is dovetailed a squarish tongue or forward prolongation of the metasternum. The latter is united with the basal abdominal segment by the dovetailing of a similar but narrower tongue between its lobes. The side pieces of the mesothorax and metathorax are called "pleurites" and bear the prefixes "meso" and "meta."

THE WINGS.—These are thin, broad, more or less leaf-like folds of the integument or body covering, which are joined to the thorax and moved by powerful muscles located within the thoracic cavity. The first or outer pair of wings of the locust and other Orthoptera serve as shields or covers for the more delicate inner pair. In the text which follows they are called "wing covers" or "tegmina." Each wing cover is a thin, more or less transparent, leathery or parchment-like plate of chitin; strengthened by a network of tubes called "nerves" or "veins." The spaces enclosed by the veins and their cross branches are called "cells." When folded and at rest upon the body the outer faces of the tegmina of a locust are vertical, with the front or costal margin below, and the posterior or sutural margin lying along the back; that of the left wing cover slightly overlapping the right.

The principal veins of the tegmina of a locust diverge from the basal end and are seven in number. The one nearest the front or lower margin of the wing cover is the "sub-marginal" or "costal

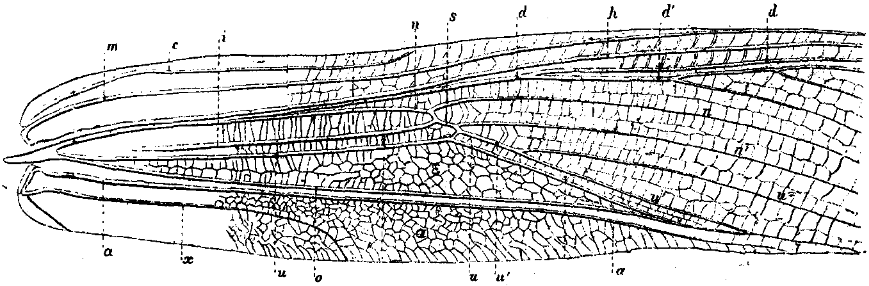


Fig. 9. Right tegmina of a locust, showing the venation. The names of the veins designated by the letters are given in the text. (After Saussure.)

vein" *(c)*. It is undivided, and may usually be traced for a little more than half the length of the tegmina, though in some locusts it is lacking. The second and longer vein, also undivided, is the "mediastinal" *(m)*. The third and much larger vein is the "humeral" *(h)*, sometimes called the "sub-costal." It gives rise to several large branches, the sub-divisions of which form the framework of the greater part of the wing cover. The larger of these branches *(d)*, is known as the "discoidal vein," its branches being designated as *(d', d'')*, etc. The fourth or "median vein" *(n)* is much smaller and soon divides into branches of nearly equal size. Above or behind the median vein is sometimes present a short, undivided vein

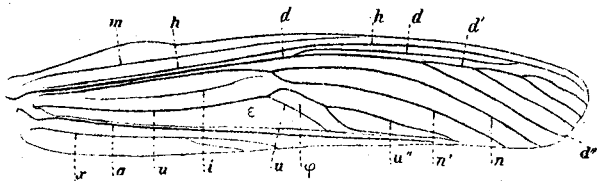


Fig. 10. Right tegmina of the locust, *Dissosteira carolina* (L.) Showing the venation. (After Saussure.)

(i), known as the "intercalary vein." Next in order is the "ulnar vein" *(u)*, which gives off several branches *(u', u''*, etc.). The upper division of this vein *(o)* is known as the "posterior ulnar" or the "sub-median vein." Close to and parallel with it near the upper or hind margin of the wing cover is the undivided anal vein *(a)*; while the uppermost vein of the wing cover, also undivided, is the "axillary vein" *(x)*.

The tegmina is divided by these veins into three areas: The "costal" or "marginal area" (M) forms the lower or front edge of the wing cover and is bounded above and behind by the humeral vein.

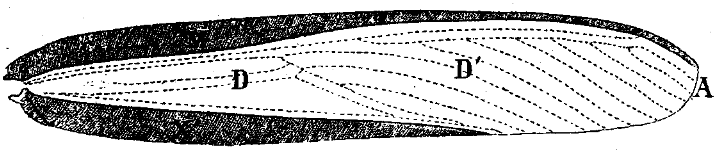


Fig. 11. Right tegmina of a locust, showing the "areas" designated in the text. (After Saussure.)

The "median" or "discoidal area" (D) is much the largest and lies between the humeral and posterior ulnar veins. The "anal" or "dorsal area" (X) is the free margin lying along the back above and behind the anal vein. The posterior end of the wing cover (A) is known as the "apical margin."

The inner or second pair of wings are joined to the metathorax, and when at rest lie folded beneath the tegmina. If, in a fresh example, the dark colored marginal vein be pulled outward or forward with a pair of forceps, it will be seen that the wing is a thin, parchment-like membrane, with a stiff front edge, which is nearly straight, while the rounded outer and hind margins are thin and flexible. When in flight, the wing is fully extended, its upper surface being convex, while its front margin is rendered still more rigid by being overlapped by the internal margin of the upper wing or tegmina. The numerous veins radiating from the base are so arranged that their elasticity causes the wing to fold upon itself like a fan as soon as its margin is released. The principal veins correspond in position to those of the tegmina, and have the same names. Both tegmina and wings are wanting in a number of species of Orthoptera, while in others the tegmina are present and the wings absent.

THE LEGS of a locust are six in number, arranged in pairs, one pair being joined to each of the divisions of the thorax. The first and second pairs are much smaller than the third, but the number and name of the joints is the same. They unite with the body at a different angle from the hind or third pair, and are therefore adapted to crawling and clinging to grass stems or other support, rather than to leaping.

The hind pair or leaping legs of the locust are composed of five parts:

The *"coxa" (c)*, or basal division, which is joined to the thorax; a small segment, the *"trochanter," (tr)*, immovably joined to the upper apical portion of the coxa; the *"femur" (f)*, a long, swollen, club-shaped segment, which makes up nearly half the length of the limb. When the animal is at rest, it extends upward and backward, with its apical end above the dorsal surface of the body. This joint contains powerful leaping muscles. The *"tibia" (ti)*, is about as long as the femur, but is very slender and of uniform diameter. When at rest it extends downward and backward, at an acute angle from the apex or knee of the femur, but in the act of jumping it is thrown backward and the limb becomes straight. It bears on each of its lower outer margins a row of spines, and at the end, one or more pairs of longer spines or spurs known as *"calcaria."* The tibiæ of the fore legs of many Orthoptera are much modified for use in burrowing or prehending food. The *"tarsus" (ta)* or foot of the locust is made up of three movable joints. The first and longest has upon its lower surface a soft pad *(p)* which, by its adhesion to foreign bodies, serves as a point of resistance in leaping. The second

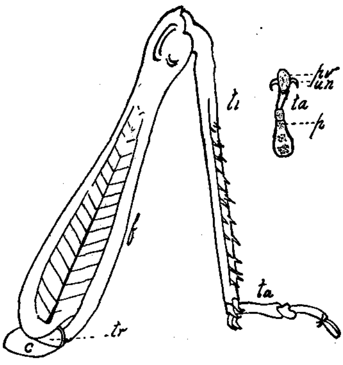


Fig. 12. Hind leg of a locust.
(After Lugger.)

joint is much shorter and carries a smaller pad. The third joint is long and slender, with two curved, pointed claws or *"ungues" (un)*; between which is a concave sucking disk or pad, known as the *"pulvillus" (pv)*. In some families of Orthoptera the tarsus is made up of four or five joints instead of three.

THE ABDOMEN.

The abdomen or hind portion of the body of the locust (See Figs. 2 and 4) is composed of ten more or less complete segments, so united as to be movable in a small degree. Each segment is composed of two parts, a *"tergum"* or upper portion, and a *"sternum"* or under piece. The tergum is crested or bent in the median line to form a ridge, the two sides, sloping downward, being known as *"tergites."* The sternum of the first or basal abdominal segment is united firmly to that of the metathorax. The tergites of this segment, in the locust, each contain a large opening closed by a membrane, the "auditory organ" or ear. However, the ears of many Orthoptera are borne upon the basal portion of the front tibiæ. Eight of the abdominal segments of the locust have a small opening on the lower margin of each "tergite." These are *"spiracles"* or external openings of tubes which serve as air passages. The ninth and tenth abdominal segments of the locust are more or less modified in both sexes. The abdomen of the female ends in a double pair of short curved horny plates, known as the *"valves of the ovipositor."* In the other families of Orthoptera in which the ovipositor is visible, these plates vary greatly in form and size. The valves in the female locust are used in forcing the earth aside, thus forming a pit in which the eggs are deposited. Between and hidden by them is the ovipositor proper.

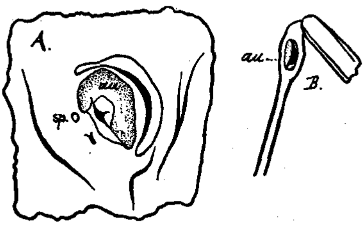


Fig. 13. Auditory organs or ears—(A), of a locust; (B), of a katydid. (After Lugger.)

The ventral portion of the last abdominal segment of the male locust is a large, upcurved, spoon-shaped piece known as the *"subgenital* plate." Attached to the tergum of the next to the last segment are a pair of appendages known as the *"cerci."* In the male locust these are unjointed, and in the different species vary much in size and shape, affording valuable characters for classification. In many of the other families they are jointed, and more or less hairy.

The cerci of the female are much smaller than those of the male, and in other Orthoptera are often wanting. The tergum or upper portion of the tenth abdominal segment is a triangular, often thick solid plate, known as the *"supra-anal"* plate. At the base of this plate and resting upon it, a pair of small projections, known as *"furcula"* are usually present. In certain genera of locusts the shape, size and relative position of these afford valuable specific characters.

The above constitute the more important external parts of the locust, the characters of which are used in determining the name of a member of the order Orthoptera. As will be seen in the pages which follow, these different parts vary much in size and in form, but the names given to them apply as well to the members of one family as to another. By referring to the accompanying figures, and by observing carefully the parts of the specimen in hand, the beginner need have little hesitation in deciding as to whether the description agrees with that specimen.

INSECTS OF THE ORDER ORTHOPTERA.

All true insects can be separated into two great groups, based upon the kind of changes or transformations which they undergo before reaching the adult or winged stage. To one group—the *Metabola*—belong those insects which undergo what is termed a complete metamorphosis. In this group there are four distinct stages—the egg, larval, pupal and imago—in the order named. No insect is hatched from the egg with wings, and when an insect reaches the winged stage it is adult, and never grows thereafter. Thus the gnats and midges are not the sons and daughters of the larger flies, but are full grown insects of themselves, which are undergoing the fourth or last stage of their lives. The second, the larval or wormlike stage, is the one in which the insect of this group is commonly the most injurious, for then it eats voraciously, and then is the only period of its life when it grows in size. The pupal, or third stage, is usually a quiescent one, the insect eating nothing and not increasing in size, but undergoing great changes of form. Thus the homely and often repulsive grubs, maggots and caterpillars, which are the larval forms of the beetles, flies and butterflies, respectively, enter the third stage as wormlike crawling creatures, and emerge from it as beautiful winged forms, sometimes glistening and gleaming with all the colors of the rainbow. This change of life and form is undoubtedly of great advantage to the most of this group of insects, as it tends to prevent the extinction of the species; since, if at a given moment the parents were swept out of existence, the young, living in a different station, would continue to represent the species.

The second group, the *Heterometabola*, comprises those insects in which the metamorphosis is incomplete; the young, when hatched from the egg being wholly wingless and of the same general form as the parent. As the insect grows it moults its skin a number of times and wings develop gradually, there being no sharp line defining the

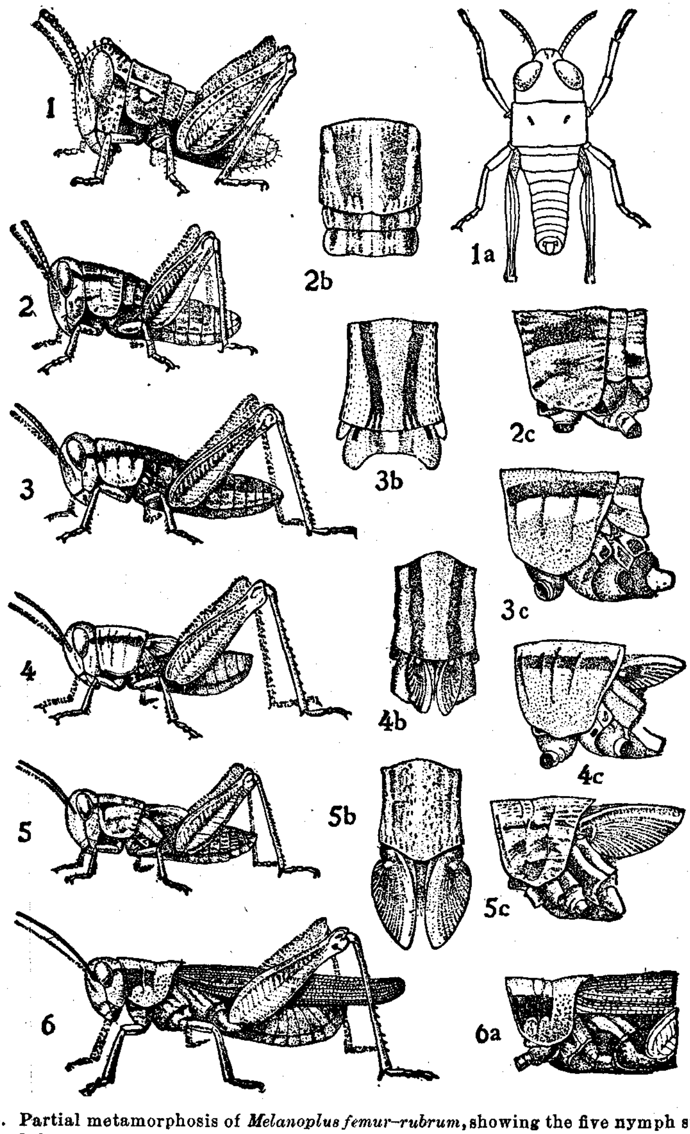


Fig. 14. Partial metamorphosis of *Melanoplus femur-rubrum*, showing the five nymph stages and the partial growth of the wings, which are first visible externally in 3, 3b, 3c. (After Packard.)

larval and pupal stages. The young of all stages are called "nymphs;" they continue active and feed from the time of hatching until they reach the final moult and emerge therefrom mature or in the imago stage.

It is to this latter group, whose members undergo an incomplete metamorphosis, that the *Orthoptera*, the order of which this paper treats, belong. From other orders of the group, they may be known by their biting mouth parts and by the fact that the wings, when present, are four in number, the first pair being thick, leathery or parchment like, and usually overlapping when at rest. They form protective covers for the second pair, which are thinner, more delicate, and folded in plaits like a fan. The name Orthoptera, is derived from two Greek words, *orthos*, straight, and *pteron*, a wing; and refers to the longitudinal folding of the hind wings. The fore wings, or tegmina, are not used in flight, the hind pair alone being used for that purpose. The wings of some species of Orthoptera are wholly wanting, while a few others have only the front pair present.

About 900 species of Orthoptera are known from the United States. Of these 148 have been taken in Indiana; specimens of all but two being in the writer's collection. Of one of these, a large field cricket, *Gryllus firmus* Scudder, a single female from Franklin County served as one of the types and is now in the collection of Mr. Scudder at Cambridge, Massachusetts. Of the other, an earwig, *Forficula auricularia* L., four specimens taken at Lafayette are in the U. S. National Museum.

ENEMIES OF ORTHOPTERA.

With the exception of the Mantids, all our Orthoptera are injurious, most of them being vegetable feeders. Were it not for the many natural enemies which prey upon them, they would abound each season in such vast numbers as to prove a veritable scourge. These enemies are many of them parasites which live only upon Orthopterous forms, and when the latter are abundant the parasites also increase in number, and soon devastate the hordes of insects. Besides these parasites, many predaceous or beneficial insects feed upon locusts and crickets; and birds, both wild and domesticated, are exceedingly fond of them. These parasites, predaceous insects and birds are, therefore, of great benefit to the farmer, and he should do all in his power to increase their number, in order to keep within bounds the different species of Orthoptera.

VEGETABLE PARASITES.—Among the most common parasites of locusts is a vegetable fungus, which in wet seasons attacks them, saps their veins and in time destroys many of their tissues. One often finds, after a long damp spell in late summer, many dead specimens of our larger locusts clinging to the tops of weeds. A close examination will show that their bodies are soft, and issuing from them in many places are the ends of fungous tubes. This locust fungus, *Empusa grilli* Fres, for some unexplained reason, impels the insects

Fig. 15. Locust—*Melanoplus bivittatus* Say—killed by a fungus. (After Lugger.)

affected with it to climb some tall weed or grass stem and cling to it with such tenacity that the body remains long after death. The spores given off from the fungus of the diseased or dead locust, are more widely scattered by this peculiar habit which the host insect has of climbing tall weeds, as they can the more readily be dispersed over wide areas.

Besides this fungous parasite other vegetable bacteria attack locusts in favorable seasons. But this takes place only in long warm, damp spells; during which the locust has sought shelter and been deprived of food. Many are then often congregated together and one individual affected by the disease may inoculate hundreds. In dry seasons, the locusts and green grasshoppers are much more healthy and abundant and the damage which they do is much greater than in a wet season.

Upon the character of the winter of any year depends largely the number of Orthoptera and other insects which will be present the next summer. Most insects pass the winter in either the egg or the pupal stage; since these forms can readily withstand long and severe cold weather, in fact may be frozen solid for weeks and retain life and vigor, both of which are shown when warm weather and food appear again. Indeed, it is not an unusually cold winter, but one of successive thawings and freezings, which is most destructive to insect life. A mild winter encourages the growth of mold which attacks the hibernating larvæ and pupæ as soon as, from excess of rain or humidity, they become sickly; and it also permits the continued activity of insectivorous mammals and birds. Thus, moles, shrews, and field mice, instead of burying themselves deeply in the ground, run about freely during an open winter and destroy enormous numbers of pupæ; while such birds as the woodpeckers, titmice and chickadees are constantly on the alert, and searching in every crevice and cranny of fence and bark of tree for the hibernating eggs and larvæ.

Animal Parasites.—A number of parasites belonging to the animal kingdom use as their chief hosts the bodies of locusts and other members of the order Orthoptera. Chief among these animal parasites is the red locust mite, *Trombidium locustarum* Riley. On the first warm, sunny days of spring, as soon as the surface of the earth is fairly dry and warm, scores of minute "red spiders" can be seen

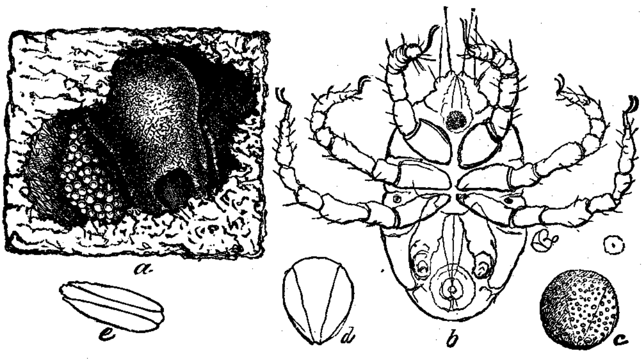


Fig. 16. *Trombidium locustarum.*—*a*, female with her batch of eggs (after Emerton); *b*, newly hatched larva, natural size indicated by the dot within the circle; *c*, egg; *d*, *e*, vacated egg shells. (After Riley.)

along any pathway in the woods and fields. They are especially common if locusts were abundant the year before. These red spiders are in fact mature red mites, the two sexes of which are shown in Fig. 17. Soon after appearing in spring, the sexes mate and the female soon deposits 300 or more small, globular eggs at a depth of a few inches in the soil. From each of these eggs there hatches, about the time the young locusts appear, a minute six-legged mite, which runs actively about in search of some host to which it may attach itself. When it happens upon a young locust, it fastens itself to the wings, wing pads or abdomen and uses its mouth parts to suck up the fluid portions of its host. In a short time its body increases in size, the legs grow smaller, and the mite resembles a small, globular mass of blood attached to the locust. Sometimes as many as twenty mites can be counted on a single host. When thus infested, the locust often becomes disabled, and drags itself about in a clumsy fashion, eats less and dies early, often before the mating and egg-laying season has arrived. In the swollen and almost legless condition which the mite soon attains, it can not move about, and so remains in one position until full grown, when it drops to the ground and enters the pupal stage from which it emerges as the "red spiderkin" of spring. It often becomes mature in late autumn and passes

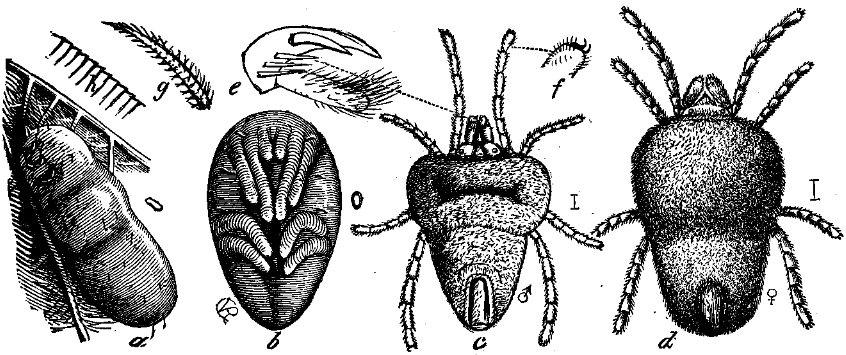


Fig. 17. *Trombidium locustarum.*—*a*, mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural sizes indicated to the right; *e*, pupal claw and thumb; *f*, pedal claws; *g*, one of the barbed hairs *h*, the striations on the larval skin. (After Riley.)

the winter in the ground where it is not idle, except when the temperature sinks below the freezing point. It feeds upon all sorts of soft food, and whenever it has access to the eggs of locusts it greedily eats them. In soil containing eggs of locusts large numbers of these mites congregate. They creep into every hole in search of these eggs and thrive upon such rich food. The great advantage of fall plowing over all other remedies against locusts is seen in regard to these red mites, as the plowing of fields in which the eggs of locusts have been deposited will destroy the young locusts hatching from them, but not the mites, which can easily work their way toward the surface.

Other parasitic animals besides these mites often attack the different species of Orthoptera. On a number of occasions I have found protruding from the abdomens of green grasshoppers and crickets a slender "hair worm" or "horse-hair snake," a species of *Gordius*. If the body of such grasshopper or cricket be cut open the interior is often found to be almost filled with this parasite, which is many times longer than its host, and it will be seen that all the important organs of the latter are pressed to one side and unable to perform their necessary functions. Locusts so affected are seldom able to propagate their kind.

Among insect enemies of the Orthoptera, which aid largely in keeping down their numbers, are "Tachina Flies," "Flesh Flies," "Bee Flies" and "Blister Beetles." Tachina flies are mostly of a gray color, and resemble large house flies. In fields where locusts are abundant, one of these flies may often be seen hovering over a large specimen, awaiting a favorable opportunity to deposit one or more of its eggs on the neck or beneath the wing. These eggs hatch into larvæ or maggots which eat their way into the body of the locust. There they seem to avoid the most vital parts, but feed upon the fatty secretions stored up for future use of the reproductive organs. Locusts so affected have a soft, flabby body, and can often be readily caught by the hand. They never mate, and perish much sooner than the healthy, unaffected individuals.

The flesh flies attack locusts, katydids and grasshoppers in much the same manner as do the tachina flies, and their maggots are often found existing as true parasites upon the vitals of these orthopterous insects. When the maggots of either of these flies become full grown, they burrow through the body wall of the locust and drop to the ground, where they enter the earth and pass through the pupal stage from which they emerge as fully winged insects, ready for attack upon a new generation of locusts.

The egg clusters of locusts, crickets and other Orthoptera in the ground are often attacked by the larval forms of bee flies and blister beetles. The bee flies are of a blackish gray color, densely covered with pale yellow hairs, and in June and July may often be seen hovering above the ground, or feeding upon the honey of various species of wild flowers. Their eggs are laid among or close to the egg masses of the locust, and their larvæ feed upon and destroy myriads of the eggs of the locusts and crickets.

Three or four species of blister beetles or "old-fashioned potato beetles" exist in Indiana, and in the winged or full grown stage are often very injurious to potatoes and allied plants. The eggs of the blister beetle are laid in the ground in late summer, and the larvæ soon hatch and move actively about in search of animal food, in the form of egg masses of other insects. They have often been found feeding upon the eggs of locusts and other Orthoptera and are undoubtedly of much aid in keeping within bounds these injurious forms.

Many of the ground beetles or *Carabidæ* feed, during both their larval and mature stages, upon locust eggs. About 350 species of this family of beetles occur in Indiana, and all are beneficial. In the mature stage they are long legged, rapid moving forms, which mostly hide by day beneath logs and rubbish and run actively about at night in search of some form of flesh upon which they may make a meal. Since insect life is the most common form which they find on or beneath the ground, it is but natural that most of their food is composed of it. The species of *Amara* and *Calosoma,* two of which are

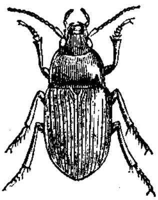


Fig. 18. *Amara obesa* Say. Twice natural size. (After Riley.)

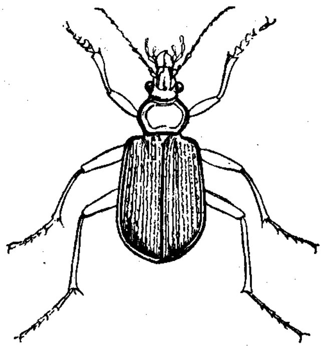


Fig 19. *Calosoma scrutator* Fab. Natural size.

figured herewith, are among the most common and beneficial of this family of beetles. The larvæ of *Amara* may, in autumn, often be found feeding on the egg masses of the locust.

Higher in the scale of animal life are many forms which are among the best friends the farmer possesses, yet many of them he destroys on sight through ignorance of their beneficial habits. Chief among these are shrews, moles, salamanders and snakes. Both shrews and moles are burrowing mammals which feed almost wholly upon insect life. True, the latter sometimes destroy the seeds of corn and vegetables, but the good which they do in destroying the eggs and larvæ of injurious insects far outweighs the bad. Salamanders, or ground puppies, live beneath logs and chunks and burrow into the surrounding region in search of eggs and larvæ, while snakes feed largely upon the young and mature of grasshoppers and locusts, yet all are destroyed at sight.

Many species of birds use as food both the young and full grown of all kinds of Orthoptera. The Division of Ornithology at Washington, and other authorities, have made investigations of the stomachs of many species of birds, and have found that the following species which occur in Indiana feed largely upon locusts, grasshoppers and other forms of Orthoptera.

LIST OF INDIANA BIRDS WHICH ARE KNOWN TO FEED UPON ORTHOPTERA.

Franklin's Gull.
Black Tern.
American Bittern.
Least Bittern.
King Rail.
Sora.
Wilson's Snipe.
Golden Plover.
Red-tailed Hawk.
Red-shouldered Hawk.
Broad-winged Hawk.
Black Hawk.
American Sparrow Hawk.
Yellow-billed Cuckoo.
Black-billed Cuckoo.
Red-headed Woodpecker.
Night Hawk.
Phoebe.
Prairie Horned Lark.
Blue Jay.
Common Crow.
Bobolink.
Cowbird.
Red-winged Blackbird.
Meadow Lark.
Killdeer.
Quail.
Ruffed Grouse.
Prairie Hen.
Wild Turkey.
Mourning Dove.
Marsh Hawk.
Baltimore Oriole.
Common Blackbird.
Vesper Sparrow.
Chewink.
Dickcissel.
Scarlet Tanager.
Butcher Bird.
Red-eyed Vireo.
Yellow-throated Vireo.
Water Wagtail.
Yellow-breasted Chat.
Mockingbird.
Catbird.
Brown Thrasher.
Hermit Thrush.
Robin.
Bluebird.

Of the foregoing list, those which feed mainly on Orthoptera during the summer season are the hawks, blackbirds, crows, blue jay, prairie chicken, mockingbird and bluebird. All of these birds are, however, beneficial in the highest degree and all should, at all times, be protected from their enemies, chief among which is the youth with his shotgun, or the small boy with egg-hunting proclivities.

About the best remedy for Orthoptera on a farm is a large flock of turkeys. Under the leadership of an experienced gobbler, almost their entire time during the summer and fall months is spent in wandering over the fields and pastures in search of the fat and juicy nymphs of locusts, grasshoppers and crickets. Indeed, most of the luscious white and brown meat of our Thanksgiving and Christmas dinners was once grass, then grasshopper, and finally turkey. No better and more practical remedy can be devised, for the damage which the insects do is, especially in these days of "turkey trusts," often more than compensated by the value of the pounds of flesh which this domesticated fowl stores up from its favorite food of locusts.

Bibliography and Synonymy.

In the preparation of this paper, the following papers and general works on Orthoptera have been consulted or are referred to in the synonymy which follows the scientific name of each species.* In order to save space the titles of the papers and works are not given in the synonymy, but each is known by a certain number, printed in open space figures, which, in the snyonymy, immediately follows the name or abbreviation of the author, and all references to that paper bear the same number. For example, Scudder's "Materials for a Monograph of North American Orthoptera," in Vol. VII of the Journal of the Boston Society of Natural History, bears the number **1 4 1** in the Bibliography, and whenever Scudd. is followed by the open space number **1 4 1**, reference is made to the paper mentioned. Thus, on page 242, under *Orphulella speciosa* (Scudder), we find in italics the name *Stenobothrus speciosus* Scudd., **1 4 1**, VII, 1862, 458. This shows that on page 458 of the "Materials for the Monograph of North American Orthoptera" there is, under the name *Stenobothrus speciosus*, a description or important notice of the species now known as *Orphulella speciosa* (Scudder). In this particular instance the original description is referred to. When in the original description a species was placed by the author in a genus different from that to which it is now referred, the name of the author is placed in parenthesis. In the example referred to, the locust described as *speciosus* was placed in the genus *Stenobothrus* by Mr. Scudder. It is now recognized as belonging to the genus *Orphullela* as at present limited. Hence Scudder's name is placed in parenthesis.

* An asterisk (*) preceding the number in the Bibliography denotes that the paper referred to has not been seen by the author, the title being quoted from Scudder's "Index to North American Orthoptera." All papers not preceded by an asterisk are in the author's library.

Most of the species of Orthoptera found in Indiana have been mentioned in so many different works that it is impossible to make reference to them all. I have therefore cited in the synonymy only such works as include descriptions or figures of the species in question or important information regarding its habits and life history. I have thus excluded most of the local lists, but have included papers which contain previous references to its occurrence in Indiana. I have also, in all instances, given the page of Scudder's "Catalogue of North American Orthoptera" on which the species is mentioned, as this catalogue is, in the main, used as the basis for the arrangement of families and genera, and for the synonymy adopted. Special students who wish a more extended synonymy are referred to Scudder's "Index to North American Orthoptera," which includes every known reference to each species up to the close of the year 1900.

BIBLIOGRAPHY.

1. *Bethune, C. J.*—"Insects of the Northern Part of British America, compiled from Kirby's Fauna Boreali-Americana: Insecta. II, Orthoptera," in Canadian Entomologist, VII, pp. 129-131. London, Ontario, 1875.

2. *Beutenmüller, Wm.*—"Notes on some Species of North American Orthoptera, with Descriptions of New Species," in Bulletin American Museum of Natural History, VI, pp. 249-252. New York, 1894.

3. *Beutenmüller, Wm.* — "Descriptive Catalogue of the Orthoptera Found Within Fifty Miles of New York City," in Bulletin American Museum of Natural History, VI, pp. 253-316, Figs. 1-15, Plates V-X. New York, 1894.

4. *Blatchley, W. S.*—"Some Indiana Acrididæ. I," in Canadian Entomologist, XXIII, pp. 74-81, 98-100. London, Ontario, 1891.

5. *Blatchley, W. S.*—"The Gryllidæ of Indiana," in Proceedings of the Indiana Academy of Science, 1891, pp. 126-144. Indianapolis, 1892.

5a. *Blatchley, W. S.*—"Two New Orthoptera from Indiana," in Canadian Entomologist, XXIV, pp. 26-27. London, Ontario, 1892.

6. *Blatchley, W. S.*—"Some Indiana Acrididæ. II," in Canadian Entomologist, XXIV, pp. 28-34. London, Ontario, 1892.

7. *Blatchley, W. S.*—"The Locustidæ of Indiana," in Proceedings of the Indiana Academy of Science, 1892, pp. 92-153. Indianapolis, 1893.

8. *Blatchley, W. S.*—"The Blattidæ of Indiana," in Proceedings of the Indiana Academy of Science, 1892, pp. 153-165. Indianapolis, 1893.

9. *Blatchley, W. S.*—"An Unusual Appearance of Schistocerca Americana," in Psyche, VI, pp. 465-466. Cambridge, 1893.

10. *Blatchley, W. S.*—"Some New Locustidæ from Indiana," in Canadian Entomologist, XXV, pp. 89-93. London, Ontario, 1893.

11. *Blatchley, W. S.*—"Some Indiana Acrididæ. III," in Canadian Entomologist, XXVI, pp. 217-223, 241-245. London, Ontario, 1894.

12. *Blatchley, W. S.*—"Notes on the Winter Insect Fauna of Vigo County, Indiana," in Psyche, VII, pp. 248-250. Cambridge, 1895.

13. *Blatchley, W. S.*—"Miscellaneous Notes," in Canadian Entomologist, XXVIII, pp. 265-266. London, Ontario, 1896.

14. *Blatchley, W. S.* — "Indiana Caves and Their Fauna," in Twenty-first Annual Report of the Department of Geology and Natural Resources, 1896, pp. 121-212, Plates IV-XII. Indianapolis, 1897.

15. *Blatchley, W. S.*—"Some Indiana Acrididæ. IV," in Canadian Entomologist, XXX, pp. 54-64. London, Ontario, 1898.

16. *Blatchley, W. S.*—"Katydids and Their Kin; or the Orthoptera of Indiana," in Gleanings from Nature, pp. 197-244, Figs. 41-70. Indianapolis, 1899.

17. *Blatchley, W. S.*—"On the Species of Nemobius Known to Occur in Indiana," in Psyche, IX, pp. 51-54. Cambridge, 1900.

18. *Blatchley, W. S.*—A Nature Wooing. Pp. 1-245, Plates I-XII, Figs. 1-63. Indianapolis, 1902.

19. *Bolivar, Ignacio.*—Essai sur les Acridiens de la tribu des Tettigidæ. Pp. 1-139, Plates I-II. Bruxelles, 1887.

20. *Bruner, Lawrence.*—"New Species of Nebraska Acrididæ," in Canadian Entomologist, VIII, pp. 123-125. London, Ontario, 1876.

21. *Bruner, Lawrence.* — "Two New Myrmecophilæ from the United States," in Canadian Entomologist, XVI, pp. 41-43, Fig. 4. London, Ontario, 1884.

22. *Bruner, Lawrence.*—"First Contribution to a Knowledge of the Orthoptera of Kansas," in Bulletin Washburn College of Natural History, I, pp. 125-139. Topeka, 1885.

23. *Bruner, Lawrence.*—"Report of the Entomologist," in Annual Report of the Nebraska Board of Agriculture, pp. 84-130. Lincoln, 1888.

24. *Bruner, Lawrence.* — "New North American Acrididæ found North of the Mexican Boundary," in Proceedings of the U. S. National Museum, XII, pp. 47-82, Plate. Washington, 1890.

25. *Bruner, Lawrence.*—"Ten New Species of Orthoptera from Nebraska, with Notes on the Habits, Wing Variation, etc.," in Canadian Entomologist, XXIII, pp. 36-40; 56-59; 70-73. London, Ontario, 1891.

26. *Bruner, Lawrence.* — "Report on Destructive Locusts," in Bulletin U. S. Division of Entomology, XXVII, pp. 9-33. Washington, 1892.

27. *Bruner, Lawrence.* — "A Change in the Name of a Recently Described Species of Orchelimum," in Entomological News, III, pp. 264-265. Philadelphia, 1892.

28. *Bruner, Lawrence.* — "The More Destructive Locusts of America North of Mexico," in Bulletin U. S. Division of Entomology, XXVIII, pp. 1-40. Washington, 1893.

29. *Bruner, Lawrence.*—"A List of Nebraska Orthoptera," in Publications of Nebraska Academy of Science, III, pp. 19-33. Lincoln, 1893.

30. *Bruner, Lawrence.*—"The Insect Enemies of Small Grains," in Report Nebraska State Board of Agriculture, pp. 359-468, Figs. 1-111. Lincoln, 1893.

31. *Bruner, Lawrence.*—"Insect Enemies of the Apple Tree and its Fruit," in Report Nebraska State Horticultural Society, pp. 153-224. Lincoln, 1894.

32. *Bruner, Lawrence.*—"Insect Enemies of the Grape Vine," in Nebraska State Horticultural Report, pp. 68-162, Figs. 1-96. Lincoln, 1895.

33. *Bruner, Lawrence.*—"Directions for Collecting, Preparing and Preserving Specimens of Orthoptera for the Cabinet," in Special Bulletin Department of Entomology, University of Nebraska, II, pp. 1-8. Lincoln, 1895.

34. *Bruner, Lawrence.*—"The Grasshoppers that Occur in Nebraska," in Annual Report Nebraska State Board of Agriculture, 1896, pp. 105-138, Figs. 1-35. Lincoln, 1897.

35. *Bruner, Lawrence.*—"Insect Enemies of the Apple Tree and its Fruit," in Annual Report Nebraska State Horticultural Society, pp. 119-212, Figs. 1-108. Lincoln, 1899.

36. *Bruner, Lawrence.*—"Report of the Entomologist. A Preliminary Report on the Insect Enemies of Clover and Alfalfa," in Annual Report Nebraska State Board of Agriculture, pp. 239-285, Figs. 1-67. Lincoln, 1899.

37. *Brunner von Wattenwyl, Carl.*—Nouveau système des Blattaires. Pp. 1-426, Plates 1-13. Vienna, 1865.

38. *Brunner von Wattenwyl, Carl.*—"Monographie der Phaneropteriden," in der K. K. Zoölogisch-Botanischen Gesellschaft in Wien, pp. 1-401, Plates I-VIII. Vienna, 1878.

39. *Brunner von Wattenwyl, Carl.*—"Monographie der Stenopelmatiden und Grillacriden," in Verhandlungen Zoölogisch-Botanischen Gesellschaft, XXXVIII, pp. 247-394, Plates V-VIII. Wien, 1888.

39a. *Brunner von Wattenwyl, Carl.*—Monographie der Pseudophylliden. Pp. 4+282, Plates I-X. Wien, 1895.

40. *Burmeister, Hermann.*—Handbuch der Entomologie, II. Pp. 459-756. Berlin, 1838.

40a. *Caudell, A. N.* — "The Phasmidæ or Walking-Sticks of the United States," in Proceedings of the U. S. National Museum, XXVI, 863-885, Plates LVIII-LIX. Washington, 1903.

40b. *Caudell, A. N.*—"Notes on the Nomenclature of Blattidæ," in Proceedings Entomological Society of Washington, V, 232-234. Washington, 1903.

41. *Comstock, J. H.*—"Orthoptera," in An Introduction to Entomology, I, pp. 87-122, Figs. 83-110. Ithaca, 1888.

42. *Comstock, J. H.* and *A. B.*—A Manual for the Study of Insects. Pp. 12+701, 6 plates. Ithaca, 1895.

43. *Davis, Wm. T.*—"The Song of Thyreonotus," in Canadian Entomologist, XXV, pp. 108-109. London, Ontario, 1893.

44. *Dodge, Chas. R.*—"Notes of a Cowcatcher Ride Through Nebraska," in Canadian Entomologist, IV, pp. 14-16. London, Ontario, 1872.

45. *Dodge, G. M.*—"New Species of Acrididæ from Nebraska," in Canadian Entomologist, VIII, pp. 9-12. London, Ontario, 1876.

46. *Dodge, G. M.*—"New Species of Orthoptera," in Canadian Entomologist, IX, pp. 111-113. London, Ontario, 1877.

47. *Doran, Edwin W.*—"The Life History of the Northern Mole Cricket," in Canadian Entomologist, XXIV, pp. 270-273. London, Ontario, 1892.

*48. *Drury, Drew.*—Illustrations of Natural History. I, pp. 28+130, Plates 1-50; II, pp. 7+92, Plates 1-50; III, pp. 26+76, Plates 1-50. London, 1770-1782.

49. *Emmons, Ebenezer.*—Agriculture of New York. V, pp. 8-272, Plates 3+47. Albany, 1854.

*50. *Fabricius, Johann C.*—Systema entomologiæ, sistens insectorum classes, ordines, genera, species, adjectis synonymis, locis, descriptionibus, observationibus. Pp. 32+832. Flensburgi et Lipsiæ, 1775.

*51. *Fabricius, Johann C.*—Species insectorum exhibentes eorum differentias specificas, synonyma auctorum, loca natalia, metamorphosin adjectis observationibus, adumbrationibus. I, pp. 8+552; II, pp. 2+494. Hamburgi et Kilonii, 1781.

*52. *Fabricius, Johann C.*—Entomologia systematica emendata et aucta, secundum classes, ordines, genera, species, adjectis synonymis, locis, observationibus, descriptionibus. II, pp. 1-62. Hafniæ, 1793.

53. *Fernald, C. H.*—The Orthoptera of New England. Pp. 1-61, Figs. 1-22. Boston, 1888.

54. *Fletcher, James.*—"The Northern Mole Cricket," in Canadian Entomologist, XXIV, pp. 23-25. London, Ontario, 1892.

*55. *Fischer, L. H.* — Orthoptera Europæa. Pp. 20+454, Plates 1-18. Lipsiæ, 1853.

56. *Fitch, Asa.*—"Third Report on the Noxious and Other Insects of the State of New York," in Transactions of the New York State Agricultural Society, XVI, pp. 321-507. Albany, 1856.

*57. *Geer, Karel de.*—Memoires pour servir à l'histoire des insectes. Orthoptera, III, pp. 399-554, Plates 21-25. Stockholm, 1773.

58. *Germar, Ernest F.*—In Burmeister's Handbuch der Entomologie, II. Berlin, 1838.

*59. *Gerstæcker, Carl Edward.* — Ueber die Locustinen-gattung Gryllacris. Wiegm., Arch. naturg., XXVI, pp. 245-278. Berlin, 1860.

60. *Glover, Townend.*—"Report of the Entomologist," in the Annual Report of the U. S. Department of Agriculture, 1870, pp. 65-91. Washington, 1871.

61. *Glover, Townend.*—"Report of the Entomologist," in Annual Report of U. S. Department of Agriculture, 1871, pp. 69-88. Washington, 1872.

62. *Glover, Townend.*—Illustrations of North American Entomology—Orthoptera. Pp. 5+11, Plates 1-18. Washington, 1872-1874.

63. *Glover, Townend.*—"Report of the Entomologist," in Annual Report of the U. S. Department of Agriculture, 1874, pp. 122-146. Washington, 1875.

*64. *Gray, Geo. R.*—Synopsis of the Species of Insects belonging to the Family of Phasmidæ. Pp. 4+48. London, 1835.

65. *Haldeman, Samuel S.*—"Description of Some New Species of Insects, with Observations on Described Species," in Proceedings of the Academy of Natural Science of Philadelphia, VI, pp. 361-365. Philadelphia, 1853.

66. *Hancock, Joseph L.*—"Unusual Flights of the Grouse Locust. (Tettigidea lateralis Say) in Northeastern Illinois," in American Naturalist, XXVIII, pp. 483-487, Plate 13. Philadelphia, 1894.

67. *Hancock, Joseph L.*—"On Illinois Grouse Locusts," in Transactions American Entomological Society, XXIII, pp. 235-244, Plates VI-IX. Philadelphia, 1896.

68. *Hancock, Joseph L.*—"Some Tettigian Studies," in Entomological News, X, pp. 275-282. Philadelphia, 1899.

69. *Hancock, Joseph L.*—The Tettigidea of North America. Pp. vii+188, Plates I-XI, Figs. 1-13. Chicago, 1902.

*70. *Harris, Thaddeus W.*—A Catalogue of the Animals and Plants in Massachusetts. VIII. Insects in Hitchcock, Edward, Report of the Geologist of Massachusetts, pp. 566-595. Amherst, 1833; Second edition, pp. 553-602. Amherst, 1835.

71. *Harris, Thaddeus W.*—A Report on the Insects of New England Injurious to Vegetation. Pp. viii+459, First edition, Cambridge, 1841.

72. *Harris Thaddeus W.*—A Treatise on some of the Insects of New England which are Injurious to Vegetation. Pp. 12+640, Figs. 1-278, Plates I-VIII. Third edition. Edited by Chas. Lewis Flint. Boston, 1862.

73. *Hart, Chas. A.*—"On the Species of Œcanthus Serv.," in Entomological News, III, pp. 33-34, Figs. 1-6. Philadelphia, 1892.

74. *Howard, L. O.*—"A Genus of Mantis Egg-Parasites," in Insect Life, IV, pp. 242-245, Figs. 28-31. Washington, 1892.

75. *Howard, L. O.*—"Damage by the American Locust," in Insect Life, VII, pp. 220-229, Figs. 19-22. Washington, 1895.

76. *Howard, L. O.*—The Insect Book. Pp. xxvii+429, Figs. 1-264. New York, 1901.

77. *Hyatt & Arms.*—Guides for Science Teaching. Insecta. Pp. xxiii+300, Figs. 1-223, Plates I-XIII. Boston, 1890.

78. *Kellogg, V. L.*—Common Injurious Insects of Kansas. Pp. 8+126. Lawrence, 1892.

*79. *Kirby, William.*—Fauna boreali-americana. The Insects, IV, pp. 39+325, Plates I-VIII. London, 1837.

*80. *Linnæus, Carl von.*—Centuria insectorum rariorum. Pp. 6-32. Upsaliæ, 1763.

*81. *Linnæus, Carl von.*—Systema naturæ. Editio decima reformata. Orthoptera, I, pp. 423-434, 1758. Editio duodecima reformata. Orthoptera, II, pp. 686-703. Holmiæ, 1767.

82. *Lintner, J. A.*—"Chimarocephala viridifasciata (DeG.)," in Second Report on the Injurious and other Insects of the State of New York, pp. 187-198, Figs. 54-59. Albany, 1885.

83. *Lintner, J. A.*—Report of the State Museum of New York, XLVIII. Pp. 440-443, Fig. 19. Albany, 1895.

84. *Lugger, Otto.*—"The Orthoptera of Minnesota," in Third Annual Report of the Entomologist of the State Experiment Station of the University of Minnesota for the year 1897. Pp. 1-296, Figs. 1-187. St. Paul, 1898.

85. *Marlatt, C. L.*—"The Principal Household Insects of the United States," in Bulletin 4, new series, U. S. Division of Entomology, pp. 1-130, Figs. 1-64. Washington, 1896.

86. *Marlatt, C. L.*—"Cockroaches," in Circular 51, second series, U. S. Division of Entomology, pp. 1-15, Figs. 1-5. Washington, 1902.

87. *McNeill, Jerome.*—"Dissosteira carolina," in Canadian Entomologist, XIX, pp. 58-59. London, Ontario, 1887.

88. *McNeill, Jerome.*—"A List of the Orthoptera of Illinois," in Psyche, VI, pp. 3-9, 21-27, 62-66, 73-78. Cambridge, 1891.

89. *McNeill, Jerome.*—"Revision of the Truxalinæ of North America," in Proceedings of the Davenport Academy of Natural Sciences, VI, pp. 179-274, Plates I-VI. Davenport, 1897.

90. *McNeill, Jerome.*—"Orchelimum Serville," in Canadian Entomologist, XXXII, pp. 77-83. London, Ontario, 1900.

91. *McNeill, Jerome.*—"Review of the Orthopteran Genus Trimerotropis," in Proceedings of the U. S. National Museum, XXIII, pp. 393-449, Plate XXI. Washington, 1901.

92. *Morse, Albert P.*—"A New Species of Stenobothrus from Connecticut, with Remarks on other New England Species," in Psyche, VI, pp. 477-479, Figs. 1-6. Cambridge, 1893.

93. *Morse, Albert P.*—"A Preliminary List of the Acrididæ of New England," in Psyche, VII, pp. 102-108. Cambridge, 1894.

94. *Morse, Albert P.*—"Notes on the Acrididæ of New England. I. Tettiginæ," in Psyche, VII, pp. 147-154, 163-167, Plate 6. Cambridge, 1894.

95. *Morse, Albert P.*—"Spharagemon; A Study of the New England Species," in Proceedings of the Boston Society of Natural History, XXVI, pp. 220-240, Figs. 1-9. Boston, 1894.

96. *Morse, Albert P.*—"New North American Tettiginæ. I," in Journal of the New York Entomological Society, III, pp. 14-16; "II," pp. 107-110. New York, 1895.

97. *Morse, Albert P.* — "Revision of the Species of the Genus Spharagemon," in Psyche, VII, pp. 287-299, Figs. 1-6. Cambridge, 1895.

98. *Morse, Albert P.*—"Notes on the Acrididæ of New England. II. Tryxalinæ," in Psyche, VII, pp. 323-327, 342-344, 382-384, 402-403, 407-411, 413-422, 443-445, Plate 7. Cambridge, 1896-'97.

99. *Morse, Albert P.* — "Notes on New England Acrididæ. III. Oedipodinæ," in Psyche, VIII, pp. 6-8, 35-37, 50-51, 64-66, 80-82, 87-89, 91-114, Plate 2. Cambridge, 1897.

100. *Morse, Albert P.*—"Notes on New England Acrididæ. IV, Acridiinæ," in Psyche, VIII, pp. 247-248; 255-260, 269-273, 279-282, 292-296, Plate 7. Cambridge, 1898.

101. *Morse, Albert P.*—"New North American Tettiginæ. III," in Journal New York Entomological Society, VII, pp. 198-201. New York, 1899.

102. *Morse, Albert P.*—"Variation in Tridactylus," in Psyche, IX, pp. 197-199, Figs. 1-5. Cambridge, 1901.

103. *Murtfeldt, Mary E.*—"The Carnivorous Habits of Tree Crickets," in Insect Life, II, pp. 130-132. Washington, 1889.

104. *Packard, Alpheus S.*—"Orthoptera," in Guide to the Study of Insects and a Treatise on Those Injurious and Beneficial to Crops. Pp. 556-577. Salem, 1869. Also edition of 1883.

105. *Packard, Alpheus S.*—"On the Cave Fauna of Indiana," in Annual Report of Peabody Academy of Science, V. pp. 93-97. Salem, 1873.

106. *Packard, Alpheus S.*—"The Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of

the Blind Species," in Memoirs National Academy of Science, IV, pp. 3-156, Plates I-XXVI. Washington, 1888.

107. *Packard, Alpheus S.*—"On Insects Injurious to Forest and Shade Trees," in Report of the U. S. Entomological Commission, V, 8+958, Plate I. Washington, 1890.

*108. *Palisot de Beauvois, A. M.*—Insectes recueillis en Afrique et en Amérique dans les royaumes d'Oware à Saint-Domingue et dans les Etats-unis pendant les années 1786-1797. Pp. 16+276, Plates 1-90. Paris, 1805-1821.

109. *Rathvon, S. S.*—"Entomology and its Relation to the Vegetable Productions of the Soil, with Reference to Both the Destructive and Beneficial Insects," in Report of the U. S. Department of Agriculture, pp. 372-390, 4 plates. Washington, 1862.

110. *Redtenbacher, Josef.*—"Monographie der Conocephaliden," in Verhandlungen der K. K. Zoölogisch-Botanischen Gesellschaft in Wien, pp. 315-562, Plates 3-4. (Author's Separate, pp. 1-248.) Wien, 1891.

111. *Rehn, James A.*—"Schistocerca alutacea and rubiginosa," in Entomological News, XIII, p. 89. Philadelphia, 1902.

112. *Rehn, James A.*—"Records of New Jersey and Pennsylvania Orthoptera," in Entomological News, XIII, pp. 309-316. Philadelphia, 1902.

112a. *Rehn, James A.*—"Notes on Some Interesting Species of Forficulidæ and Blattidæ from the Eastern United States," in Entomological News, XIV, 1903, pp. 125-126.

113. *Riley, Chas. V.*—First Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. Pp. 1-181, Figs. 1-98. Jefferson City, 1869.

114. *Riley, Chas. V.*—Fifth Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. Pp. 1-160, Figs. 1-75. Jefferson City, 1873.

115. *Riley, Chas. V.*—"Katydids," in the Sixth Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri, pp. 150-169, Figs. 43-55. Jefferson City, 1874.

116. *Riley, Chas. V.*—Seventh Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. Pp. viii+196, Figs. 1.39. Jefferson City, 1875.

117. *Riley, Chas. V.*—Eighth Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. Pp. 1-185, Figs. 1-55. Jefferson City, 1876.

118. *Riley, Chas. V.*—Ninth Annual Report on the Noxious, Beneficial and other Insects of the State of Missouri. Pp. vi+129, Figs. 1-33. Jefferson City, 1877.

119. *Riley, Chas. V.*—The Locust Plague in the United States; being more particularly a treatise on the Rocky Mountain locust or so-called grasshopper, as it occurs east of the Rocky Mountains, with practical recommendations for its destruction. Pp. 1-236, Plates 1-3. Chicago, 1877.

120. *Riley, Chas. V.*—"The Thick-thighed Walking-stick," in Report U. S. Department of Agriculture, 1878, pp. 241-245, Plate III. Washington, 1879.

121. *Riley, Chas. V.*—"General Index and Supplement to the Nine Reports on the Insects of Missouri," in Bulletin U. S. Entomological Commission, VI, pp. 1-178. Washington, 1881.

122. *Riley, Chas. V.*—"Orthoptera," in The Standard Natural History, II, pp. 167-203, plate. Boston, 1884.

123. *Riley, Chas. V.*—"Report of the Entomologist," in Annual Report of the U. S. Department of Agriculture, 1885, pp. 10+137, Plates I-IX. Washington, 1886.

124. *Riley, Chas. V.*—"Our Shade Trees and their Insect Defoliators," in Bulletin U. S. Division of Entomology, X, pp. 1+69. Washington, 1887.

125. *Riley, Chas. V.*—"Injury done by Roaches to the Files in the Treasury in Washington," in Insect Life, I, pp. 67-70, 190-191. Washington, 1888.

126. *Riley, Chas. V.*—"Some Insect Pests of the Household, IV, Cockroaches," in Insect Life, II, pp. 266-269. Washington, 1890.

127. *Riley, Chas. V.*—"Destructive Locusts. A Popular consideration of a few of the more injurious locusts of the United States, together with the best means of destroying them," in Bulletin 25, U. S. Division of Entomology, pp. 1-62, Plates 1-12, map. Washington, 1891.

128. *Saussure, Henri D.*—Orthoptera Nova Americana (Diagnoses Praeliminaires) I, pp. 1-16; II, pp. 1-33; III, pp. 1-17. Paris, 1859-1862.

*129. *Saussure, Henri D.*—Orthopteres de l'Amerique moyenne. Pp. 1-279, Plates 1-2. Geneva and Paris, 1864-1869.

130. *Saussure, Henri D.*—"Essai d'un Systeme des Mantides," in Mittheilungen der Schwiez Entomological Gesellschaft, III, pp. 49-73. Schaffhausen, 1869.

131. *Saussure, Henri D.*—Synopsis des Mantides Americains. Pp. 1-184, Plates 1-2. Geneve et Bale, 1871.

132. *Saussure, Henri D.*—"Etudes sur les insectes Orthopteres," in Mission Scientifique au Mexique et dans l'Amerique Centrale, pp. 6+533, Plates 7-8. Paris, 1870-1879.

133. *Saussure, Henri D.*—Melanges Orthopterologiques. I, pp. 1-460, Plates 1-7; II, pp. 1-834, Plates 1-29. Geneva, 1877-1878.

134. *Saussure, Henri D.*—"Prodromus Oedipodiorum Insectorum ex ordine Orthopterorum," in Memoir de las Societe de physique et d'histoire naturelle de Genève, XXVIII, pp. 1-254, Plate I. Geneva, 1884.

135. *Saussure, Henri D.* and *Zehntner, Leo.*—"Orthoptera genuina. Blattidæ, Mantidæ," in Biologia Centrali Americana. Orthoptera, pp. 13-197, Plates I-X. London, 1893-1894.

*136. *Saussure, Henri D.* and *Pictet, Alphonse.* "Orthoptera gennina. Locustidæ," in Biologia Centrali Americana, Zoölogia Orthoptera. Pp. 285-458, Plates 14-22. London, 1897-1899.

137. *Say, Thomas.* American Entomology, or Descriptions of the Insects of North America. I, pp. 8+112, Plates 1-18; III, pp. 1-138, Plates 37-54. Philadelphia, 1824-1828.

138. *Say, Thomas.*—"Description of new Hemipterous Insects collected in the Expedition to the Rocky Mountains, performed by order of Mr. Calhoun, Secretary of War, under Command of Major Long," in Journal Academy of Natural Science of Philadelphia, IV, pp. 307-345. Philadelphia, 1825.

139. *Say, Thomas.* The Complete Writings of Thomas Say on the Entomology of North America. Edited by John Lawrence Le Conte, M. D. I, pp. 24+412, Plates 1-54; II, pp. 4+814. New York, 1859.

140. *Scudder, Samuel H.*—"On the Genus Raphidophora Serville; with descriptions of four species from the Caves of Kentucky, and from the Pacific Coast," in Proceedings of the Boston Society of Natural History, VIII, pp. 6-14. Boston, 1861.

141. *Scudder, Samuel H.*—"Materials for a Monograph of the North American Orthoptera, including a Catalogue of the Known New England Species," in Journal of the Boston Society of Natural History, VII, pp. 409-480. Boston, 1862.

142. *Scudder, Samuel H.*—"The Songs of the Grasshoppers," in American Naturalist, II, pp. 113-120, Figs. 1-4. Salem, 1868.

143. *Scudder, Samuel H.*—"Notes on the Stridulation of some New England Orthoptera," in Proceedings of the Boston Society of Natural History, XI, pp. 306-313. Boston, 1868.

144. *Scudder, Samuel H.*—"A Century of Orthoptera, Decade I. Gryllides," in Proceedings of the Boston Society of Natural History, XII, pp. 139-143. Boston, 1868.

145. *Scudder, Samuel H.*—"Revision of the Large, Stylated Fossorial Crickets," in Memoirs of the Peabody Academy of Science, I, pp. 1-28, Plate I. Salem, 1869.

146. *Scudder, Samuel H.*—"Descriptions of new species of Orthoptera in the collection of the American Entomological Society," in Transactions of the American Entomological Society, II, pp. 305-307. Philadelphia, 1869.

147. *Scudder, Samuel H.*—"Notes on the Orthoptera collected by Dr. F. V. Hayden in Nebraska," in Report of the U. S. Geological Survey of Nebraska and Portions of Adjacent Territories, pp. 247-261. Washington, 1872.

148. *Scudder, Samuel H.*—"The Distribution of Insects in New Hampshire," in Hitchcock's Report on the Geology of New Hampshire, I, pp. 331-380, Plates A-C. Concord, 1874.

149. *Scudder, Samuel H.*—"Spharagemon,—A Genus of Oedipodidæ; with a Revision of the Species," in Proceedings of the Boston Society of Natural History, XVII, pp. 467-471. Boston, 1875.

150. *Scudder, Samuel H.*—"Revision of two American Genera of Oedipodidæ," in Proceedings of the Boston Society of Natural History, XVII, pp. 478-485. Boston, 1875.

151. *Scudder, Samuel H.*—"A Century of Orthoptera. Decade II. —Locustariæ," in Proceedings of the Boston Society of Natural History, XVII, pp. 454-462. Boston, 1875.

152. *Scudder, Samuel H.*—"A Century of Orthoptera. Decade III. —Acrydii (Pezotettix Caloptenus)," in Proceedings of the Boston Society of Natural History, XVII, pp. 472-478. Boston, 1875.

153. *Scudder, Samuel H.*—Entomological Notes, IV. Pp. 1-91. Boston, 1875.

154. *Scudder, Samuel H.*—"The Chirp of the Mole Cricket," in The American Naturalist, X, pp. 97-98. Salem, 1876.

155. *Scudder, Samuel H.*—"Brief Synopsis of North American Earwigs, with an Appendix on the Fossil Species," in Bulletin of the U. S. Geological and Geographical Survey of the Territories, II, No. 3, pp. 249-260. Washington, 1876.

156. *Scudder, Samuel H.*—"List of the Orthoptera Collected by Dr. A. S. Packard in Colorado and the Neighboring Territories During the Summer of 1875," in Bulletin of the U. S. Geological and Geographical Survey of the Territories, II, No. 3, pp. 261-267. Washington, 1876.

157. *Scudder, Samuel H.*—"Synoptical Tables for Determining North American Insects. Orthoptera.—U. S. Forficularia," in Psyche, I, pp. 177-178. Cambridge, 1876.

158. *Scudder, Samuel H.*—"Critical and Historical Notes on Forficulariæ, including descriptions of new Generic forms, and an Alphabetical Synonymic List of the Described Species," in Proceedings of the Boston Society of Natural History, XVIII, pp. 287-332. Boston, 1876.

159. *Scudder, Samuel H.*—"Report on the Orthoptera Collected by the U. S. Geological Survey West of the One-hundredth Meridian, under the direction of Lieut. Geo. M. Wheeler, during the Summer of 1875," in Annual Report of the Chief of Engineers for 1876. Appendix JJ, pp. 498-515. Washington, 1876.

160. *Scudder, Samuel H.*—"New Forms of Saltatorial Orthoptera from the Southern United States," in Proceedings of the Boston Society of Natural History, XIX, pp. 35-41. Boston, 1877.

161. *Scudder, Samuel H.*—Entomological Notes, VI. Pp. 1-55. Boston, 1878.

162. *Scudder, Samuel H.*—"The Florida Orthoptera collected by J. H. Comstock," in Proceedings of the Boston Society of Natural History, XIX, pp. 80-94. Boston, 1877.

163. *Scudder, Samuel H.*—"Remarks on Calliptenus and Melanoplus, with a Notice of the Species found in New England," in Proceedings of the Boston Society of Natural History, XIX, pp. 281-286. Boston, 1878.

164. *Scudder, Samuel H.*—A Century of Orthoptera. Pp. 1-84. Boston, 1879.

165. *Scudder, Samuel H.*—"A Few Notes on North American Acridii," in Canadian Entomologist, XII, pp. 75-76. London, Ontario, 1880.

166. *Scudder, Samuel H.*—"A List of Orthoptera Collected by Dr. Alpheus S. Packard in the Western United States in the Summer of 1877," in Report of the U. S. Entomological Commission, II. Appendix 2, pp. 23-28, Plate 17. Washington, 1880.

167. *Scudder, Samuel H.*—"The Orthopteran Genus Hippiscus," in Psyche, VI, pp. 265-274, 285-288, 301-304, 317-320, 333-336, 347-350, 359-363. Cambridge, 1892.

168. *Scudder, Samuel H.*—"The Songs of our Grasshoppers and Crickets," in Twenty-third Annual Report of the Entomological Society of Ontario, 1892, pp. 62-78, Figs. 36-54. Toronto, Ontario, 1893.

169. *Scudder, Samuel H.*—"Walking-sticks," in Harper's Magazine, LXXXVIII, pp. 454-461, 11 figures. New York, 1894.

170. *Scudder, Samuel H.*—"A Preliminary Review of the North American Decticidæ," in Canadian Entomologist, XXVI, pp. 177-184, London, Ontario, 1894.

171. *Scudder, Samuel H.*—"The North American Ceuthophili," in Proceedings of the American Academy of Arts and Sciences, XXX, pp. 17-113. Boston, 1894.

172. *Scudder, Samuel H.*—"Summary of the United States Phasmidæ," in Canadian Entomologist, XXVII, pp. 29-30. London, Ontario, 1895.

173. *Scudder, Samuel H.*—"Index to the Mantidæ of North America North of Mexico," in Canadian Entomologist, XXVIII, pp. 207-215. London, Ontario, 1896.

174. *Scudder, Samuel H.*—"Some American Crickets," in Harper's Magazine, XCIII, pp. 691-696. New York, 1896.

175. *Scudder, Samuel H.*—"North American Species of Nemobius," in Journal New York Entomological Society, IV, pp. 99-107. New York, 1896.

176. *Scudder, Samuel H.*—"The Species of Nemobius found in North America," in Psyche, VII, pp. 431-434. Cambridge, 1896.

177. *Scudder, Samuel H.*—"The Genera of North American Melanopli," in Proceedings of the American Academy of Arts and Sciences, XXXII, pp. 193-206. Boston, 1897.

178. *Scudder, Samuel H.*—"Diapheromera femorata," in Psyche, VIII, pp. 30-31. Cambridge, 1897.

179. *Scudder, Samuel H.*—"The Species of the Genus Melanoplus," in Proceedings of the American Philosophical Society, XXXVI, No. 154, pp. 5-35. Philadelphia, 1897.

180. *Scudder, Samuel H.*—"Biological and other Notes on American Acrididæ," in Psyche, VIII, pp. 99-102. Cambridge, 1897.

181. *Scudder, Samuel H.*—"Revision of the Orthopteran Group Melanopli (Acrididæ), with Special Reference to North American Forms," in Proceedings U. S. National Museum, XX, pp. 1-421, Plates I-XXVI. Washington, 1897.

182. *Scudder, Samuel H.*—"The Orthopteran Group Scudderiæ," in Proceedings of the American Academy of Arts and Sciences, XXXIII, No. 15, pp. 271-290. Boston, 1898.

183. *Scudder, Samuel H.*—"The Described Species of Xiphidium in the United States and Canada," in Canadian Entomologist, XXX, pp. 183-184. London, Ontario, 1898.

184. *Scudder, Samuel H.*—"The Orthopteran Genus Schistocerca," in Proceedings of the American Academy of Arts and Sciences, XXXIV, pp. 441-476. Boston, 1899.

185. *Scudder, Samuel H.*—"The North American Species of Orphulella," in Canadian Entomologist, XXXI, pp. 177-188. London, Ontario, 1899.

186. *Scudder, Samuel H.*—"Short Studies of North American Tryxalinæ," in Proceedings of the American Academy of Arts and Sciences, XXXV, pp. 39-57. Boston, 1899.

187. *Scudder, Samuel H.*—"The Species of Myrmecophila in the United States," in Psyche, VIII, pp. 423-428. Cambridge, 1899.

188. *Scudder, Samuel H.*—"Catalogue of the Described Orthoptera of the United States and Canada," in Proceedings of the Davenport Academy of Natural Sciences, VIII, pp. 1-101, Plates I-III. Davenport, 1900.

189. *Scudder, Samuel H.*—"A List of the Orthoptera of New England," in Psyche, IX, pp. 99-106. Cambridge, 1900.

190. *Scudder, Samuel H.*—"The Distribution of Leptysma marginicollis Serv.," in Psyche, IX, p. 116. Cambridge, 1900.

191. *Scudder, Samuel H.*—"The Species of Diapheromera (Phasmidæ) found in the United States and Canada," in Psyche, IX, pp. 187-189. Cambridge, 1901.

192. *Scudder, Samuel H.*—"Miogryllus and Its Species in the United States," in Psyche, IX, pp. 256-258. Cambridge, 1901.

193. *Scudder, Samuel H.*—"The Species of Gryllus on the Pacific Coast," in Psyche, IX, pp. 267-270. Cambridge, 1901.

194. *Scudder, Samuel H.*—"The Species of Gryllus found in the United States East of the Sierra Nevadas," in Psyche, IX, pp. 291-296. Cambridge, 1902.

195. *Scudder, Samuel H.*—"On the United States Orthoptera which have been referred to the Genus Tridactylus," in Psyche, IX, pp. 308-310. Cambridge, 1902.

196. *Serville, J. G. Audinet.*—Histoire naturelle des Insectes. Orthopteres. Pp. xviii+777, Plates 1-14. Paris, 1839.

197. *Smith, John B.*—"Grasshoppers, Locusts and Crickets," in Bulletin New Jersey Agricultural College Experiment Station, XC, pp. 1-34. New Brunswick, 1892.

198. *Smith, Sidney I.*—"On the Orthoptera of the State of Maine," in Proceedings of the Portland Society of Natural History, I, pp. 143-151. Portland, 1868.

199. *Smith, Sidney I.*—"Report of the Entomologist," in Annual Report of the Connecticut Board of Agriculture, 1872-1873, pp. 345-383. Hartford, 1873.

200. *Stal, Carl.*—Recensio Orthopterorum; Revue Critique des Orthopteres decritis par Linné, de Geer et Thunburg. I, pp. 4+154; II, pp. 4+121; III, pp. 4+105. Stockholm, 1873-1875.

*201. *Stoll, Caspar.*—Representation exactement colorée d'apres nature des spectres ou phasmes, des mantes, des sauterelles, des grillons des criquets, et des blattes, qui se trouvent dans les quartres parties du monde, l'Europe, l'Asie, l'Afrique et l'Amerique, rassemblées et décrites. I. Spectres et mantes, pp. 6+79, Plates 1-25. Amsterdam, 1787-1813.

202. *Thomas, Cyrus.*—"Insects Injurious to Vegetation in Illinois," in Transactions of the Illinois State Agricultural Society, V, pp. 401-468. Springfield, 1865.

203. *Thomas, Cyrus.*—"Descriptions of Grasshoppers from Colorado," in Proceedings of the Academy of Natural Sciences of Philadelphia, pp. 74-84. Philadelphia, 1870.

204. *Thomas, Cyrus.*—"A List and Descriptions of new species of Orthoptera," in Annual Report of the U. S. Geological Survey of the Territories, II, 1870, pp. 265-284. Washington, 1871.

205. *Thomas, Cyrus.*—"Notes on the Saltatorial Orthoptera of the Rocky Mountain Regions," in Preliminary Report of the U. S. Geological Survey of Montana and Portions of Adjacent Territories. 1871, pp. 423-466, Plates I-II. Washington, 1872.

206. *Thomas, Cyrus.*—"Synopsis of the Acrididæ of North America," in Hayden's Report of the U. S. Geological Survey of the Territories, V, 1873, pp. 1-258, plate. Washington, 1873.

207. *Thomas, Cyrus.*—"Descriptions of some new Orthoptera, and Notes on some Species but Little Known," in Bulletin U. S. Geological and Geographical Survey of the Territories, I, No. 2, pp. 63-71. Washington, 1874.

208. *Thomas, Cyrus.*—"Report upon the Collections of Orthoptera made in Portions of Nevada, Utah, California, Colorado, New Mexico and Arizona, during the Years 1871, 1872, 1873 and 1874," in Wheeler's Report upon the Geological and Geographical Explorations and Surveys West of the One Hundredth Meridian, V, pp. 843-908, Plates XLIII-XLV. Washington, 1875.

209. *Thomas, Cyrus.*—"A List of the Orthoptera of Illinois," in Bulletin Illinois Museum Natural History, I, pp. 59-69. Springfield, 1876.

210. *Thomas, Cyrus.*—"A List of Orthoptera Collected by J. Duncan Putnam, of Davenport, Iowa, during the summers of 1872, 1873, 1874 and 1875, chiefly in Colorado, Utah and Wyoming Territories," in Proceedings Davenport Academy of Natural Sciences, I, pp. 249-268, Plate XXXVI. Davenport, 1876.

211. *Thomas, Cyrus.*—"The Acrididæ of Illinois," in Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois, IX, pp. 73-140, Figs. 1-24. Springfield, 1880.

212. *Uhler, P. R.*—"Orthopterological Contributions," in Proceedings of the Entomological Society of Philadelphia, II, pp. 543-555. Philadelphia, 1864.

213. *Uhler, P. R.*—In Harris's Treatise on Insects Injurious to Vegetation, third edition.

214. *United States Entomological Commission* (C. V. Riley, C. Thomas, A. S. Packard). First Annual Report for the Year 1877 relating to the Rocky Mountain Locust. Pp. 16+477+295, 3 maps, 5 plates, 111 figures. Washington, 1878.

215. *United States Entomological Commission* (C. V. Riley, C. Thomas, A. S. Packard). Second Report for the Years 1878 and 1879, relating to the Rocky Mountain Locust and the Western Cricket. Pp. 18+322+80, 9 maps, 17 plates, 10 figures. Washington, 1880.

216. *United States Entomological Commission* (C. V. Riley, C. Thomas, A. S. Packard). Third Report relating to the Rocky Mountain Locust, the Western Cricket, the Army Worm, Canker Worms, and the Hessian Fly. Pp. 14+347+12, 4 maps, 64 plates, 13 figures. Washington, 1883.

217. *Walker, E. M.*—"Notes on some Ontario Acrididæ," in Canadian Entomologist, XXX, pp. 122-126. London, Ontario, 1898.

218. *Walker, E. M.*—"The Canadian Species of Trimerotropis," in Canadian Entomologist, XXXIV, pp. 1-11. London, Ontario, 1902.

219. *Walker, Francis.*—Catalogue of the Specimens of Dermaptera Saltatoria and a Supplement to the Blattariæ in the Collection of the British Museum. I, pp. 1-224; IV, pp. 605-809. London, 1869-1870.

220. *Walsh, B. D.*—"The Snowy Tree Cricket," in Practical Entomologist, I, p. 126. Philadelphia, 1866.

221. *Walsh, B. D.*—"Habits of the Tree Cricket (Œcanthus niveus), in Practical Entomologist, II, pp. 54-94. Philadelphia, 1867.

222. *Weed, Clarence M.*—Life History of American Insects. Pp. 12+272, Plates 1-21. New York, 1897.

223. *Wheeler, W. M.*—"Notes on the Oviposition and Embryologic Development of Xiphidium ensiferum Scudder," in Insect Life, II, pp. 222-225. Washington, 1890.

A DESCRIPTIVE CATALOGUE OF THE ORTHOPTERA KNOWN TO OCCUR IN INDIANA.

The order *Orthoptera* may be subdivided into two classes or sub-orders, which in turn are subdivided into seven families. The sub-orders may be distinguished by the following table:

KEY TO SUB-ORDERS OF ORTHOPTERA.

a. Legs of equal or nearly equal size, the hind femora not being enlarged for leaping. Organs for producing sound absent. Tegmina and wings of nymphs, when present, in a normal position. Ovipositor concealed by the sub-genital plate..NON-SALTATORIA, p. 167

aa. Legs of unequal size, the hind femora fitted for leaping, being much thickened and swollen, and usually much longer than the middle femora. Organs for producing sound usually present. Tegmina and wings of nymphs, when present, in a reversed position. Ovipositor usually exserted so as to be plainly visible................ SALTATORIA, p. 210

NON-SALTATORIA.

To this class or sub-order belong four of the seven recognized families of Orthoptera. These may be distinguished one from another by the following table:

KEY TO FAMILIES OF NON-SALTATORIAL ORTHOPTERA.

a. Body short, narrow, more or less flattened. Head horizontal, the mouth in front. Tegmina leathery, very short, without veins; meeting in a straight line down the back. Tarsi three-jointed, without pulvilli or pads. Abdomen of both sexes terminating in horny forceps-like appendages.....................FORFICULIDÆ, p. 168

aa. Body either short and wide, or elongate and narrow. The mouth at either lower or back portion of head (depending upon the position of the latter when at rest). Tegmina usually parchment like, thickly veined. Tarsi five-jointed. Abdomen terminating in cerci, but these never distinctly forceps-like.

b. Body short, broad, oval, depressed. Head almost wholly concealed beneath the pronotum; the mouth posterior (at back portion when at rest). Ocelli generally two. Pronotum shield shaped, transverse. Legs compressed. Insects of rapid motion...............................BLATTIDÆ, p. 172

bb. Body elongate, narrow. Head, free, not covered by pronotum; the latter longer than broad. Ocelli three or wanting. Legs slender, not compressed. Insects of slow motion.

c. Head oblique; mouth inferior. Ocelli three. Antennæ short. Pronotum generally longer than any other segment. Front pair of legs, raptorial, fitted for grasping. Cerci jointed...................MANTIDÆ, p. 198

cc. Head sub-horizontal; mouth sub-inferior. Ocelli often wanting. Antennæ generally longer than the body. Pronotum but little longer than head. Front pair of legs simple. Cerci without joints.....PHASMIDÆ, p. 203

Family FORFICULIDÆ.

This family of the order *Orthoptera* comprises those short, narrow, flattened insects, with legs of equal size, commonly known as "earwigs." They are so different from the larger and better known Orthoptera that many writers have placed them in a distinct order, the *Dermaptera* or *Euplexoptera*.

The *Forficulidæ* have the head flattened and horizontal with the mouth in front. The thorax is short and narrower than the head. The tegmina or wing covers are leathery or horny in texture, meet in a straight line down the back, are without veins and cover only a portion of the abdomen. The inner wings, when present, are very large, and bear numerous radiating veins which act as the bars of a fan in folding and unfolding the wings. When at rest, these wings are folded both lengthwise and crosswise beneath the protecting tegmina. The abdomen ends in a pair of appendages which somewhat resemble forceps. Were it not for these, the earwigs would resemble very closely the *Staphylinidæ* or rove beetles of the order Coleoptera. Those species which possess inner wings use these forceps to aid in folding and unfolding those organs, and they are also used as clasping organs during the mating of the sexes. As the earwigs never leap, their hind femora are not enlarged. The tarsi are never more than three-jointed and have no pads between the claws. No organs for producing sound are present, and, as far as known, hearing organs are also absent.

The name "earwig" was given to these insects in Europe, where they are abundant and better known than in this country. It is a common belief among peasants and the uneducated masses, that these insects will, when opportunity offers, enter the ears of human beings and injure the sense of hearing. Such belief is, of course, wrong and nonsensical, the insects being wholly harmless. Like the members of the next family, the *Blattidæ* or cockroaches, they live in cracks and crannies in walls and floors, beneath rubbish and the bark of logs and stumps. From these retreats they come forth only by night to feed upon dead insects and upon small snails and other sluggish moving forms. Like other nocturnal insects they are attracted by light, and on the ground beneath the electric lights of cities in Florida and Old Mexico, I have found them in numbers. The female is said to brood over the eggs, but to abandon the young as soon as hatched. In this she resembles some of our common myriapods of the genus *Lithobius*, which are often found beneath logs and rubbish curled up around their eggs, but which are never seen in company with the young.

Earwigs are common in the cities along the seacoast, especially those of the Southern States and tropical and semi-tropical countries. Inland, especially in temperate and cold regions, they are scarce. The family is not, as yet, divided into sub-families. Six genera and fourteen species are listed by Scudder from the United States. Of these, three species, representing two genera, have been taken in Indiana. They belong to that division of the family in which the sixth joint of antennæ is as long as, or very nearly as long as, the first. The following key will serve to separate the two genera:

KEY TO GENERA OF INDIANA FORFICULIDÆ.

a. Sixth joint of antennæ cylindrical, many times longer than broad; second tarsal joint produced beneath the third................ I. FORFICULA, p. 169

aa. Sixth joint of antennæ plainly obconic, about three times as long as broad. Second tarsal joint minute, simple, compressed......... II. LABIA, p. 171

I. FORFICULA Linnæus (1758).

Size, medium; whole body more or less flattened, rather long and slender. Antennæ a little more than half as long as the body, 10 to 14-jointed, the joints cylindrical, more than four times as long as broad. Abdomen not expanded in the middle; all the dorsal segments before the last, of nearly equal length in both sexes. First tarsal joint a little longer than the third; the second short, dilated at the apex and lobed, passing beneath the third joint.

This genus is the richest in species of any of the family, and is more widely spread than any, being found wherever earwigs occur. Six species belonging to it are known from the United States, two of which have been taken in Indiana. These may be separated by the following:

KEY TO INDIANA SPECIES OF FORFICULA.

a. Wings wanting; antennæ 12-jointed................1 *aculeata*, p. 170

aa. Wings protruding beyond the tips of tegmina; antennæ 14-15-jointed. 2 *auricularia*, p. 170

1. **Forficula aculeata** Scudder.

Forficula aculeata Scudd., 156, II, 1876, 254, 256; Id., 157, I, 1876; 177; Id., 158, XVIII, 1876, 262, 310; Id., 164, 1879, 41; Id., 188, 1900, 5; Beut., 3, VI, 1894, 256.

Antennæ 12-jointed. Pronotum longer than broad, narrower than the head. Tegmina nearly twice as long as the pronotum, truncate. Inner wings wanting. Forceps of male, three-fourths as long as the abdomen, slender, arcuate, bent downward a little at apex of basal third; becoming again horizontal a little before the tip; a slight pointed tooth present at second bend. Forceps of female shorter than those of male, nearly straight, the inner edges touching for most of their length, the tip incurved.

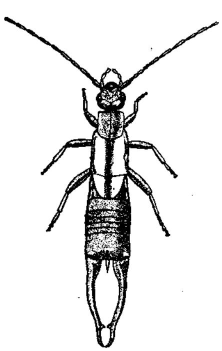


Fig. 20. *Forficula aculeata* Scudder. Male, two and one-half times natural size. (Original.)

Color, dark chestnut brown. Palpi, legs, edges of pronotum and outer two-thirds of tegmina, yellow.

Measurements: Length of body, male, 10 mm., female, 11 mm.; of antennæ, male, 7.5 mm., female, 7 mm.; of tegmina, male and female, 3 mm.; of forceps, male, 5 mm., female, 3.5 mm.

This earwig was taken a mile southwest of Mt. Vernon, Posey County, on April 9, 1901. It was found to be fairly common beneath rubbish and leaves in some woods along the bank of the Ohio River. It has not been noted elsewhere in the State, though it is liable to be found anywhere within its bounds as its range includes the northern United States east of the Mississippi River. The type specimens came from northern Illinois and southern Michigan.

2. **Forficula auricularia** Linnæus.

Forficula auricularia L., 81, Ed. X, I, 1758, 423: Scudd., 155, II, 1876, 254; Id., 157, I, 1876, 177; Id., 158, XVIII, 1876, 311; Id., 188, 1900, 5; Beut., 3, VI, 1894, 256; Brun., 35, 1899, 133; Rehn., 112[a], XIV, 1903, 125.

"Fusco-ferruginous; antennæ 14-15-jointed; basal joint, sides of pronotum, and legs testaceous; tegmina and wings dull luteous, the former half as long again as the pronotum; forceps of male usually as long as the abdomen; horizontal, depressed, and dilated at the base, and beyond rather strongly arcuate, tapering to a point, the extreme base of inner edge tuberculato-denticulate, with a distinct inner tooth at base of arcuate portion. Body (average), 11 mm.; forceps, male, 4-8 mm.; female, 3 mm."—*Scudder.*

I have not seen this earwig in Indiana, but Rehn, *loc. cit.*, states that four males, collected by F. M. Webster, at Lafayette, Indiana, about May 15, 1889, are in the collection of the U. S. National Museum. It is an introduced species, which has before been recorded in the United States from New York and New Jersey.

II. Labia Leach (1815.)

Size, small. Body, flattened and slender, the abdomen slightly widened in the middle. Antennæ about half as long as the body, 10 to 13-jointed, the joints moniliform, or of equal size throughout, obconic, about three times as long as broad. Both tegmina and wings present in our species. First and third tarsal joints equal, the second minute, simple, compressed. Forceps seldom more than half as long as the abdomen; in the male, simple, arcuate, horizontal; in the female, simple, straight, incurved at the tip, unarmed.

This genus differs from the preceding principally in the simple character of its middle tarsal joint, and in the shorter obconic joints of the antennæ. Four species are accredited to the United States, one of which occurs in Indiana.

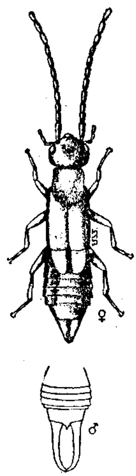


Fig. 21. *Labia minor* (L.) Female. Four times natural size. Abdomen of male showing form of forceps. (After Lugger.)

3. Labia minor (Linnæus.) The Little Earwig.

Forficula minor L., 81, Ed. X, I, 1758, 423; Burm., 40, II, 1838, 754; Fisch., 55, 1853, 52, 70, Plate VI, Fig. 7.

Labia minor Glov., 62, 1872, Plate X, Fig. 3; Scudd., 155, II, 1876, 257; Id., 157, I, 1876, 178; Id., 158, XVIII, 1876, 320; Id., 188, 1900, 6; Comst., 41, 1888, 91; Fern., 53, 1888, 53; Beut., 3, VI, 1894, 257; Lugg., 84, 1898, 86, Figs. 49, 50.

Labia minuta Scudd., 141, VII, 1862, 415; Pack., 104, 1869, 507; Glov., 62, 1872, Plate I, Fig. 10.

Antennæ 10-12-jointed. Pronotum narrower than the head, scarcely longer than broad. Tegmina nearly twice as long as the pronotum, the wings, when at rest, extending fully half their length beyond the tip of tegmina. Forceps of male about three-fourths the length of abdomen, rather heavy, minutely toothed on the inner edge. Last ventral segment of male with a slender, apical, compressed, upcurved tubercle. The entire body is covered with fine, soft, yellowish hairs.

Color: Head and sides of abdomen nearly black; mouth parts, antennæ, thorax, tegmina, exposed parts of wings and middle of upper side of abdomen, yellowish brown; last segment of abdomen and forceps, reddish brown; legs and last two joints of the antennæ, honey yellow.

Measurements: Male, length of body, 5 mm.; of antennæ, 3.2 mm.; of tegmina, 2 mm.; of forceps, 2 mm.

Although the range of this little earwig is said to cover Europe and the United States, and Canada east of the Rocky Mountains, I failed to detect it in Indiana until May 12, 1903, when I took a single male from beneath the bark about the base of a sweet gum tree near Grand Chain, Posey County. It doubtless occurs throughout the State, but is overlooked on account of its small size. A close search about electric lights in the cities and towns of the State will doubtless reveal its presence in numbers.

Family BLATTIDÆ.

The members of the family *Blattidæ,* commonly known as cockroaches, may be known from the other families of Orthoptera by their depressed, oval form; by their nearly horizontal head which is bent under and almost concealed by the broad pronotum, so that when at rest the mouth projects back between the bases of the first pair of legs; by their slender depressed legs of equal length and size; and by the absence of either ovipositor or forcipate appendages at the end of the abdomen. The ocelli are usually but two in number and the tarsi are 5-jointed.

The pronotum is generally transverse or shield-shaped, with rounded angles. The rings of the abdomen overlap each other and are capable of great extension and depression, so that these insects seem to be pre-eminently fitted for living in the narrow crevices and cracks which they inhabit. The legs are of peculiar structure in that they are long and more or less flattened, thus enabling the cockroaches to run with surprising swiftness, so that the family has been placed by some writers in a separate sub-order, the *Cursoria*, or runners. The wing covers, or tegmina, are leathery, translucent, and when well developed, overlap when at rest; while the wings never exceed the tegmina in length, and in some cases are rudimentary or even wanting.

From the other Orthoptera (except the *Mantidæ*) the *Blattidæ* differ widely in the manner of oviposition, as the eggs are not laid one at a time, but all at once in a peculiar capsule or egg case called an oötheca. These capsules vary in the different species as regards the size, shape, and the number of eggs they contain, but they are all similar in structure. Each one is divided lengthwise by a membranous partition into two cells. Within each of these cells is a single row of cylindrical pouches, somewhat similar in appearance to those of a cartridge belt, and within each pouch is an egg.

Fig. 22. Oötheca of *Blatta orientalis*; *a*, side; *b*, end view. Natural size indicated by outline figure. From "Household Insects", published by U. S. Div. of Entomology.

The female cockroach often runs about for several days with an oötheca protruding from the abdomen, but finally drops it in a suitable place and from it the young, in time, emerge. While this method of oviposition is the one practiced by all the species of common occurrence in the United States, there seem to be exceptions to it, as Dr. C. V. Riley has recorded the fact of an introduced tropical species, *Panchlora poeyi* Sauss., being viviparous, the young emerging alive from the body of the parent, and a careful dissection of the latter showing no trace of either eggs or oötheca.

All young cockroaches resemble the parents in form but are wholly wingless, the wings not appearing until after the fifth or last moult. The young are often mistaken for the mature by persons who have not made a careful study of the life history of the insects; and those of one or two well-known and common forms have, in the past, even been described or figured as distinct wingless species by some of the leading entomologists of the country.

To the paleontologist, interested in tracing back the ancestry of insects, the *Blattidæ* become at once a group of surpassing interest, for some of the oldest known insects are cockroaches from the Silurian and Carboniferous rocks. Between 130 and 140 fossil species of the family are known from the Paleozoic rocks of the United States, principally from the Carboniferous formations, but some from all the ages as far back as the middle Silurian. Mr. S. H. Scudder, of Cambridge, Mass., the most eminent authority on insect paleontology, says of the cockroach: "Of no other type of insect can it be said that it occurs at every horizon where insects have been found in any numbers; in no group whatever can the changes wrought by time be so carefully and completely studied as here; none other has furnished more important evidence concerning the phylogeny of insects."

The Blattidæ are pre-eminently tropical insects, and though abundantly represented in individuals, the number of species inhabiting the United States is comparatively few, but 34 being listed in Scudder's Catalogue. These are divided among seven sub-families and eighteen genera. Aside from two or three sub-tropical species which are often introduced in bananas and other fruit, but which soon die, and are not, therefore, considered in the present paper, nine species have been taken in Indiana. These represent but two of the sub-

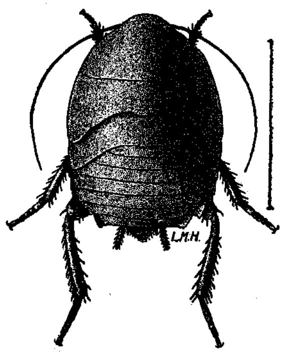


Fig. 23. Nymph of *Nyctobora holosericea* Klug. One of the more common tropical roaches introduced on fruit.* (After Lugger.)

families and five of the genera, belonging to that division of the family in which all the femora, or at least the middle and hind pair are spined on the under side. These sub-families may be separated by the following table:

A SYNOPSIS OF THE SUB-FAMILIES OF BLATTIDÆ KNOWN TO OCCUR IN INDIANA.

a. Last ventral segment of the female abdomen plane, not compressed and not divided; fore femora rarely armed beneath on the inner margin with many distinct spines; if so armed, then the subgenital styles are unequal, or one is wanting......BLATTINÆ, p. 175

*Nymphs of this sub-tropical roach have been taken in Indianapolis and Terre Haute A mature male was sent me from Mt. Carmel, Illinois, by Dr. J. Schneck. It was an inch and a fourth in length, a uniform dark brown in color, with numerous small hairs on the pronotum and tegmina.

aa. Last ventral segment of the female abdomen compressed so as to form a carina or ridge on its under side, and divided so as to be bi-valved; fore femora armed beneath with many spines on the inner margin............................PERIPLANETINÆ, p. 191

Sub-family BLATTINÆ.

In this sub-family the body of the male is elongate; that of the female usually distinctly broader. The head is strongly depressed and almost wholly covered by the pronotum. The antennæ in our species are setaceous. The posterior border of the pronotum is truncate or rounded. Both pronotum and tegmina are free from hairs. The tegmina are coriaceous or membranaceous, rarely corneous, in texture. The median vein of the wings sends but few branches to the apex; while the radial vein emits many parallel, simple veinlets to the costal margin. The tarsi are without pulvilli or pads. The last ventral segment of the female is relatively plane, not compressed or divided. The supra-anal plate of both sexes is but little produced, triangular, entire. The sub-genital plate of the male (except in the genus *Blattella*) bears a pair of minute styles.

To this sub-family belong all the native species of roaches found in Indiana, and one common introduced species, *Blattella germanica* L. The native species, as far as synonymy goes, are a badly mixed lot —so badly mixed, in fact, that more time has been spent upon them than upon any other group treated in this paper, and in the end the results are more unsatisfactory and less certain than in any other. This is due to the fact that the sexes differ so widely in appearance that they have been described as different species, and often placed in wholly different genera. Most of the descriptions have been made by foreign entomologists, who never saw a specimen in the field, and for that reason knew nothing of the relationship of the different individuals before them. However, the two sexes are so seldom found mating, that even the field naturalist can not be certain as to their relationship. I have collected Indiana *Blattidæ* for 15 years, and, as yet, am only positive as to the sexes of one of our native species—*Temnopteryx deropeltiformis* Brunn. The conclusions at which I have arrived regarding the others are based mainly upon finding both sexes at the same time beneath the same hiding places on a number of occasions. This, however, is not positive proof that the sexes belong where I have placed them.

Saussure, followed by Scudder, has stated that the tegmina in both sexes of the genus *Temnopteryx* are abbreviated, yet this is not true of *T. deropeltiformis* Brunn., the only one of the United States species in which both sexes are known. Prof. Lawrence Bruner, an acknowledged authority on North American Orthoptera, writes me that, as far as he knows, "all the females of *Temnopteryx* are short-winged, and all the males long-winged like the majority of the species of *Ischnoptera*." Prof. A. P. Morse kindly examined Mr. Scudder's collection for me, and states that, as far as he was able to ascertain, it contains no short-winged males of *Temnopteryx*.

Saussure and Scudder, in their "Keys to Genera of Blattinæ," also state that in the genus *Ischnoptera* the "tegmina are completely developed or in the female rarely abbreviate." In all my collecting, I have never seen a long-winged female of *Ischnoptera*. Bruner has written me that he does not possess a long-winged female or a short-winged male of the genus, and Morse also states that Scudder's collection contains no long-winged females of *Ischnoptera*. From these facts, and from others gathered in the field and mentioned under the different species, I have concluded that the species of *Phyllodromia* and *Temnopteryx* listed by Scudder in his Catalogue* are but the females of certain species of *Ischnoptera* and have so placed them in the present paper. As a result, representatives of but three genera of the sub-family *Blattinæ* occur in the State. These may be separated by the following

KEY TO GENERA OF INDIANA BLATTINÆ.

a. Sub-genital stylets present in the males. Tegmina of females abbreviate, reaching but little, if any, beyond the middle of the broad abdomen.† (Native species.)

b. Tegmina corneous; those of female obliquely truncate at apex. Ulnar vein of wings of male without branches to the vena dividens....................III. TEMNOPTERYX, p. 176

bb. Tegmina membranaceous or somewhat coriaceous; those of female usually broadly rounded at apex; sometimes angulate, but not truncate. Ulnar vein of wings of male emitting complete branches to the apical margin and incomplete branches to the vena dividens....................IV. ISCHNOPTERA, p. 178

aa. Sub-genital stylets absent in the males. Tegmina of both sexes fully developed. Size small, body narrow. (Introduced species.) V. BLATTELLA, p. 187

III. TEMNOPTERYX Brunner (1865).

Body oblong, that of male rather slender; that of female stouter, with the abdomen broader than the thorax. Head large and flattened; the vertex swollen. Antennæ longer than the body, rather stout. Ocelli wanting. Pronotum and tegmina somewhat corneous

*He does not list *T. deropeltiformis* Brunn.

†In the females of *I. pennsylvanica* they sometimes cover three-fourths of abdomen, but never reach its tip.

in texture, quite flat, the former nearly semi-orbicular in shape, much the broader in the female, the hind border a little rounded in the male, truncate in the female. Tegmina fully developed and much surpassing the abdomen in the male (of our species); abbreviate and with the apex obliquely truncate in the female. Abdomen very flat above, convex beneath. Supra-anal plate of the male, transverse, rounded; that of the female triangular. Sub-genital plate of the male, narrow, bearing two stylets; the one on the left usually the larger. Cerci rather long and stout, 10-jointed. Last ventral segment of the female abdomen broadly rounded, entire.

As noted above, I consider that certain species heretofore ascribed to this genus are females of species of *Ischnoptera*. This eliminates the nominal species *T. major* Sauss.-Zehnt. and *T. virginica* Brunn. of Scudder's Catalogue, representatives of which occur in Indiana, and leaves *T. deropeltiformis* Brunn. as our sole representative of the genus.

4. TEMNOPTERYX DEROPELTIFORMIS Brunner.

Temnopteryx deropeltiformis Brunn., 37, 1865, 87; Bl., 8, 1893, 160.

Main characters as given above. Disk of male pronotum with three impressions, one shallow, median and longitudinal, the other two deeper, semicircular and lateral. Tegmina of female covering about one-third of the abdomen, their inner edges meeting; those of male much surpassing the abdomen.

Color, a uniform dark mahogany brown, except the tibiæ and tarsi of all the legs, which are a light reddish brown, the contrast between the two colors, in living specimens, being very striking. Wings of male transparent, slightly infuscated, the veins and anterior border light brown.

Measurements: Length of body, male, 14 mm., female, 15 mm.; of pronotum, male, 3.5 mm., female, 4.5 mm.; of tegmina, male, 15.5 mm., female, 5 mm.; width of pronotum, male, 4.5 mm., female, 6 mm.

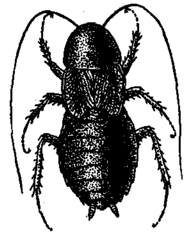


Fig. 24. *Temnopteryx deropeltiformis* Brunner. Female one and one-third times natural size. (Original.)

In Indiana this handsome roach has, as yet, been noted only in Vigo and Crawford counties. In the former it was found in but one locality, the border of a marsh in a low sandy woods three miles east of Terre Haute. A single pair were taken on May 28, 1893, and on June 18, probably a dozen specimens were secured. They were hiding beneath small logs and sticks, and the males, when deprived of their shelter, flew actively away, while the females could but crawl, and that rather sluggishly for a Blattid, toward a new hiding place. A mature male was taken in the same place on May 12, 1894. In June, 1902, a number were found in Crawford County beneath flat stones and rubbish on the tops of high hills near Wyandotte Cave. A single female was also captured while feeding upon a species of fleshy fungus (*Agaricus*) in dense woods in Marshall County, Illinois, about eight miles west of Terre Haute. Brunner (*loc. cit.*) recorded it from "Amerique du Nord," and I can find no other note of its occurrence in the United States.

IV. Ischnoptera Burmeister (1838).

Body of male rather narrow, oblong; that of female broader, orbicular. Antennæ nearly or fully double the length of the body. Pronotum small, orbicular or of the form of an ellipse; in the male often much narrowed in front. Tegmina membranaceous, more or less translucent, longer than the abdomen in the males, abbreviated (in our species) in the females. Wings hyaline; "the discoidal (ulnar) vein, instead of sending longitudinal branches exclusively to the apical margin, sends also small oblique branches to the anal vein (vena dividens)." Cerci long and relatively stout, 12-jointed. Supra-anal plate of the male broad, the apex either truncate or rounded; that of female narrower, triangular and obtuse. Sub-genital plate of male bearing two rather long stylets which are often deflexed. Last abdominal plate of female entire.

Five species of our native roaches belong to this genus. They may be separated as follows:

KEY TO INDIANA SPECIES OF ISCHNOPTERA.

a. Size large; length of body of male, 19 or more mm.; of body, including tegmina, 25 or more mm.

- *b.* General color fuscous or chestnut brown; the center of disk of pronotum dark, the sides yellow.
  - *c.* Pronotum elliptical, nearly as wide in front as behind, the sides flaring, but little deflexed; the center of disk rufous........................5 *pennsylvanica*, p. 179
  - *cc.* Pronotum notably narrower in front than behind, the sides strongly deflexed; the center of disk black.............. 6 *inæqualis*, p. 182
- *bb.* General color light reddish or yellowish brown; the sides of pronotum not markedly different in color from the center of disk...7 *major*, p. 183

aa. Size medium; length of body of male, less than 15 mm.; of body, including tegmina, less than 20 mm.

d. General color of male, light reddish or yellowish brown; of female, reddish brown, the abdomen darker; inner edges of tegmina of female meeting or slightly overlapping.............8 *uhleriana*, p. 184

dd. General color of male, dark reddish brown or chestnut; of female, piceous; inner edges of tegmina of female widely separated.........9 *intricata*, p. 186

5. Ischnoptera pennsylvanica (De Geer). The Pennsylvania Cockroach.

Blatta pennsylvanica De G., 57, III, 1773, 537, Plate 44, Fig. 4; Thom., 202, V. 1865, 440. (Male).

Platamodes pennsylvanica Scudd., 141, VII, 1862, 417; Glov., 62, 1872, Plate I, Figs. 1, 3; Riley 122, II, 1884, 172; Comst., 41, 1888, 93.

Ischnoptera pennsylvanica Brunn., 37, 1865, 135; Sauss., 132, VI, 1870, 63, Plate II, Fig. 35; Bl., 8, 1893, 158; Id., 16, 1899, 202, Fig. 43; Beut., 3, VI, 1894, 259; Lugg., 84, 1898, 96, Fig. 58; Scudd., 188, 1900, 7.

Blatta borealis Sauss., 128, 1862, 4, (Female).

Phyllodromia borealis Brunn., 37, 1865, 101; Scudd., 188, 1900, 8; Id., 189, IX, 1900, 100.

Ectobia flavocincta Scudd., 141, VII, 1862, 419; Brunn., 37, 1865, 57; Comst., 41, I, 1888, 93; Bl., 8, 1893, 161. (Female).

Blatta flavocincta Fern., 53, 1888, 51.

Ectobia lithophila Scudd., 141, VII. 1862, 418 (Immature).

Male: Size, large. Pronotum elliptic, the front border slightly the narrower, its margin straight; the hind border rounded; an ob-

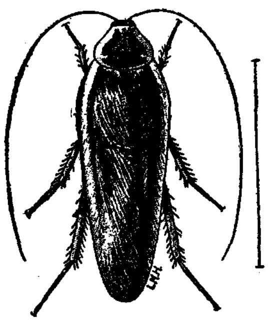


Fig. 25. *Ischnoptera pennsylvanica* (De Geer). Male. (After Lugger).

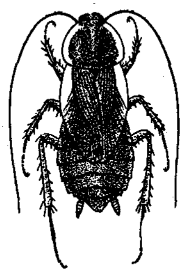


Fig. 26. *Ischnoptera pennsylvanica* (De Geer).=*Phyllodromia borealis* Sauss.= *Ectobia flavocincta* Scudd. (Female. Original.)

lique depression on each side, near the base. Tegmina membranaceous, more or less transparent, long and rather narrow, extending much beyond the tip of abdomen. Wings as long as tegmina. Subgenital styles deflexed.

Female: Size medium, the abdomen broader than thorax, its greatest breadth contained less than twice in its total length. Pronotum much wider and of firmer texture than in the male; the disk a little convex and with no impressions; the hind margin nearly truncate; the front margin narrower, rounded; the lateral margins somewhat flaring, their posterior third slightly upturned. Tegmina broad, overlapping, covering from a half to three-fourths of abdomen, their apices rounded; the veins prominent. Inner wings narrow, about half the length of tegmina.

General color, chestnut brown to fuscous, the females the darker. Antennæ dusky; face reddish brown in center, the margins yellow. Disk of pronotum chestnut brown, margined on sides, and sometimes nearly in front, with whitish yellow. Tegmina of male smoky brown, lighter in freshly moulted specimens; those of female dark reddish brown; the outer basal two-thirds (male) or one-half (female) rather broadly margined with yellowish. Upper surface of female abdomen very dark brown. Legs of both sexes pale yellowish brown.

Measurements: Length of body, male, 21 mm., female, 16 mm.; of antennæ, male, 28 mm., female, 18 mm.; of pronotum, male and female, 5 mm.; of tegmina, male, 22 mm., female, 6-10 mm.; width of pronotum, male, 5.5 mm., female, 7 mm.

While I have never taken the sexes *in coitu*, there is no doubt in my mind but that the female of *pennsylvanica* is the roach heretofore known as *Blatta* or (*Phyllodromia*) *borealis* Sauss., and *Ectobia flavocincta* Scudd. That these last two names are synonymous has been shown by Scudder.*

As far back as May 27, 1894, I made the following entry in my field note book: "*Platamodes pennsylvanica* and *Ectobia flavocincta*, both mature and very common beneath the bark of red oak stumps and dead trees. Are the latter the females and the former the males of the same species? I often think so, but as yet have no positive proof." I have since on many occasions taken the two forms together, but have never seen a female of *pennsylvanica* nor a male of *flavocincta*, unless the latter be the female of the former. I can find no mention or description of the female of *pennsylvanica* in any work at my command. All illustrations of the species which have been published are of the male.

On the other hand, all mention and descriptions of *P. borealis* which note the sexes, with a single exception, relate to the female.

*Psyche, IX, 1900, 100.

The exception noted is that of Saussure who, in his original description of *borealis,* mentions the male, stating that the elytra are short, the supra-anal plate triangular, acuminate and sub-carinate. This is true of all the specimens of *borealis* in my collection. Several of them have oötheca partly protruding from the abdomen and the genital organs of all are similar. Prof. Morse has compared specimens of what I have called *flavocincta* with Scudder's types, and pronounces them the same.

I. pennsylvanica is the most common of our native roaches, having been taken in the State wherever collections have been made, beneath the loose bark of logs and old stumps. It is usually seen in the wingless stages, the mature individuals being common only from May 5th to October. The half grown young, described by Scudder as *Ectobia lithöphila,* are of a shining, dark brown color, the dorsal surface of thoracic segments often lighter. As the long-winged males are attracted by light, country houses are often badly infested with them; and where food is scarce, the wall paper is sometimes much injured for the sake of the paste beneath. What the hordes of young which dwell under the bark of logs live upon is a question as yet unsettled, but the larvæ of other insects undoubtedly form a portion of their food, as in two instances I have found them feeding upon the dead grubs of a *Tenebrio* beetle; while living as well as decaying vegetable matter probably forms the other portion. The mating of the imagoes probably occurs in late spring and early summer, the newly hatched young being most abundant from mid-August until December. Females with oötheca protruding have been taken as early as May 19th and as late as September 3d. The young in various stages of growth survive the winter in the places mentioned, they being the most common insects noted in the woods at that season. Cold has seemingly but little effect upon them, as they scramble away almost as hurriedly when their protective shelter of bark is removed on a day in mid-January with the mercury at zero, as they do in June when it registers 100° in the shade.

The empty oötheca of this species are very common objects beneath the loose bark of logs and especially beneath the long flakes of the shellbark hickory. They are chestnut brown in color, from 5 to 9 mm. in length by 4 mm. in breadth, and are much less flattened than those of *Blattella germanica* described below. The dorsal or entire edge is slightly curved, or bent inward, after the fashion of a small bean, while the other edge is minutely serrate. The young, after hatching, evidently escape in the same manner as do those of the Oriental cockroach, as no break is visible in the empty capsule. The general range of *pennsylvanica* is given by Scudder as "Northern United States and Canada east of the Rocky Mountains."

6. ISCHNOPETRA INÆQUALIS Sauss.—Zehnt.

Ischnoptera inæqualis Sauss.—Zehnt., 135, 1893, 36, Plate 6, Figs. 14-17; Scudd., 188, 1900, 7.

Male: "Fuscous or fusco-ferruginous, with brownish antennæ. Head with face testaceous; in middle and on vertex, black. Pronotum elliptical, with distinct impressions, the disk slightly convexed, smooth, wholly black or fuscous or castaneous, with lateral margins testaceous, translucent. Tegmina fuscous or slightly rufous in color, basal area with anterior margin hyaline. Wings subvitreous, with anterior and apical margins rather broadly infuscated. Vena ulnaris with six or seven branches; besides this, with incomplete branch and other rudimentary ones, not reaching the vena dividens.

Female: "Pronotum horny, parabolic, with anterior and lateral margins semi-elliptical, and the posterior margin transverse, broad, subangular, with lateral angles slightly rounded. Disk a little convex, with no impressions; fuscous-black in color, with yellow lateral margins. Tegmina abbreviate, covering first segment of the abdomen, blackish-fuscous in color with distinct veins, apex widely rounded and costal area yellowish in color. Wings rudimentary, yellowish, not covering medial segment, with apex fuscous or spotted."

Measurements: Length of body, male, 21 mm., female, 16 mm.; of pronotum, male, 5.2 mm., female, 5 mm.; of tegmina, male, 23 mm., female, 8 mm.; width of pronotum, male, 6.3 mm., female, 6.5 mm.; of tegmina, male, 6.8 mm., female, 5.2 mm.

Specimens from Crawford County, Indiana, were identified for me as this species by Prof. L. Bruner. I have since secured a copy of the description of Sauss.-Zehnt.—the only one extant—quoted above, with which the Indiana examples fairly agree. The species is very close to *I. pennsylvanica*, and may prove only a variety. The measurements are very nearly the same. The general color of the pronotum and tegmina is darker, approaching a fuscous. The pronotum is proportionally narrower in front, with the sides more distinctly deflexed and the sub-basal impressions more distinct. The females of the two are even more difficult to distinguish than the males.

The Crawford County specimens were taken in late June beneath flat rocks and chunks on high hills near Wyandotte Cave. Sauss.-Zehnt., like many other foreign systematists, give a very general range to the species they describe, recording this one from "North America, Texas, North Mexico."

7. ISCHNOPTERA MAJOR (Sauss.-Zehnt.)

Temnopteryx major Sauss.-Zehnt., 135, 1893, 54; Scudd., 188, 1900, 8.

Male: Size, large. Pronotum broadly elliptic, larger than in either of the two preceding species, membranaceous, the sides flaring, translucent; two deep oblique impressions on either side near the base. Tegmina membranaceous, hyaline, longer than abdomen. Wings as long as tegmina.

Female: Body, stout, broad. Pronotum, short and wide, hornlike, with no impressions; the hind margin nearly straight, the front margin rounded. Tegmina, abbreviated; covering only the basal segment of abdomen; rather broad, their inner edges overlapping, their apices broadly rounded. "Sulcus analis deep, scarcely curved anterior to the apex, reaching to three-fourths of the sutural margin." Wings very small, narrow, pointed. Supra-anal plate large, triangular, keeled, with apex bluntly rounded.

Color: Male, a nearly uniform, light reddish brown. Two basal joints of antennæ yellow, the remaining portion, as also the cerci, dark brown. Lateral margins of pronotum and of basal half of tegmina translucent whitish. Abdomen and legs pale yellowish brown. Female: Pronotum reddish brown, the lateral margins indistinctly yellowish or paler than the disk. Tegmina darker brown, their outer margins dull yellowish. Abdomen and cerci piceous. Antennæ as in male; the legs darker.

Measurements: Length of body, male, 21 mm., female, 17.5 mm.; of pronotum, male, 5.5 mm., female, 5.3 mm.; of tegmina, male, 21 mm., female, 6.5 mm.; width of pronotum, male, 6.3 mm., female, 7 mm.; of tegmina, male, 6.2 mm., female, 5 mm.

This roach has been taken in Indiana only in the vicinity of Wyandotte, Crawford County. Immature females were first found May 9, 1899, and mature individuals of the same sex on July 7th of that year. In 1902 more persistent searching proved the females to be common during the last week of June and the first one of July, several being taken with oötheca protruding. A single male, the only one seen, was secured on July 3d. There is little doubt but that it is one of the same species as the female, as it was found with two of them, and differs from any other roach taken in the State. It is of the exact color of *I. uhleriana* Sauss., described below, and is very likely to be taken for an unusually large form of that insect. It may be possible that it is a light form of *I. couloniana* Sauss., of which the females are unknown, as it agrees very well, except in color, with the description of that species. If so, that name would have priority over *major*, of which the males have not hitherto been found. There is no doubt of its being a true *Ischnoptera*. The female somewhat resembles that of the common *I. pennsylvanica*, but is broader bodied, with the front half not tapering. The yellow margin of pronotum and tegmina is much less distinct. The tegmina do not vary in length, as do those of the female *pennsylvanica*.

In the region mentioned *I. major* occurs beneath flat rocks on the sides and crests of the higher hills, especially in limestone glades where the red cedar abounds. It has heretofore been recorded only from Tennessee.

8. ISCHNOPTERA UHLERIANA Saussure.

Ischnoptera uhleriana Sauss., **128**, III, 1862, 8; Id., **129**, 1864, 82; Id., **132**, VI, 1870, 55; Sauss.—Zehnt., **135**, 1893, 36, Plate 3, Figs. 21-23; Scudd., **188**, 1900, 7; Id., **189**, IX, 1900, 100. (Male.)

Platamodes unicolor Scudd., **141**, VII, 1862, 417; Fern., **53**, 1888, 53.

Ischnoptera unicolor Brunn., **37**, 1865, 134; Sauss., **133**, VI, 1870, 56; Bl., **8**, 1893, 160; Beut., **3**, VI, 1894, 259; Lugg., **84**, 1898, 97, Fig. 59; Scudd., **188**, 1900, 8. (Male).

Temnopteryx virginica Brunn., **37**, 1865, 86; Beut., **3**, VI, 1894, 261; Scudd., **188**, 1900, 8. (Female).

Male: Size, small, body narrow. Antennæ slender, tapering, slightly longer than the body. Pronotum, small, elliptical; the hind margin rounded, the sides somewhat deflexed, translucent; the impressions near base of disk, distinct, oblique. Tegmina fully developed, longer than the abdomen, rather wide. Wings as long as tegmina; the ulnar vein with five or six apical branches and several shorter ones. Supra-anal plate triangular.

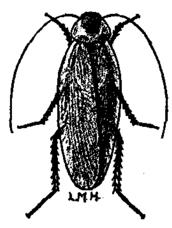


Fig. 27. *Ischnoptera uhleriana* Sauss. Male. (After Lugger.)

Female: Body broader than that of male. Pronotum semi-orbicular, sub-corneous, the hind margin nearly straight, the disk sub-convex, the impressions less distinct. Tegmina abbreviated, covering less than half the abdomen, their inner edges slightly overlapping, their apices rounded; usually slightly emarginate near the inner or sutural angle. Wings short and narrow, covering only first abdominal segment. Supra-anal plate triangular.

Color: Male, usually a uniform light reddish brown. Head and posterior margin of pronotum sometimes a little darker. Eyes, black. Wings, sub-vitreous, with reddish brown veins. Female, darker, the head, pronotum and usually the tegmina dark reddish brown, the tegmina sometimes chestnut brown. Top of abdomen fuscous brown to piceous. Legs pale reddish brown.

Measurements: Length of body, male, 12 mm., female, 11 mm.; of pronotum, male, 3 mm., female, 3.3 mm.; of tegmina, male, 16 mm., female, 3.7 mm.; width of pronotum, male, 4 mm., female, 3.7 mm.

This light colored roach probably occurs throughout the State, having been taken in numbers in Crawford, Vigo, Putnam, Marion, Kosciusko and Lake counties. The males are often seen about electric lights in the cities; but when first reaching maturity about May 10, they are gregarious beneath the bark of logs and under chunks and rubbish in open woods. The females appear fewer in numbers, but are probably overlooked, their tegmina being so short that they resemble the nymphs of their own or other species.

The first record of the female in the State was made June 2, 1894, as follows: "In a flat woods, seven miles east of Terre Haute, I found a new species of cockroach quite common beneath the bark of oak stumps. The wings short, covering less than one-half abdomen. It may be the female of *I. unicolor* Scudd., as several of the long-winged forms of the latter were beneath the same shelter." Since then, I have usually found this short winged form in company with the males of *I. unicolor*; and have taken them with oötheca protruding in the first week of July. Some of the first ones taken were sent to Scudder, who pronounced them *T. virginica* Brunner, and they agree in all respects with the original description of that species, which was made from a single female, and of which the male is unknown. Since no female of *I. unicolor* has been described except by Sauss.-Zehnt. under the name of *I. uhleriana,* I believe the *T. virginica* to be the female of *I. unicolor.* Scudder, in Psyche (IX, 100), states that he has compared the types of *uhleriana* and *unicolor* and that they are identical. He had previously seen Indiana specimens of *unicolor* and pronounced them that species. Prof. L. Bruner has recently sent me specimens of both sexes of *uhleriana* from Nebraska under the name of *I. borealis* Brunn. It is very probable that that species is also a synonym of *uhleriana,* though only a comparison of the different types will decide. Brunner states that *I. unicolor* may be distinguished from *I. borealis* by the much lighter color and the disposition of the nerves of the wings; but the color varies much with age; while Saussure has shown that in certain species of *Ischnoptera,* the venulation of the wings is also very variable.*

*Miss. Scientif. Mex., p. 64.

9. Ischnoptera intricata sp. nov.

Female: Size, small; body, short and broad. Antennæ slender, about as long as body; the joints with numerous short hairs. Pronotum sub-orbicular, smooth, shining; the disk convex, its sides sloping; the hind margin straight or nearly so. Tegmina abbreviate, reaching only to second abdominal segment, their inner edges separated by a space equal to half their breadth; and gradually tapering obliquely on apical third to the sub-acute apex. Wings minute, narrow, reaching only to first abdominal segment. Abdomen notably broader than thorax; its width equaling two-thirds the total length. Supra-anal plate short, triangular, obscurely keeled; the preceding segment, smaller and more distinctly keeled. Subgenital plate broadly convex, entire.

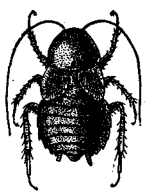


Fig. 28. *Ischnoptera intricata* sp. nov. Female. One and one-third times natural size. (Original.)

Color: A nearly uniform shining piceous; the outer margins of tegmina sometimes chestnut brown. Legs dark reddish brown; wings light brown.

Male: Size small, body narrow. Pronotum elliptical, sub-corneous, the lateral margins strongly deflexed; the hind margin but little convex; the disk with an irregular distinct depression on either side. Tegmina much longer than the abdomen, rather wide, the veins distinct.

Color, dark reddish brown to piceous, the tegmina and legs lighter. Antennæ light wood brown, the joints very hairy. Head and under side of thorax piceous. Pronotum reddish brown, the posterior margin darker. Tegmina and legs dull yellowish or golden brown. Under side of abdomen reddish brown.

Measurements: Length of body, male, 14.5 mm., female, 12 mm.; of pronotum, male, 3.5 mm., female, 4 mm.; of tegmina, male, 15.5 mm., female, 4 mm.; width of pronotum, male, 5 mm., female, 6 mm.; width of tegmina, male, 5 mm., female, 3.5 mm.

The single male which I refer to this species was taken beneath a flat rock on the slope of a high hill near Wyandotte, Crawford County, May 9, 1899. The females were found to be quite common in the same locality in the last week in June, 1902. Several females were also secured beneath chunks in oak woods near Lake James, Steuben County, on August 7th, two of which had oötheca protruding. I am by no means certain that the male belongs with the females; if not, the name applied will be referred to the latter sex.

V. BLATTELLA Caudell (1903).

The members of this genus have the body elongate; the head almost completely hidden by the pronotum, which is small and sub-orbicular; the eyes large and reniform, the ocelli more or less distinct. Antennæ setaceous, sparsely clothed with long hairs, unicolorous and much longer than the body. Tegmina and wings reaching to or beyond the tip of abdomen, membranaceous or slightly coriaceous. Inner wings with the ulnar vein undivided and without incomplete branches to the vena dividens. Supra-anal plate of male elongated, either triangular or broadly rounded, sometimes almost orbicular; sub-anal plate of the same sex with the styles rudimentary or wanting. Last abdominal sternite of the female, large, triangular, obtuse but not notched.

This genus is represented in Indiana by but one introduced species which is cosmopolitan in its range.

10. BLATTELLA GERMANICA (Linnæus). The German Cockroach. The Croton Bug. The Water Bug.

Blatta germanica L., **81**, II, 1767, 688; Sauss., **132**, VI, 1870, 28; Comst., **41**, 1888, 93, Fig. 87; Fern., **53**, 1888, 50, Fig. 20; Kell., **78**, 1892, 108, Fig. 59; Lugg., **84**, 1898, 90, Fig. 53; Scudd., **188**, 1900, 8.

Ectobia germanica Scudd., **141**, VII, 1862, 418; Pack., **104**, 1869, 576, Fig. 569; Glov., **62**, 1872, Plate 1, Fig. 4; Id., **63**, 1874, 132, Fig. 3; Riley, **122**, II, 1884, 171, Fig. 247; Id., **125**, I, 1888, 68, 191.

Phyllodromia germanica Brunn., **37**, 1865, 90; Pack., **104**, 1883, 576, Fig. 569; Riley, **126**, II, 1890, 266, Fig. 57; Bl., **8**, 1893, 162; Id., **16**, 1899, 204, Fig. 44; Beut., **3**, VI, 1894, 258.

Ectobia (Phyllodromia) germanica Marl., **85**, 1896, 92, Fig. 42; Id., **86**, 1902, 10, Fig. 5.

Blattella germanica Caud., **40b**, V, 1903, 234.

Ischnoptera bivittata Thom., **210**, I, 1876, 250, Plate XXXVI, Figs. 1, 2.

This is one of the smallest and, at the same time, one of the most common of the Blattidæ known to occur in the State. The general color is yellowish brown, the females often darker; all the limbs much lighter than the body; the pronotum with two dark brown, longitudinal bands separated by a yellowish stripe. The tegmina and wings of the male extend to the end of abdomen, those of the female are a little longer. Antennæ dark brown, exceeding slightly the tips of the closed tegmina. The body of the male is longer and narrower than that of the female.

Measurements: Male—Length of body, 13 mm.; of tegmina, 10 mm.; width of body, 4 mm.; Female—Length of body, 10 mm.; of tegmina, 11 mm.; of antennæ, 13 mm.

The "Croton bug," so called because it made its appearance in New York City in numbers about the time the Croton Aqueduct was completed, is a native of Central Europe, but like the Oriental roach, has become cosmopolitan. It seldom if ever occurs in numbers in the country, but is one of the worst insect pests with which the inhabitants of the larger cities of the United States have to deal, and is found in every town of any size in Indiana. It is the most fecund of all the roaches and the seasons of mating and hatching of the young are, perhaps, more irregular than in any other species. Adult forms are evidently to be found at all seasons of the year, as I have taken them in December, April and October. It is not so much a lover of filthy surroundings as is the Oriental roach, and hence frequents more

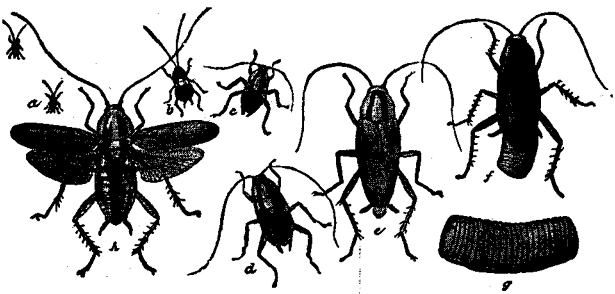


Fig. 29. *Blattella germanica* L.; *a*, first stage; *b*, second stage; *c*, third stage; *d*, fourth stage; *e*, adult; *f*, adult female with egg case; *g*, egg case, enlarged; *h*, adult, with wings spread. All natural size except *g*.—From "Household Insects," published by U. S. Div. of Entomology.

often than that species the dwellings of the better class of people. It delights in warm, moist places, and is especially abundant and destructive in buildings which are heated by steam.

As an evidence of its abundance under favorable conditions, I will mention that a single person captured for me over thirty adult specimens and fully half that number of young, in less than ten minutes in the kitchen of the leading hotel of the city of Terre Haute. Where it once obtains a foothold and the surroundings of temperature and food supply are favorable, it is almost impossible to eradicate, as its small flattened form enables it to hide and breed in cracks and crevices which none of the other roaches can enter.

Like many other omnivorous animals, Croton bugs find in wheaten flour a food substance which is rich in nutrition and easily digested, and so they prefer wheat breads and starchy materials to all other foods. On account of this liking they often do much harm to cloth bound books by gnawing their covers in search of the paste beneath.

They also seem to have a peculiar liking for paints of various kinds, and in the office of the U. S. Coast and Geodetic Survey, at Washington, have done much damage by eating off the blue and red paints from the drawings of important maps. Glover, *loc. cit.*, states that in his office "They made a raid on a box of water colors where they devoured the cakes of paint, vermilion, cobalt and umber alike; and the only vestiges left were the excrements in the form of small pellets of various colors in the bottom of the box."

The oötheca of the Croton bug is very light brown, a little over twice as long as broad, 7.5x3.5 mm., with the sides somewhat flattened and the edges parallel. Within it the eggs, thirty-six in number, are arranged in the usual two rows. It is carried about by the mother roach for several days with from half to three-fourths of its length protruding from the abdomen, and when dropped in a favorable place the young, evidently very soon, emerge from it; for in a bottle in which a female with protruding oötheca was placed at eleven o'clock p. m. the young were found to have emerged on the following morning at eight. They were then wholly white, except the lateral edges of the abdomen, where a blackish tinge was evident. By five o'clock in the afternoon of the same day, having meanwhile eaten their fill of moistened wheaten bread, they had become too large for their skins, and had moulted for the first time. They then measured 3 mm. in length, and the head, pronotum, abdomen, and apical half of antennæ were black, while the other two thoracic rings and the basal half of antennæ were a grayish white. The half grown young are very dark brown, with the first four or five segments bordered with yellow, and with traces of a lighter median stripe.

In giving a remedy for this and other roaches I can not do better than to quote from Mr. Marlatt's excellent bulletin as follows:

"Like the crows among birds, the roaches among insects are apparently unusually well endowed with the ability to guard themselves against enemies, displaying great intelligence in keeping out of the way of the irate housekeeper and in avoiding food or other substances which have been doctored with poison for their benefit. Their keenness in this direction is unquestionably the inheritance of many centuries during which the hand of man has ever been raised against them.

"*Fumigation.*—A thoroughly effective and simple means of ridding one's premises of roaches has been found, however, and is in fumigating with hydrocyanic-acid gas. The experience of the last year or two has demonstrated that this gas, formerly employed for disinfecting nursery stock and orchard trees (notably citrus) from scale and other insects, is equally effective against household insects, and is particularly applicable and satisfactory against all species of house roaches. The gas is extremely poisonous to human beings, but by observing the proper precautions, may be employed with complete safety. A special circular (No. 46, Second Series, U. S. Div. Ent.) has been prepared by Dr. L. O. Howard, giving the steps of the process in detail.

"In addition to the hydrocyanic-acid gas treatment noted above, two or three other forms of fumigation may be employed against house roaches. Wherever roaches infest small rooms or apartments which may be sealed up nearly air-tight, and also on shipboard, the roach nuisance can be greatly abated by the proper use of poisonous gases, notably bisulphide of carbon. This substance distributed about a pantry or room in open vessels, will evaporate, and, if used at the rate of one pound to every 1,000 cubic feet of room space, will destroy roaches. Unless the room can be very tightly sealed up, however, the vapor dissipates so rapidly that its effect will be lost before the roaches are killed. The hatches of ships, especially of smaller coasting vessels, may be battened down, a very liberal application of bisulphide of carbon having been previously made throughout the interior. If left for twenty-four hours the roaches and all other vermin will unquestionably have been destroyed. In the use of this substance it must be always borne in mind that it is violently explosive in the presence of fire, and every possible precaution should be taken that no fire is in or about the premises during the treatment. It is also deadly to higher animals, and compartments should be thoroughly aired after fumigation.

"*Poisons and Repellents.*—As just noted, roaches often seem to display a knowledge of the presence of poisons in food, and, notwithstanding their practically omnivorous habits, a very little arsenic in baits seems to be readily detected by them. In attempting to eradicate roaches from the Department storerooms, where cloth-bound books are kept, various paste mixtures containing arsenic were tried, but the roaches invariably refused to feed on them in the least. This applies particularly to the German roach, or Croton bug, and may not hold so strongly with the less wary and perhaps less intelligent larger roaches.

"A common remedy suggested for roaches consists in the liberal use of pyrethrum powder or buhach, and when this is persisted in considerable relief will be gained. It is not a perfect remedy, however, and is at best but a temporary expedient, while it has the additional disadvantage of soiling the shelves or other objects over which it is dusted. When used it should be fresh and liberally applied. Roaches are often paralyzed by it when not killed outright, and the morning after an application the infested premises should be gone over and all the dead or partially paralyzed roaches swept up and burned. Flour of sulphur dusted about where roaches abound has proven very effective as a repellent.

"There are many proprietary substances which claim to be fairly effective roach poisons. The usefulness of most of these is, however, very problematical, and disappointment will ordinarily follow their application. The only one of these that has given very satisfactory results is a phosphorus paste, also sold in the form of pills. It consists of sweetened flour paste containing 1 to 2 per cent. of phosphorus, and is spread on bits of paper or cardboard and placed in the runways of the roaches. It has been used very successfully in the Department to free desks from Croton bugs, numbers of the dead insects being found in the drawers every day during the time the poison was kept about. It is also a repellent."

For no other insects have so many quack remedies been urged and are so many newspaper remedies published. Many of them have their good points, but the majority are worthless. In fact, rather than put faith in half of those which have been published, it were better to rely on the recipe which T. A. Janvier gives (in his charming article on "Mexican Superstitions and Folk-lore," published in a recent number of Scribner's Magazine) as current among the Mexicans:

"*To Get Rid of Cockroaches.*—Catch three and put them in a bottle, and so carry them to where two roads cross. Here hold the bottle upside down, and as they fall out repeat aloud three *credos*. Then all the cockroaches in the house from which these three came will go away."

Sub-family PERIPLANETINÆ.

The two Indiana members of this sub-family are our largest roaches. Both are introduced species which have become thoroughly naturalized, and one of them is better known than any of our indigenous or native forms. The main distinguishing character of the sub-family is that pertaining to the last ventral segment of the female, which is keeled or boat-shaped, and divided into two valves. The head is large, flattened or slightly concave and not wholly covered by the pronotum. The antennæ are setaceous, more or less pubescent, the joints obconic and very short. The tegmina and wings are variable in the different species, being fully developed, abbreviated, or wholly wanting. The sub-anal plate of the male is furnished with two small styles on its apical margin. In our species the first joint of the hind tarsi is as long as, or longer, than the other joints combined.

Two genera of the sub-family, each represented by a single species, occur in Indiana.

KEY TO GENERA OF INDIANA PERIPLANETINÆ.

a. Tegmina of neither sex reaching tip of abdomen, those of the female much shorter. Distance between the eyes greater than length of last joint of maxillary palpus..................VI. BLATTA, p. 192

aa. Tegmina of both sexes much surpassing the abdomen. Distance between the eyes less than the length of last joint of maxillary palpus..................................VII. PERIPLANETA, p. 195

VI. BLATTA* Linnæus (1758).

In this genus the eyes are farther apart than the scrobes or pits in which the antennæ are inserted. The tegmina of the female are very short in both sexes and their outer border is less rounded than in *Periplaneta.*

11. BLATTA ORIENTALIS Linnæus. The Oriental Cockroach. The "Black Beetle."

Blatta orientalis L., **81**, I, 1758, 434; Harr., **72**, 1862, 145, Fig. 66; Rathv., **109**, 1862, 374, Figs. 4, 5; Caud., **40b**, V, 1903, 234.

Periplaneta orientalis Burm., **40**, II, 1838, 504; Brunn., **37**, 1865, 226; Riley, **122**, II, 1884, 172, Figs. 246, 248; Id., **126**, II, 1890, 267; Comst., **41**, I, 1888, 93; Fern., **53**, 1888, 52, Fig. 21; Hyatt and Arms., **77**, 1890, 102, Plate IV, Figs. 54, 55; Bl., **8**, 1893, 156; Id., **16**, 1899, 199, Fig. 41; Marl. **85**, 1896, 91, Fig. 41; Id., **86**, 1902, 9, Fig. 4; Lugg., **84**, 1898, 92, Figs. 51, 54.

Kakerlac orientalis Serv., **196**, 1839, 72.

Stylopyga orientalis Scudd., **141**, VII, 1862, 416; Id., **188**, 1900, 9; Glov., **62**, 1872, Plate I, Figs. 5, 6; Plate VII, Fig. 12; Id., **63**, 1874, 132, Fig. 4; Beut., 3, VI, 1894, 260, Plate V, Figs. 2, 3.

General color dark mahogany brown, the limbs lighter, the pronotum without a yellow margin. Female with rudimentary tegmina which do not exceed 5 mm. in length. Male with the tegmina and wings well developed, the former covering three-fourths of the abdomen, the latter almost as long. Supra-anal plate of the male truncate; that of the female rounded with a shallow notch at the end.

*Mr. A. N. Caudell has recently shown (Proc. Ent. Soc., Wash., V, 1903, 234), that *orientalis* L., is the type species of the genus Blatta; hence, the generic name *Blatta* is here used instead of *Stylopyga* of Scudder's Catalogue.

Measurements: Length of body, male, 22.5 mm., female, 27.5 mm.; of tegmina, male, 14 mm., female, 4.5 mm.; of pronotum, 6 mm.; width of pronotum, 8 mm.

In Indiana the Oriental roach is found in all the larger towns and cities, and is one of the most noisome and disagreeable insects with which certain classes of their inhabitants have to contend. It seldom occurs in houses in thinly settled localities, and never, as far as my observation goes, beneath the bark of logs and stumps.

As its name indicates, it is a native of Asia, but has been carried from one country to another by shipping. It delights in filth and darkness, and hence in the holds of vessels, the cellars and basements

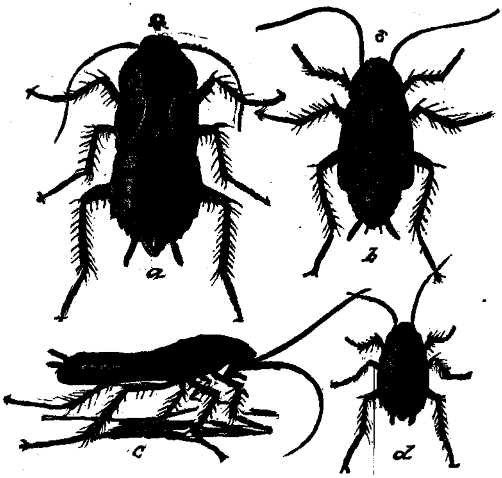


Fig. 30.—*Blatta orientalis*; *a*, female; *b*, male; *c*, side view of female; *d*, half grown specimen. All natural sizes. From "Household Insects," published by U. S. Div. of Entomology.

of tenement houses, and in all damp, dirty places it swarms by thousands, undoubtedly doing much good as a scavenger, but infinitely more harm on account of its omnivorous and insatiable appetite. Like most other members of the family, it feeds mainly at night, appearing to detest and avoid the light, as one can readily prove by taking a lighted lamp suddenly into its haunts, when a hurried scrambling will take place toward its daylight retreats, and but a few moments will elapse before the last of the busy marauders will have disappeared. Of this and other species Marlatt has written:

"The damage they do is not only in the products actually consumed, but in the soiling and rendering nauseous of everything with which they come in contact. They leave, wherever they occur in any numbers, a fetid, nauseous odor, well known as the 'roachy' odor, which is persistent, and can not be removed from shelves and dishes without washing with soap and boiling water. Food supplies so tainted are beyond redemption. This odor comes partly from their excrement, but chiefly from a dark colored fluid exuded from the mouth of the insect, with which it stains its runways, and also in part, doubtless, from the scent glands, which occur on the bodies of both sexes between certain segments of the abdomen, and which secrete an oily liquid possessing a very characteristic and disagreeable odor. It frequently happens that shelves on which dishes are placed become impregnated with this roachy odor, and this is imparted to and retained by dishes to such an extent that everything served in them, particularly liquids, as coffee or tea, will be noticed to have a peculiar, disgusting, foreign taste and odor, the source of which may be a puzzle and will naturally be supposed to come from the food rather than from the dish."

The Oriental roach is probably the most carnivorous of all our Blattidæ, though, like most others, it is fond of starchy food. It is known to feed upon meat, cheese, woolen clothes, and even old leather, and is said to be especially fond of the festive "bed-bug," *Acanthia lectularia* L., which soon disappears from a house infested with the Oriental roach. This roach is, however, far too great a nuisance in itself to be introduced as a means of eradicating even the bed-bug.

The eggs of the Oriental roach are sixteen in number, and the large, horny capsule or oötheca in which they are packed is carried about by the mother for a week or longer when she drops it in a warm and sheltered place. Along one side of the capsule, which resembles in form and color a diminutive seed of the papaw, *Asimina triloba* Duval, is a seam where the two edges are cemented closely together. When the young are hatched they excrete a liquid which dissolves the cement and enables them to escape without assistance, leaving their infantile receptacle as entire as it was before they quitted it.

This species is notably gregarious in habit, the individuals living together in colonies in the most friendly way, the small ones being allowed by the larger ones to sit on them, run over them and nestle beneath them without a show of resentment. The young pass through a variable number, sometimes as many as seven, moults, the skin splitting along the back and the insect emerging white and soft, but soon hardening and assuming its normal color.

Besides the remedies given on a previous page for roaches in general, a simple trap has been tried by Mr. Marlatt which was fairly successful in lessening the numbers of the Oriental roach. This "consists of any deep vessel or jar, against which a number of sticks are placed, and bent over so that they project into the interior of the vessel for a few inches. The vessel is partially filled with stale beer or ale, a liquid for which roaches seem to have a special fondness. In the morning these vessels are found charged with great quantities of dead and dying roaches which have climbed up the inclined sticks and slipped off into the vessel."

Another remedy which may be used for any of the household species is a mixture of plaster of Paris, one part, and flour, three or four parts, in a saucer, and placed where the roaches abound, with another flat plate nearby containing pure water, both supplied with several bridges to give easy access, and one or two thin boards floating on the water touching the margin. The insects readily eat the mixture, become thirsty and drink, when the plaster sets and clogs the intestines. The insects disappear in a few weeks, the bodies no doubt being eaten by the survivors.

VII. Periplaneta Burmeister (1838).

The members of this genus have the eyes closer together than the scrobes or pits of the antennæ. The tegmina of both sexes reach much beyond the abdomen, and the inner wings are as long as the tegmina.

But one species has as yet been taken in the State, though another may occur here, so that the following key is given for their separation:

KEY TO SPECIES OF PERIPLANETA.

a. Tegmina much exceeding the abdomen; their outer margin of the same color as the remainder of the wing......12 *americana*, p. 195

aa. Tegmina but little exceeding the abdomen; a bright yellow stripe along the basal half of their outer margin............*australasiæ.*

12. Periplaneta americana (Linnæus). The American Cockroach.

Blatta americana L., 81, I, 1758, 434; Rathv., 109, 1862, 375 (in part); Pack., 216, 1883, 309, Plates XXV–XXXV.

Periplaneta americana Burm., 40, II, 1838, 503; Scudd., 141, VII, 1862, 416; Id., 188, 1900, 9; Brunn., 37, 1865, 232; Glov., 62, 1872, Plate I, Fig. 2; Riley, 122, II, 1884, 172; Id., 125, I, 1888, 68, 190; Id., 126, II, 1890, 266; Fern., 53, 1888, 51; Bl., 8, 1893, 157; Id., 16, 1899, 202, Fig. 42; Beut., 3, VI, 1894, 259, Plate V, Fig. 4; Marl., 85, 1896, 90, Figs. 38, 39; Id., 86, 1902, 8, Figs. 1, 2; Lugg., 84, 1898, 93, Fig. 55.

Kakerlac americana Serv., 196, 1839, 68.

General color, light reddish brown. Pronotum broadly margined on the sides and narrowly in front with yellow, thus enclosing a large, bi-lobed brown spot. Tegmina and wings reaching much beyond the abdomen in both sexes. Supra-anal plate of female more pointed and median notch narrower and deeper than in *B. orientalis.*

Measurements: Length of body, male, 27 mm., female, 30 mm.; of pronotum, 8 mm.; of tegmina, male and female, 27.5 mm.; width of pronotum, 10.5 mm.

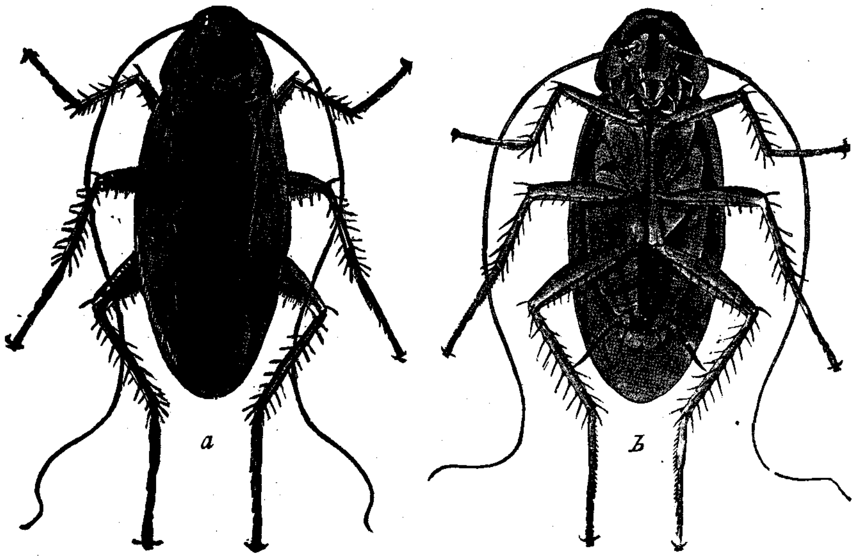


Fig. 31. ***Periplaneta americana; a,*** **view from above; *b,* from beneath; both enlarged one-third. From "Household Insects," Published by U. S. Div. Entomology.**

The American cockroach is, as its specific name indicates, a native of tropical and sub-tropical America; but, like *B. orientalis,* it has spread to the four corners of the earth. It is by far the largest species found in the State, but is much less common than *orientalis,* as I have specimens from but two counties, Putnam and Marion. It doubtless occurs, however, in all the larger towns of the State. It is found in numbers in some of the leading hotels of Indianapolis, but usually confines itself to the basement and first floor, and appears to be much more cleanly in its choice of an abiding place than does the closely allied Oriental roach.

Catesby, as far back as 1748, wrote of this species in Carolina as follows:

"*The Cockroach.*—These are very troublesome and destructive vermin, and are so numerous and voracious that it is impossible to keep victuals of any kind from being devoured by them without close covering. They are flat, and so thin that few chests or boxes can exclude them. They eat not only leather, parchment and woolen, but linen and paper. They disappear in winter and appear most numerous in the hottest days in summer. It is at night they commit their depredations, and bite people in their beds, especially children's fingers that are greasy. They lay innumerable eggs, creeping into the holes of old walls and rubbish, where they lie torpid all the winter. Some have wings and others are without—perhaps of different sexes."*

Catesby's wingless examples were in all probability the young, as, like most other insects, the wings are not acquired until the final moult. Marlatt says that the "domesticity of the American roach resulted from ages of association with the aborigines. It has now become thoroughly cosmopolitan, and is unquestionably the most injurious and annoying of the species occurring on vessels. It is sometimes numerous also in greenhouses, causing considerable injury to tender plants. It is a notorious house pest, and occasionally vies with the German roach in its injuries to book bindings. The backs, sometimes entirely, of both cloth and leather bound books, are eaten off to get at the starchy paste used in the binding."

The young of the American roach require about a year to reach maturity. The rate of growth of it and other species depends, however, largely on the food and temperature conditions, and under unfavorable circumstances the nymph stage is much prolonged. "The abundance of roaches is, therefore, apparently not accounted for so much by their rapidity of multiplication as by their unusual ability to preserve themselves from ordinary means of destruction and by the scarcity of natural enemies."

PERIPLANETA AUSTRALASIÆ **Fab.** The Australian Roach.

This species will doubtless be found to inhabit the State, as it has been recorded from Florida, Nebraska and Minnesota. It is a little smaller than *P. americana,* from which it can be separated by the characters given in the key. Like the last two species, it inhabits houses, and in the Southern States it is more abundant and troublesome than either of them.

*Natural History, Carolina, 1748, Vol. II, p. 10.

Family MANTIDÆ.

This family is composed of elongate, slow moving insects, the most noticeable character of which is the possession of a long, slender prothorax with the first pair of legs so modified as to be fitted for grasping and holding their prey. The old name given to the group was therefore *Raptoria* or graspers. The head is large, oblique, loosely joined to the prothorax in such a manner as to be freely movable; the antennæ are slender, and rarely as long as the body. The ocelli are present and three in number. The pronotum is longer than any other segment. The abdomen of the female is much broader than that of the male, and is without a visible ovipositor. The fore-legs are stout, raptorial and terminate in a single claw which, with the five-jointed tarsi, is placed in a groove on the under side of the spinous tibiæ when at rest. The middle and hind pairs of legs are long, slender, and fitted for slow motion. Tegmina and wings are present, but in the female are often abortive. As with the other non-saltatorial families, ears and organs for producing sound are absent.

The members of this family have numerous popular names, the most common of which is the "praying mantid," given them on account of the position which they take when at rest or when waiting to grasp another insect. The knees are then bent, and the front legs held as though in supplication. In the Southern States they are often called "mule killers," from the common belief that the brownish liquor which they give off from the mouth is fatal to mules. This name is, however, often also applied to the "whip-scorpion," a large member of the order *Arachnida*, which inhabits the Southern States. The mantids are all carnivorous, feeding principally upon the different forms of other insects. They are thus in the main beneficial, in this respect differing widely from all other members of the order Orthoptera, unless it be the tree crickets of the genus *Œcanthus*, which feed upon plant lice. They capture their prey by stealth, crawling upon it very slowly, and when within reaching distance, seizing it with a sudden and rapid movement. Like other predatory insects, they have very voracious appetites. A member of a European species, *Mantis religiosa*, which was introduced on nursery stock in New York State, was observed to eat, in one day, three large grasshoppers and a daddy-long-legs and then tackled another mantis from which he was separated with difficulty. The eggs of mantids are laid in a curiously formed egg case or "oötheca," which is secreted by the female.

Only two of the six known sub-families are represented in the United States, and one of these only by a single genus and species along the southern border. The other is the

Sub-family MANTINÆ.

The insects belonging to this sub-family have the upper surface of the middle and fore femora and tibiæ rounded, instead of carinate. The head is unarmed, whereas, in the other sub-family, the *Vatinæ*, it bears on the middle an erect process, as long as the rest of the head. To the *Mantinæ* belong eleven known genera and sixteen species from the United States. Of these two species, belonging to different genera, have been taken in Indiana.

KEY TO GENERA OF INDIANA MANTINÆ.

a. Broadest portion of pronotum far in advance of the middle; the sides in front distinctly tapering. Fore femora armed on the lower outer margin with large spines only.........VIII. STAGMOMANTIS, p. 199

aa. Broadest portion of pronotum but little, if any, in advance of the middle; the sides in front parallel, or nearly so. Fore femora armed on the lower outer margin with minute spines between the large ones.....................................IX. GONATISTA, p. 201

VIII. STAGMOMANTIS Saussure (1869).

Body of male narrow, of female much broader. Head large, compressed, triangular. Antennæ short and fine, inserted about the middle of the face below the center of the eyes. Vertex narrow, transverse, a little elevated above the eyes. Pronotum very long, in our species forming two-fifths the whole body; the apical third wider, the edges carinate and armed with minute, distant teeth. Tegmina of female shorter than abdomen, opaque and bearing a distinct spot or stigma of different texture near the center. Tegmina of male, in our species, longer than abdomen with stigma often indistinct or wanting. Wings of the female, when expanded, of the form of a quarter circle; those of the male longer and narrower. Abdomen of female, large, more or less dilated; that of male narrow, the subgenital plate large.

Two species occur in the United States, one of which is found in the southern half of Indiana.

13. STAGMOMANTIS CAROLINA (Linnæus). The Carolina Mantis. The Rearhorse.

Gryllus carolinus L., 80, 1763, 13.

Mantis carolina L., 81, II, 1767, 691; Rathv., 109, 1862, 376, Figs. 8–10; Riley, 113, I, 1869, 169, Figs. 94, 95; Id., 216, III, 1883, 37, Figs. 19ab; Id., 124, X, 1887, 44, Figs. 20ab; Glov., 62, 1872, Plate II, Figs. 1–16.

Stagmomantis carolina Sauss., 130, III, 1869, 65; Id., 131, 1871, 46; Id., 132, VI, 1872, 247, Plate V, Fig. 5; Plate VI, Fig. 12; How., 74, IV, 1892, 243, Figs. 29, 31; Id., 76, 1901, 326, Figs. 215, 216; Scudd., 173, XXVIII, 1895, 210; Id., 188, 1900, 12; Bl., 13, XXVIII, 1896, 265; Id., 16, 1899, 209, Fig. 46.

Phasmomantis carolina Riley, 122, II, 1884, 173, Fig. 249.

Color: Male, grayish brown. Tegmina semi-transparent, grayish, more or less mottled with smoky brown; sometimes almost wholly of the latter color. Body and feet often greenish yellow. Female, either wholly green or of the color of the male; the stigmatic patch black bordered with pale yellow, more distinct in the green form.

Fig. 32. *Stagmomantis carolina* L. Female.

Measurements: Length of body, male, 49 mm., female, 52 mm.; of pronotum, male, 17 mm., female, 20 mm.; of tegmina, male, 32, mm., female, 23 mm.

This mantid is a species of southern range and in Indiana occurs only in the south half, being quite common in the counties bordering the Ohio River. It extends as far north as Marion and Putnam counties, where it is found sparingly. I have taken it in Floyd, Perry and Lawrence counties, and have had a dozen or more specimens brought to me in Indianapolis, all of them females. Mr. S. G. Evans, of Evansville, in a letter says: "The Mantids are found here of all sizes and colors, the eggs and young being almost as common as mosquitoes. I have, on several occasions, placed male and female together in a glass jar, and the female always devoured the male, and generally while in the act of copulating, the bodies remaining together until the male was almost consumed." At Indianapolis the females evidently reach maturity about September 1st, most specimens being brought in about that date or later. The green and brown forms of the female are about equally numerous. In Putnam County it has been noted by Mr. John S. Michaels near Bainbridge.

When in the presence of its prey the Carolina mantis moves almost imperceptibly along, stealing toward its victim like a cat approaching a mouse. When sufficiently near, the foreleg is suddenly extended to its full length and the unlucky insect is immediately caught and impaled by the spines between the tibiæ and tarsi, carried to the mouth and deliberately eaten piecemeal while yet alive and struggling to escape. When the two sexes are captured and placed together the female soon begins to feed upon her liege lord, and finally devours all portions of him which are in the least degree digestible.

The eggs of the Carolina mantis are laid in tough cases about an inch long which are attached to the twigs of trees. The case is tough and horny, and the eggs are laid in parallel rows, perhaps forty in a row, issuing from a common longitudinal middle line. All of the eggs stand on end and are inclined somewhat toward the central channel. A cluster of eggs has a braided appearance, but consists simply of a continuous ribbon of mucus folded in close flutings and having an egg deposited in the bight or angle of each fold. The eggs are deposited simultaneously with the deposition of this ribbon by the mother insect, and the whole mass is at first soft and flexible, but rapidly hardens by exposure to the air. In this manner the species survives the winter and in May, when insect life begins to abound, the young emerge and use their prominent, staring eyes to good advantage in seeking plant lice and other minute forms which furnish them their first of many meals. The eggs are frequently parasitized by a very peculiar chalcis fly, *Podagrion mantis* which penetrates the tough egg mass with its long ovipositor, and whose larvæ feed upon the eggs. Thus egg masses taken by the observer in the winter and kept for the hatching of the young will frequently in the spring give out those parasites instead of the young mantids.

IX. Gonatista Saussure (1869).

Body short and broad. Head short, compressed. Antennæ inserted opposite the base of the eyes, hair-like, of considerable length. Eyes very large, globose, prominent. Ocelli large in the male, smaller in the female. The face, in appearance, somewhat excavated on account of the prominence of the eyes. Crest of vertex a straight transverse line a little elevated above the eyes. Pronotum of medium length and breadth; the disk depressed, but with an elevation or bump on the front and middle thirds with a depression between and with two small tubercles on the hind margin; widest about the middle; the front margin truncate; the sides of the front half parallel, those of posterior half a little converging. Tegmina of female broad, covering three-fourths of abdomen; the reticulation dense and irregular; the stigma small, narrow, often indistinct. Those of male narrower; surpassing the abdomen, more membranaceous. Wings ample, about as long as tegmina; those of the female forming a quarter of a circle, colored; those of male transparent or a little spotted. Fore limbs rather stout, the tibiæ with five or six large spines on the lower outer border, with numerous small ones intervening; the inner border with twelve or more strong spines. Abdomen depressed, of medium width in the male; large and broad in the female, the border coarsely serrate or lobed.

One species is known from the southern United States and West Indies.

14. Gonatista grisea (Fabricius). The Grizzled Mantis.
Mantis grisea Fab., 52, II, 1793, 22.
Gonatista grisea Sauss., 131, 1871, 23; Id., 132, VI, 1872, 231, Plate 5, Figs. 1, 2; Scudd., 173, XXVIII, 1896, 211, 214; Id., 188, 1900, 13; Bl., 13, XXVIII, 1896, 265.
Mantis phryganoides Serv., 196, 1839, 198.
Gonatista cubensis Sauss., 130, III, 1869, 61.

Color: Female, grayish, more or less mottled with fuscous. The tegmina with two oblique fuscous crossbars on apical half. Inner wings bluish black. Fore legs gray tinged with greenish and sprinkled with fuscous. The middle and hind legs with narrow fuscous crossbars.

Measurements: Female, length of body, 36 mm.; of pronotum, 11 mm.; of tegmina, 20 mm.

A single female of this southern mantid was taken in Vanderburgh County by Mr. S. G. Evans and by him sent to the Agricultural College of Michigan, from which it came into my possession. Mr. Evans writes that he must have supposed it to be a short bodied form of *Stagmomantis carolina* and has no recollection of the exact date, or the place in the county in which it was found. It may possibly, therefore, have been introduced on tropical fruits. It is common in Cuba and San Domingo and has been taken in Georgia and at Key West and Fernandina, Florida.

Family PHASMIDÆ.

To this family of non-saltatorial Orthoptera belong the insects commonly known as "walking-sticks." The body is long and exceedingly slender; the head nearly horizontal, not covered by the pronotum and usually quadrate or four sided; the antennæ long and rather coarse; the eyes small; the ocelli often wanting. The pronotum is very short. The tegmina and wings are wanting in our species, though present and rudimentary in some tropical forms. The legs are long, slender and of equal size, the fore femora being often bowed and the fore tarsi terminating, like the others, in a pair of claws.

Our species of *Phasmidæ* are remarkable for their resemblance to twigs of different plants; while some of the tropical species are so modified as to resemble leaves; frequently bearing so close a resemblance to the foliage as to deceive a keen observer. Their movements are, in general, very slow, though the males can run with some rapidity when in pursuit of the opposite sex. They feed during their entire lives upon leaves, being especally fond of those of oak and wild cherry. The eggs are dropped loosely and singly upon the ground by the mother, where they remain through the winter, thus tiding the insect over the cold season. The outer case or shell of the egg is hard and often sculptured, and those of our common species resemble small beans. The young, when hatched, trust to chance and their peculiar shape to escape those higher animal forms which are ever ready to prey upon every moving object which promises them a bit of sustenance.

The family is, in the main, a tropical one, and is very feebly represented in the United States, where but four of the dozen known sub-families are represented by seven genera and sixteen nominal species. Two of these sub-families are each represented in Indiana by a single genus and species.*

KEY TO SUB-FAMILIES OF PHASMIDÆ OCCURRING IN INDIANA.

a. Tibiæ not furnished at apex with a short sunken space to receive the base of the tarsi when bent upon them. Mesothorax never less than four times as long as the prothorax, generally more. Hind femora armed beneath near the apex with one or more spines........ BACUNCULINÆ, p. 204

aa. Tibiæ furnished on the under side at apex with a short, sunken space to receive the base of the tarsi when bent upon them. Mesothorax never more than three times as long as the prothorax, generally less. Hind femora without spines..........ANISOMORPHINÆ, p. 207

*Mr. A. N. Caudell has recently published a monograph of the U. S. species of Phasmidæ in the Proceedings of the U. S. National Museum, XXVI, 1903, the nomenclature of which I have followed.

Sub-family BACUNCULINÆ.

This sub-family comprises the longest and most slender of the United States walking-sticks. The mesothorax is usually five or more times as long as the prothorax. The antennæ, except in the genus *Sermyle,* are more than twice as long as the front femora. The tibiæ are without a sunken areola beneath the apex.

Four of the United States genera belong to this sub-family. Of these, two are represented only in the Gulf and adjoining states; and a third only in the Rocky Mountain Region and California. The species of the other genus, *Diapheromera,* are widely distributed. Among them belongs our most common Indiana "walking-stick."

X. DIAPHEROMERA Gray (1835).

Body long, slender and cylindrical. Head smooth, longer than broad; obliquely attached to the thorax; the eyes small. Antennæ inserted in front of the eyes, more than twice as long as fore femora, furnished with 30 or more segments. Pronotum about the length of head. Mesonotum longer than any other segment; metanotum three-fourths the length of the mesonotum. Median segment much shorter than metanotum, transverse, quadrate. Legs very long and slender, the femora of the middle pair in the male of our species much swollen; armed, like those of hind pair, on under side near the apex with an acute spine, most prominent in the male. Cerci of the male long, terete and incurved; those of the female short, straight.

Five species occur in the United States, of which the most common and widespread is

15. DIAPHEROMERA FEMORATA (Say). The Thick-thighed Walking-stick.

Spectrum femoratum Say, **138**, II, 1824, 297; Id., **137**, III, 1828, Plate 27; Id., **139**, 1859, I, 82, 197, Plate 37; Emm., **49**, V, 1854, 142, Plate 7, Figs. 1, 2; Rathv., **109**, 1862, 377, Fig. 11.

Diapheromera femorata Harr., **71**, 1841, 119; Id., **72**, 1862, 146, Fig. 67; Pack., **104**, 1869, 573, Fig. 566; Glov., **62**, 1872, Plate I, Fig. 7; Plate X, Fig. 1; Id., **63**, 1874, 134, Fig. 6; Scudd., **148**, I, 1874, 379, Plate A, Fig. 3; Id., **172**, XXVII, 1895, 30; Id., **169**, LXXXVIII, 1894, 456, 460; Id., **178**, VIII, 1897, 30: Id., **188**, 1900, 14; Id., **191**, IX, 1901, 187; Riley, **120**, 1878, 241, Plate 3, Figs. a-c; Id., **122**, II, 1884, 176, Fig. 253; Comst., **41**, 1888, 95, Fig. 91; Id., **42**, 1895, 108, Fig. 118; Fern., **53**, 1888, 49, Fig. 19; Beut., 3, VI, 1894, 262, Plate 10, Fig. 10; Weed., **222**, 1897, 6, Plate 5; Lugg., **84**, 1898, 100, Fig. 61; Bl., **16**, 1899, 208, Fig. 45; How., **76**, 1901, 323, Fig. 214; Caud., **40**[a], 1903, 874, Figs. 4, 6.

Color variable, being either gray, brown or greenish brown. The body of the male is usually greenish brown, sometimes almost wholly green; the head yellowish with three lengthwise fuscous stripes; the front legs and the tibiæ of the others usually green. The female is duller, generally grayish brown, often with paler specks and mottlings on the head and back.

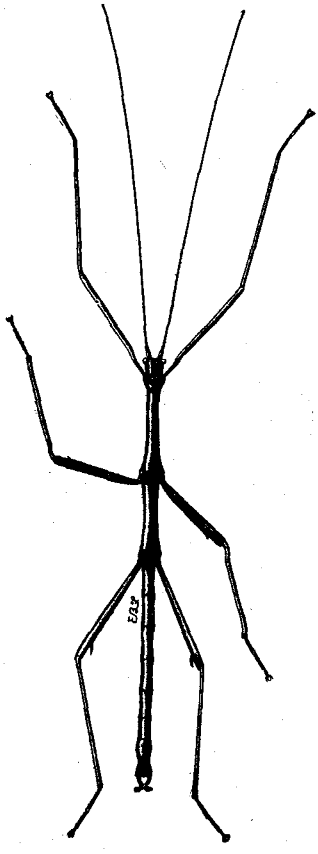


Fig. 33. *Diapheromera femorata* (Say). Male.

The male is easily distinguished by the shorter and more slender body; longer legs and antennæ; the narrower and less dilated front femora; the swollen middle femora and by the greater stoutness of the spines near the ends of the middle and hind femora.

Measurements: Length of body, male, 70 mm., female, 77 mm.; of antennæ, male, 65 mm., female, 45 mm.; of hind femora, male, 21 mm., female, 16 mm.

The thick-thighed walking-stick is a rather common insect throughout the State, though the average observer will probably see but one or two of them a year. They reach maturity in August, and may often be found upon the leaves of oak or wild cherry, especially on isolated trees along fence rows. One of my students at Terre Haute once brought in on October 15th, 100 or more which he had gotten from a wild cherry tree on whose leaves they had been feeding. It moves very slowly and has a habit of remaining motionless and apparently dead for a considerable length of time. On such occasions it usually stretches itself out from a twig, with its front legs and antennæ extended, and then can scarcely be distinguished from a prolongation or branch of the twig. Many people who see them thus for the first time and afterwards watch them moving slowly away, can scarcely be persuaded that they are not real twigs, gifted in some mysterious manner with life and motion.

In feeding, they eat the edges of a leaf, preferably those of an oak or wild cherry, usually straddling it with their legs, and in an hour will devour a piece an inch long by a third of an inch wide. Riley records that on occasions they are so numerous as to do much damage to oak, hickory, locust and other trees. In Yates County, New York, in 1878, Dr. Riley found them very abundant in a woodland of 50 acres, which they had attacked in numbers two and four years previously. He states that: "By the middle of August the bulk of the pests were going through their last moult, and by the end of autumn they had stripped most of the trees, showing, however, a decided preference for the black, red and rock-chestnut oaks, over the white oaks and hickories, which they affect but little until after the first mentioned trees are stripped. The underbrush was also very effectually cleaned of its foliage, and the insects hung from and clung to the bare twigs and branches in great clusters. They settle to roost on the witch-hazel, but do not defoliate it until the other trees mentioned are pretty bare. Sumach and thorn are also little affected, while peach and apple in an adjoining orchard were untouched. Whenever they have entirely stripped the trees and shrubs they move in bodies to fresh pastures, crowding upon one another and covering the ground, the fence rails, and everything about them so that it is impossible for a person to enter the woods without being covered by them. The timber affected can be recognized by its seared and leafless appearance from a great distance, and upon entering the woods the ear is greeted by a peculiar seething noise, resulting from the motion of the innumerable jaws at work on the leaves. Their depredations first begin to attract attention soon after wheat harvest, and are most noticeable in September. The injury to the trees done in 1874 and 1876 was manifest in the death of most of the black oaks, and, according to the owner's observations, trees die in three years after the first attack."

The eggs, of which each female lays about 100, are a little less than 3 mm. in length, long oval in shape and of a polished black color with a whitish stripe on one side. They resemble a small, plump bean or seed of other leguminous plant. "They are simply dropped loosely upon the ground from whatever height the female may happen to be, and, during the latter part of autumn where the insects are common, one hears a constant pattering, not unlike drops of rain, which results from the abundant dropping of these eggs, which in places lay so thick among and under the dead leaves that they may be scraped up in great quantities. From general observations of specimens kept in confinement, it would appear that each female is capable of laying upwards of 100. The eggs remain upon the ground all through the winter and hatch for the most part during the month of May. Some of them, however, continue hatching much later, so that all through the summer and even into the fall, young individuals may be found. The insect changes very little in appearance from birth to maturity except so far as color is concerned, and moults but twice. Growth is rapid, averaging, under favorable circumstances, about six weeks from birth to maturity. With age the green color gives way to various shades of gray and brown. In this way we find great correspondence with its surroundings. While the vegetation is green, the walking sticks are green also; when the foliage turns in autumn, they change color correspondingly, and when the foliage is stripped they so closely resemble, in both appearance and color, the twigs upon which they rest—the habit of stretching out the front legs and feelers greatly enhancing the resemblance—that when they are few in number it is difficult to recognize them. A few green specimens, more particularly of the males, may always be found, even among the mature individuals."

This Walking-stick appears to be abundant in any certain locality only every other year. This is in part due to an increase of the insect's natural enemies on those years in which they are most abundant. These enemies are several species of true bugs *(Hemiptera-Heteroptera)* crows and other birds. The main reason for the greater number of Walking-sticks on alternate years is, however, thought to be due to the fact that the larger proportion of the eggs, especially those laid late in the autumn, take two years in hatching. If at any time the insect threatens to become injurious in the woodlands of the State, it can be held in check by burning the leaves on the ground in the winter season, thus destroying the hibernating eggs.

Sub-family ANISOMORPHINÆ.

In this sub-family the antennæ are more than twice as long as the anterior femora. The tibiæ are furnished with a sunken areola beneath the apex, which receives the base of the tarsi when bent; coxæ visible from above; tarsi distinctly five-jointed. Mesothorax not more than three times as long as the prothorax. Intermediary segment invisible.

A single genus of this sub-family is represented in the United States.

XI. ANISOMORPHA Gray (1835).

Body of male elongate, slender; that of the female much larger and more robust. Head short, quadrate, horizontally attached to the thorax; and eyes larger than in *Diapheromera*. Antennæ shorter and stouter than there, though longer than the fore femora; the basal joint but little longer and little stouter than the second. Pronotum the length of the head. Mesonotum twice as long as pronotum and a third longer than metanotum. Front segments of abdomen but little longer than broad. Legs of nearly equal length, stout and thick, shorter than in the preceding genus, unarmed. Cerci of both sexes short, stout, cylindrical, projecting a little from beneath the large supra-anal plate.

Two species occur in the southern United States, one of which extends northward into Indiana.

16. ANISOMORPHA FERRUGINEA (Palisot de Beauvois). The Lesser Two-striped Walking-stick.

Phasma ferrugineum Pal. de Beauv., 108, 1805-1821, 167, Plate XIV, Figs. 6-7.

Anisomorpha ferruginea Gray., 64, 1835, 18; Burm., 40, II, 1838, 570; Scudd., 172, XXVII, 1895, 30; Id., 188, 1900, 15; Caudell 40a, XXVI, 1903, 880, 882, Plate LIX, Fig. 2.

Color: Fuscous or ferruginous, inconspicuously striped with narrow dusky dorsal and lateral stripes; these in the female less distinct, and often obsolete on a portion of the abdomen. Antennæ dull reddish brown. Under side of body dull clay yellow, brownish when dried. Legs brownish red.

Head but little longer than broad. Body of female six to six and a half times longer than broad; of male, about twelve times as long as broad.

Measurements: Length of head, male, 3 mm., female, 5.5 mm.; of body, male, 30 mm., female, 56 mm.; of antennæ, male, 22 mm., female, 34 mm.; of hind femora, male, 9 mm., female, 12 mm.

This southern Walking-stick has been taken in Indiana only near Wyandotte, Crawford County, and Grand Chain, Posey County, being found in large numbers in both localities. The first ones taken were in Crawford County, on June 28, 1902, when the young about an inch and a half long were found beneath loose flakes of bark on oak and other trees. In the first week in September I again visited the locality and found scores of pairs of them, all mating, beneath the loose bark of old oak snags and stumps. A half-dozen or more pairs were often found within an area of a foot or two square, the large, heavy bodied female bearing her diminutive liege lord upon her back.

When picked up by the fingers, there is exuded from glands on the sides of the thorax a vapor from the male and a white milky fluid from the female. This possesses a peculiar, though somewhat pleasing odor, which has been likened to that of the common Everlasting, *Gnaphalium obtusifolium* L. The secretion is doubtless used as a de-

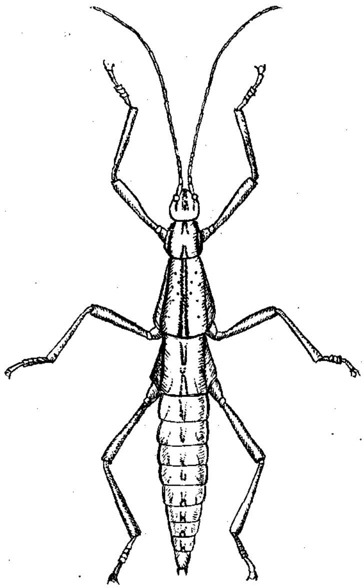


Fig. 34. *Anisomorpha ferruginea* (Pal de Beauv). Female. Natural size. (After Caudell.)

fense against certain enemies, being probably very distasteful, and perhaps harmful, to birds and rapacious insects. Scudder (Psyche I) has noted this secretion, and concludes that the *Phasmidæ* with their slender form and sluggish movements have especial need of such a weapon as these glands furnish.

None of the specimens of *ferruginea* noted were feeding, though they probably live upon the leaves of oak and other trees. The species was later found in numbers in Posey County, and probably occurs in most of the counties bordering the Ohio River. It is but one of many forms of insect and plant life which have their most northern habitat in the southern third of Indiana. Specimens in the U. S. National Museum are from Florida, Louisiana, Kentucky and Pennsylvania.*

*Since the above was in type *a ferruginea* has been taken as far north as Medora, Jackson County.

SALTATORIA.

Belonging to this class or sub-order, are three families which comprise the great majority of our best known Orthoptera. They are the true "hoppers" or leapers of the order; their hind limbs, in the course of ages, having become so modified as to be adapted in the highest degree to the life which they lead. Possessing, also, in many instances, ample organs of flight, which enable them, when disturbed, to move rapidly to a distance, the males have evolved in connection therewith organs of sound, by which they may call the members of the opposite sex to them. Were it not for these calling organs the two sexes would, during their varied movements, often be widely separated, and perhaps be unable to locate one another after settling in a new position. The males alone possess these organs of sound, and they only when wings are present. All the wingless forms lack also "auditory organs" or ears, since these would be useless unless some means of producing sound were present. The families belonging to this group may be separated by the following table:

KEY TO FAMILIES OF SALTATORIAL ORTHOPTERA.

a. Antennæ much shorter than the body, variable in form. Ocelli three. Tarsi three-jointed. Calling organs of male, when present, situated on the hind femora and lower border of tegmina. Organs of hearing, when present, located on the basal segment of the abdomen. Ovipositor composed of two pairs of short, horny, more or less curved plates, whose tips diverge............ACRIDIDÆ, p. 211

aa. Antennæ much longer than the body, bristle shaped, delicately tapering. Ocelli often wanting. Tarsi four or three-jointed. Calling organs of male, when present, situated on the dorsal field of the tegmina. Organs of hearing, when present, located near the base of the fore tibiæ (rarely on the prosternum). Ovipositor (except in certain crickets) an elongated blade or needle; its parts compact.

b. Ocelli generally wanting. Tarsi four-jointed. Tegmina with the sides sloping. Calling organ of male, when present, located on basal half of tegmina and limited to the anal area. Ovipositor, when exserted, forming a strongly compressed, generally sword-shaped blade, the tip not expanded.......... LOCUSTIDÆ, p. 340

bb. Ocelli variable. Tarsi three-jointed. Tegmina flat above, the sides bent abruptly downward. Calling organ of male, when present, extending across both anal and median areas of the tegmina. Ovipositor, when exserted, forming a nearly cylindrical straight or upcurved needle, the tip often enlarged...... GRYLLIDÆ, p. 407

Family ACRIDIDÆ.

To this family of saltatorial Orthoptera belong those short-horned grasshoppers or locusts which are so common in our meadows and pastures and along our roadsides from mid-April until after the heavy frosts of late autumn. Their antennæ are, with few exceptions, much shorter than the body, filiform, clubbed or ensiform in shape, the joints distinct, and often, especially toward the base, depressed. The head is usually short, and in the leading sub-families is extended horizontally. Ocelli are always present, and foveola usually so, the variations in form and size of the latter affording characters much used in classification.

The pronotum is variable in form and size, but in most species forms a buckler or saddle-shaped shield covering the three segments of the thorax. In one sub-family, the *Tettiginæ*, it extends back over the abdomen. The tegmina and wings, when present and in repose, rest partly horizontal on the dorsal surface of the abdomen and partly reflexed against its sides. The auditory or hearing organ, when present, is located on the side of the basal ring of the abdomen. The anterior and middle legs are equal or nearly so in size, and much smaller and shorter than the hind legs; the femora of the latter being, as in the other *Saltatoria*, very much enlarged in their basal halves. The tarsi are three-jointed and similar in structure on all the legs; the first joint, usually the longest, has the under side marked with two cross impressions which, when seen from below, give the impression that it is composed of three segments. The third or apical segment of the tarsus ends in a pair of curved claws which enable the insect to catch and cling to blades of grass and other objects on which it may alight. Between these claws there is in the species of all the sub-families except those of the *Tettiginæ* a circular pad or cushion, called the pulvillus or arolium. The ovipositor consists of four short, horny pieces, the so-called valves, projecting from the tip of the abdomen, two of which curve upward and two downward.

The call notes made by the males of the *Acrididæ* are produced in two ways. In one group, whose members call only when at rest, the sound is produced by rubbing the inner surface of the hind femur against the outer surface of the tegmina. Landois has shown that in this group, the inner surface of the femur is furnished along the lower margin with a longitudinal row of minute, lancet-shaped, elastic teeth, ranging in number from 85 to 93, which are scraped across the veins of the tegmina, thus producing a low, buzzing sound. Those which stridulate in this manner mostly belong to the sub-families *Tryxalinæ* and *Acridinæ*.

The members of the sub-family *Œdipodinæ* usually sound their call during flight by rubbing together the upper surface of the front edge of the wings and the under surface of the tegmina, thus pro-

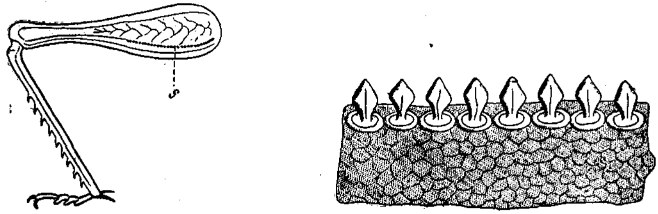


Fig. 35. Inside of hind femora of a locust. *s*, ridge with teeth. Ridge and teeth greatly enlarged. (After Landois.)

ducing a sharp, crackling sound which has been likened to that of burning stubble. By paying close attention the observer can soon learn to know each species by its peculiar call. Like the other families of Orthoptera, the males alone of the *Acrididæ* have musical organs, which is quite the reverse among some animals higher in the scale of life, where the females make most of the music and oftentimes much of the noise.

The great majority of Indiana Acrididæ pass the winter in the egg stage, the eggs being deposited by the mother insect in early

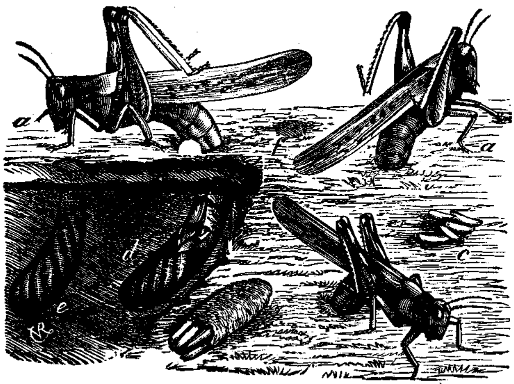


Fig. 36. Locust in the act of laying eggs. (After Riley.)

autumn. When ready to oviposit, she forms a hole in the ground or other nidus to a depth corresponding to the length of her abdomen. The eggs are then deposited one at a time to the number of 30 to 60, being placed in regular order in this hole. During the process a glutinous fluid is emitted around them which at length hardens and binds them together, thus forming a bean-shaped mass. The hole above the mass is then closed with dirt intermixed with this fluid which, when it hardens, renders it partially impervious to water. However, if the winter is an open one with many changes of temperature, many of the eggs are apt to be destroyed. By far the larger number of eggs are deposited in the earth in the manner shown in the accompanying cut. A few species, however, oviposit in rotten or

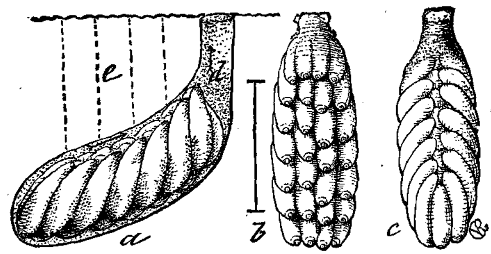


Fig. 37. Egg mass of locust. *a*, from the side, within burrow; *b*, from beneath; *c*, from above; enlarged. (After Riley.)

decaying wood. About mid-April the eggs begin to hatch and the sprightly little insects, devoid of wings but otherwise like their parents, are soon seen on every hand.

Born with one earthly desire—a voracious appetite—and with one valuable possession—a pair of strong, broad jaws, which move in and out like the blades of a pair of scissors—the little hopper soon begins to use the latter to appease the former, and for twenty-four hours a day and seven days in a week, he gnaws away at the soft, green, succulent grass which surrounds him on every side. Such a procedure can have but one result. His body soon becomes too big for its surround-

Fig. 38. Molting of a locust. *a*, nymph ready to change: *b*, the skin split along the back and the adult emerging; *c*, continues the process; *d*, the adult insect drying out; *e*, perfect adult. (After Riley.)

ings. Something must give way, and that something is his skin. He casts it aside, however, with but little reluctance, for a new one is ready to take its place, and immediately begins to satiate his appetite once more. Five successive times his skin gets too small for his body and is cast aside. Between each of these moults the wings are growing, and when the fifth skin is shed he emerges a mature and full fledged insect.

However, all locusts do not pass the winter in the egg state. Three or four species hatch in early autumn and the young in various stages can, in suitable localities, be seen jumping vigorously about on any warm sunny day in mid-winter. If their presence at such a season comes to the attention of a newspaper reporter, the press of the entire State is apt to teem with warnings of a coming "grasshopper plague," of which the youngsters are thought to be the advance guard. These hibernating young are the first to reach maturity the next spring, usually becoming full grown about the 20th of April.

A number of species of Acrididæ, especially of those belonging to the genus *Melanoplus*, possess, in the adult stage, only rudimentary tegmina and wings, and resemble immature insects or nymphs in appearance. A close examination will show, however, that these adults have the tegmina in the proper position, while in the immature stages of these and other forms, the tegmina and wings are inverted, being twisted about so that the faces and margins are just the opposite of what they are in the perfect insect.

About 540 species of *Acrididæ* are known from the United States. These are divided among four sub-families, all of which are represented in the Indiana fauna, 63 species having been taken in this State. These sub-families may be separated by the following table:

A SYNOPSIS OF THE SUB-FAMILIES OF ACRIDIDÆ KNOWN TO OCCUR IN INDIANA.

a. Size, very small; pronotum extending to or beyond the end of abdomen; tegmina represented by small scales or lobes on the sides of the body; claws of tarsi without a pad or cushion between them....................TETTIGINÆ, p. 215

aa. Size, larger; pronotum never extending over the abdomen; tegmina usually well developed, but sometimes abbreviated or even wanting; claws of tarsi furnished with a small cushion or pad between them.

b. No spine or tubercle on the prosternum between the front pair of legs.

c. Face or front head very oblique, usually meeting the vertex at an acute angle; the fastigium horizontal or a little ascending; foveolæ usually present and well developed; median carina of the pronotum never raised in the form of a crest, or cut by more than one sulcus.......... TRYXALINÆ, p. 232

cc. Face or front of head nearly or quite vertical and rounded where it meets the vertex; the fastigium almost always sloping sharply downward; foveolæ generally obscure; median carina of pronotum often crested and usually cut by more than one sulcus............ŒDIPODINÆ, p. 251

bb. A distinct conical or cylindrical spine present on the front margin of the prosternum......................ACRIDINÆ, p. 285

Sub-family TETTIGINÆ.

The members of this sub-family, known as the "grouse locusts," are our smallest Acridians. They are readily known from all other locusts by having the pronotum prolonged and tapering backward to such an extent that it reaches to or beyond the tip of the abdomen. The tegmina are rudimentary, being represented only by small oval lobes or scales, placed on the sides of the body and usually covering a small portion of the base of the wings. The wings are usually present and well developed, especially in their anal area, though both they and the tegmina are, in a few instances, wanting. The prosternum is prolonged in front by a half circular "chin piece" which envelops the maxillæ and other mouth parts like a muffler; no arolia or pads are present between the terminal claws of the tarsi. The males of most of the species are much narrower bodied than the females; their sub-anal plate, viewed from the side, is conical or triangular; the supra-anal plate lanceolate or triangular. The valves of the ovipositor are armed with small rounded teeth on their outer edges, and their extremities sharply diverge.

These little grouse locusts are the only members of our Indiana Acrididæ which pass the winter in the imago or mature stage. On the approach of winter they hide beneath chunks, chips, rubbish, the loose bark of logs, or beneath the bottom rails of old fences. Sometimes a warm sunny day in mid-winter tempts them forth in numbers, and on such occasions, the earth seems to swarm with them as they leap before the intruder, their hard bodies striking the dead leaves with a sound similar to that produced by falling hail. If the winter is an open one, with alternate periods of thawing and freezing, many of them doubtless perish. On the first warm days of spring they can be collected by hundreds from any grass-covered hillside having a sunny southern exposure, or from the boggy places along the margins of lakes and streams. Hancock has written entertainingly of their habits as follows:

"The jump of the grouse locust is peculiar in that it is quick and inconspicuous and in this that it alights almost invariably on the ground. The young of the larger Orthoptera usually alight on grass or stems of plants, dodging behind them for protection. The remarkable color of these little Acridians, harmonizing in every instance with the soil, makes it sometimes difficult to locate them. This protective resemblance is carried out to perfection, the little insects living on the soil scattered with debris faded out by the hot sun, and the lights and shadows, in whatever way they play, are copied exactly. No shade, color or arrangement of markings seems impossible of simulation, and every individual is a study in color harmony.

"The grouse locusts feed upon the vegetable mold or decomposing soil sometimes mixed with algæ, or on the lichens, mosses, tender sprouting grasses, sedges, germinating seeds of plants and debris found in such situations. Particularly sought-after morsels are the various colored surface clays and the black muck, consisting of rich vegetable mold. They are ravenous eaters, as one might infer from the dietary list just mentioned, and the fecal excrement, on reaching the end of the abdominal appendages, is thrust away from the body by a rapid kick of the hind tibia.

"In the middle of May (Illinois) the first eggs are laid in the ground, the female accomplishing this act by making a shallow burrow with her ovipositor. The young larvæ, hatched from this brood, mature by fall, passing the following winter in the adult state. The broods hatched in late June and early July are often immature by the time winter arrives, and we find them hibernating in the pupa state. Thus it is that the Tettiginæ are about the earliest insects to be found in the spring, appearing as early as March. The time of incubation varies with the temperature, the early broods of *Tettix* hatching in twenty-three days, but as the days become warmer this period is shortened to sixteen days. The number of eggs of *Tettix* and *Paratettix* vary considerably, but there are more often 10, 13 or 16 in each burrow; in *Tettigidea* varying from 12 to 26.

"During the life of these little Tettigians they are more or less constantly in danger of enemies among the arachnida, insecta, and some of the vertebrata. The larva of a red mite (Trombidian) is one of the most frequent sources of annoyance. Acting as a parasite the Trombidian larva clings on the body and attaches itself out of the reach of the victim. There it remains to sap the juices of the host's body. It is found on many species. Among insect pests, ants and bugs are sometimes deadly to them. In a wet ditch in June the writer found a number of small dark-brown ants dragging along the ground a female *Tettix ornatus* which had just been killed by them. When endeavoring to capture some *Tettix* at the same place my attention was drawn to a colony of these ants acting in a panicky state of excitement, the cause of this being that they had darted upon the insect the author was pursuing, tumbling it over and biting it savagely about the neck. The little locust finally escaped by a vigorous jump.

"According to P. R. Uhler, *Galgulus oculatus*, a true bug, is a serious enemy. 'This insect may often be seen,' says Uhler, 'in the month of May walking about between the stones on the low banks of brooks and streams, where *Tettix* and *Paratettix* abound, watching an opportunity to seize one of these insects, and when the favorable moment arrives, leaping suddenly upon one of them, clasping it with tight embrace between the front femora and tibiæ and then sucking out its vital juices.' "

Toads, fishes and birds also feed upon them when opportunity offers.

Nine genera, 45 species and numerous varieties of these grouse locusts are described from the United States in the latest monograph of the group.* Of these 12 species, representing five genera, have been taken in Indiana. The genera found in the State may be separated by the following table:

KEY TO GENERA OF INDIANA TETTIGINÆ.

a. Antennæ with 12 to 14 joints; front femora more or less compressed, carinate above.

- *b.* Vertex of head extending beyond the front of eyes, wider than one of them; its front angulate or rounded, not truncate.
  - *c.* Front dorsal margin of pronotum when truncate not advanced upon the head to the eyes; facial ridges not forked; front of vertex, when viewed from the side, angulate or sub-rounded.
    - *d.* Pronotum with its median carina raised in the form of a crest and more or less arched lengthwise; the front margin produced in an angle over the back of the head. Upper notch or sinus on the hind margin of lateral lobe of pronotum shallow, about one-half as deep as the lower.......................
XII. NOMOTETTIX, p. 218

*"The Tettigidæ of North America," by Dr. J. L. Hancock, Chicago, 1902.

dd. Pronotum with its median carina low, not arched; its front not produced forward. Upper notch or sinus on hind margin of lateral lobe of pronotum nearly as deep as the lower....XIII. TETTIX, p. 219

cc. Front dorsal margin of pronotum truncate and advanced upon the head to the eyes; facial ridges with their lower halves strongly forked; front of vertex, when viewed from the side, distinctly rounded.................... XIV. NEOTETTIX, p. 226

bb. Vertex of head not extending beyond front of eyes, usually narrower than one of them; its front usually truncate........ XV. PARATETTIX, p. 227

aa. Antennæ with 21 or 22 joints; front femora distinctly and broadly grooved or sulcate above................XVI. TETTIGIDEA, p. 228

XII. NOMOTETTIX Morse (1894).

The members of this genus can be easily distinguished from the other Tettigians by the characters given in the key. The high arched crest of the pronotum, and (in our species) its projection forward in an angle over the back of the head, are especially notable. Between the posterior portion of the eyes and the median line of the pronotum a pair of nipple-like tubercles are usually present. The antennæ are short and filiform with 12, rarely 13, joints. The pronotum in most specimens reaches only to end of abdomen, the inner wings then being rudimentary. An occasional example of some of the species is found in which the pronotum is prolonged and the wings well developed. These, according to Morse, are examples of a reversion to the earlier long-winged type of females. The hind femora are wider and stouter proportionally than in the other genera.

Seven nominal species of Nomotettix have been described from the United States. Of these, but one has, as yet, been taken in Indiana.

17. NOMOTETTIX COMPRESSUS Morse. The Crested Grouse Locust.

Nomotettix compressus Morse, 96, III, 1895, 15; Scudd., 188, 1900, 15; Hanc., 69, 1902, 55, 58.

Batrachidea cristata Bl., 4, XXIII, 1891, 100 (not Harris).

Batrachidea carinata Bl., 6, XXIV, 1892, 33 (not Scudd.).

Body small, compressed, granulate; grayish or fuscous brown in color, the sides of pronotum often ornamented with one or two irregular shaped velvety black or black and white spots. Vertex nearly twice as wide as one of the eyes, a little higher than the eyes and extending in front of them, its front border sub-rounded. Pronotum strongly compressed, its front dorsal margin advanced in an angle over the head to the posterior third of the eyes. Median carina of pronotum strongly crested and arcuate; so compressed and thin in section that the punctulations of its surface appear translucent when held against the light. In the shorter and more common form the pronotum exceeds but slightly the tip of abdomen and the wings do not reach its apex; in the long form the pronotum extends 3 mm. and the wings 4 mm., beyond the tip of abdomen.

Measurements: Length of body, male, 7.5 mm., female, 8 mm.; of antennæ, 3 mm.; of pronotum, male, 7.3 mm., female, 8 mm.; of hind femora, male, 4.3 mm., female, 5 mm. Length of pronotum, long form, 10 mm.

This crested grouse locust probably occurs in most portions of Indiana, having been taken by the writer in Perry, Monroe, Vigo and Lake counties, while Dr. Hancock has found it abundant at Dune Park, Porter County. In the southern portion of the State it makes its home on the sides of dry sunny banks in pastures where the grass is scant or has been cropped short, and where the species of "Everlasting," *Antennaria* and *Anaphalis*, delight to grow. In such places it may be taken by the score in late autumn or early spring. In the northern counties it lives, says Hancock, "on dry, sandy soil, lightly covered by fragments of twigs, leaves, and various fine debris accumulated from past seasons. It frequently seeks retreat among prickly pear cactus on mossy covered ground, slightly sheltered by trees, among sand dunes. It is a curious little species, and though sometimes quite common locally, it requires the exercise of tact on hands and knees to capture the sprightly little insects. In the cool October morning they did not appear to jump far, but as the sunlight warmed the ground they became more active. Some were in the last pupa stage, but the majority were adult."

But two specimens of the long-winged form have been taken among the hundreds of short-winged ones collected in this State, a male in Vigo County and a female in Perry County. On account of the greater length of the pronotum, its median crest does not appear so prominent nor so strongly arched in the long-winged form as in the more common one. Dr. Hancock, in a recent letter, has given the varietal name *atavus* to this long-winged form.

XIII. Tettix Charpentier (1841).

In this genus the median carina of the pronotum is distinct but not arched or raised in the form of a crest. The vertex is wider than one of the eyes, and its front projects beyond them. Antennæ short, stout or slender, usually composed of 14 joints. Pronotum with its front margin truncate, or scarcely angulate, but little produced forward upon the head, reaching to end of abdomen in short-winged forms and much beyond it in long-winged forms of the same species; the upper lateral notch or sinus nearly as deep as the lower. Eleven species of the genus have been described from the United States, five of which are known to occur in Indiana. These may be distinguished by the following

KEY TO INDIANA SPECIES OF TETTIX.

a. Median carina of pronotum more or less distinctly elevated along its entire length; dorsal surface of pronotum higher in the middle, sloping on the sides; its surface rugose or wrinkled, as well as granulated.

b. Body slender, the posterior portion of pronotum long drawn out; vertex viewed from above, obtusely angulate, its median carina not projecting beyond the sides....18 *granulatus*, p. 220

bb. Body less slender; pronotum less prolonged posteriorly; front of vertex rounded, its median carina distinctly projecting....

c. Front half of pronotum with its median carina but little raised; middle femora of male but slightly enlarged, the expanded portion but one-third as long as broad........ 19 *ornatus*, p. 222

cc. Front half of pronotum with its median carina compressed and more elevated, more or less arcuate; middle femora of male enlarged, their expanded portion nearly or quite one-half as long as broad.............20 *hancocki*, p. 223

aa. Median carina of pronotum indistinct, being not at all or very little elevated; dorsal surface of pronotum flat, or nearly so, the surface granulated, rarely if at all rugose.

d. Body rather slender, the posterior portion of pronotum prolonged, acute; vertex distinctly depressed in front; eyes prominent; frontal costa straight and narrowly sulcate.............. 21 *arenosus*, p. 224

dd. Body more robust, the pronotum less prolonged posteriorly; vertex but little depressed in front; eyes of medium size; frontal costa, when viewed from the side, distinctly sinuate.......... 22 *obscurus*, p. 225

18. TETTIX GRANULATUS (Kirby).

Acrydium granulatum Kirby, 79, 1837, 251.

Tettix granulatus Scudd., 141, VII, 1862, 474; Id., 188, 1900, 16; Thos., 206, V, 1873, 182; Riley, 117, VIII, 1876, 150, Fig. 47; Id., 119, 1877, 230, Fig. 42; Id., 214, I, 1878, 256, Fig. 11; Id., 122, II, 1884, 192, Fig. 268; Lint, 82, II, 1885, 197, Fig. 59; Bol., 19, 1887, 91; Fern., 53, 1888, 46, Fig. 18; Morse, 94, VII, 1894, 154, 163, Plate 6, Figs. 3, 3a; Bl., 11, XXVI, 1894, 220; Beut., 3, VI, 1894, 309; Hanc., 67, XXIII, 1896, 237, Plate VI, Figs. 3, 3a; Plate IX, Fig. 28; Id., 68, X, 1899, 279; Id., 69, 1902, 69, Plate IV, Figs. 2, 2a; Lugg., 84, 1898, 107, Fig. 63.

Tettix morsei Hanc., 68, X, 1899, 280.

Color variable, usually wholly grayish or reddish brown, sometimes blackish, often with a whitish median band along the full length of the pronotum. Surface of pronotum and legs finely granulated; the dorsal surface of pronotum also rugose with numerous short ridges or

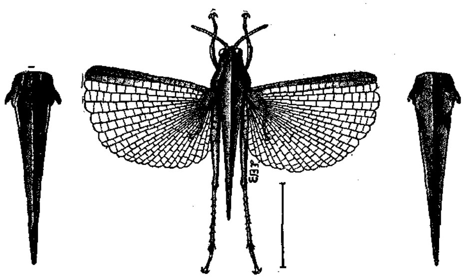


Fig. 39. *Tettix granulatus* (Kirby). (After Lugger.)

wrinkles. Anterior border of vertex considerably advanced in front of eyes, obtusely angulate or very slightly rounded, the mid-carina projecting but little if any beyond the sides. Face very oblique, eyes small. Body, especially that of male, very slender. Pronotum with front margin truncate, its posterior portion long drawn out, the apex acute, passing the hind femora; its median carina prominent throughout but not crested. Inner wings reaching to or slightly beyond tip of pronotum; in life bluish or bottle green in color. A form with the pronotum and wings more or less abbreviated is occasionally found with the common form. To it Hancock has given the varietal name *variegatus*.

Measurements: Length of body, male, 8.5 mm., female, 11 mm.; of pronotum, male, 11 mm., female, 13.5 mm.; of hind femora, male, 6 mm., female, 7 mm.

This slender grouse locust doubtless occurs throughout the State, having been taken in Lake, Porter, Fulton, Marshall, Marion and Franklin counties. It is probably much more abundant in northern than in southern Indiana, as its general range is northerly, extending from ocean to ocean and northward through British America. It has an especial liking for marshy and boggy tracts about the margins of lakes and tamarack swamps, though it is likely to occur anywhere in low wet woods. In Vigo County I found it hibernating beneath logs along the sandy border of a large river bottom pond. The light band along the middle line of pronotum is in a high degree protective when the locust dwells among the grasses and sedges of marshy tracts, as it harmonizes with the dried blades of these plants. Hancock has found *granulatus* in Wisconsin on the ground "about prostrate tree trunks, which were molding in decay and covered with greenish lichens and moss. The yellowish and brownish fallen leaves were everywhere scattered over the bed of the forest. Occasionally, when the wind was not blowing, the author was able to mark the presence of Tettigids by the sound made as they jumped upon the dried leaves." Morse says that "in New England this species prefers sedgy meadow lands and swales on sandy soil occasionally flooded by rains or freshets and perpetually moist. The bulk of my specimens were taken on a boggy swamp which had been filled in with sand, and on which water stood more or less of the time."

19. TETTIX ORNATUS (Say). The Ornate Grouse Locust.

Acrydium ornatum Say, **137**, I, 1824, Plate V.

Acridium ornatum Say, **139**, I, 1859, 10, Plate 5, Fig. 1.

Tetrix ornatus Harr., **70**, 1835, 577; Id., **72**, 1862, 186.

Tettix ornatus Scudd., **141**, VII, 1862, 474; Id., **188**, 1900, 17; Glov., **62**, 1872, Plate V, Figs. 1, 2; Plate XII, Fig 10; Thos., **206**, V, 1873, 183; Riley, **122**, II, 1884, 192; Lint., **82**, II, 1885, 197; Bol., **19**, 1887, 90; Fern., **53**, 1888, 46; Bl., **4**, XXIII, 1891, 100; Id., **11**, XXVI, 1894, 220; Id., **16**, 1899, 236, Fig. 62; Morse, **94**, VII, 1894, 152, Plate 6, Figs. 2, 2a–c; Beut., **3**, VI, 1894, 310; Hanc., **67**, XXIII, 1896, plate VI, Figs. 1, 2; Plate VIII Fig. 20; Plate IX, Fig. 29; Id., **69**, 1902, 78, Plate III, Fig. 4; Plate XI, Fig. 3; Lugg., **84**, 1898, 108, Fig. 64.

Tettix triangularis Scudd., **141**, VII, 1862, 475; Thos., **206**, V, 1873, 185; Bol., **19**, 1887, 91; Fern., **53**, 1888, 47; Beut., **3**, VI, 1894, 310; Lugg., **84**, 1898, 109; Hanc., **69**, 1902, 80.

Body of moderate size; color extremely variable; usually dark grayish, sometimes rusty brown or fuscous; often ornamented with two or four irregular velvety brown spots on dorsal surface of pronotum, more rarely a large whitish spot in front of these; the hind femora often with one or two white blotches on its outer face. Surface of pronotum and legs everywhere finely granulate; the posterior half of the pronotum usually rugose, with numerous short, oblique wrinkles or ridges. Vertex extending in front of eyes, somewhat rounded in front, its median carina projecting forward beyond the sides. Pronotum variable in length, in the long form less prolonged backward than in *granulatus*, its dorsal front margin truncate; the median carina distinct but not as high as in *granulatus*. Inner wings fully developed, extending a little beyond the apex of pronotum. The form with pronotum and wings shorter is, as shown by the synonymy, the one formerly known as *T. triangularis* Scudd.

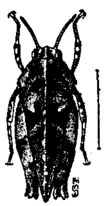


Fig. 40.

Tettix ornatus (Say). (After Lugger.)

The two forms have been proven by Hancock to interbreed and the measurements intergrade, the following table showing the extremes:

Measurements: Length of body, male, 8.5-12.5 mm.; female, 9-13.5 mm; of pronotum, male, 7.5-10.5 mm., female, 8-12 mm.; of hind femora, male, 4.5-5.5 mm., female, 5-7 mm.

The ornate grouse locust seems to be rather common in Indiana, having been taken in Crawford, Posey, Marion, Putnam, Lake, Porter and Laporte counties. It may be taken any month in the year but in late autumn and early spring is most abundant, being then usually found along the edges of dry open woods and on gravelly hillsides, while in summer it is occasionally found in company with *Paratettix cucullatus* about the borders of streams and ponds. It sometimes makes its home in grassy plots and lawns, especially those which are wooded, in the outskirts of cities, and is then often seen sunning on the cement and other sidewalks along their margins. The form *triangularis* more often occurs in sandy localities, and in some places far outnumbers the typical form.

On a bright sunny afternoon in late November, I once found both forms of *ornatus* very common on a sloping hillside two miles north of Indianapolis. A clover field was here adjoining an open woods pasture, and the second crop had been cut in October for the seed. Many of the dead stalks had fallen close along the fence row separating the fields, and here the Tettix were in abundance, their bodies all grayish brown, and corresponding very closely to the dead clover stems; so closely, indeed, that they were not visible until they hopped, and then had to be "marked down" before they were captured. Beneath the bottom rails of the old fence they had found a comfortable abiding place and winter retreat, and on this bright afternoon had been tempted forth to bask in the sunlight and perchance to feed upon the green clover leaves which were yet abundant in places among the dead and fallen stems.

20. TETTIX HANCOCKI Morse. Hancock's Grouse Locust.

Tettix hancocki Morse, **101**, VII, 1899, 200; Scudd., **188**, 1900, 16; Hanc., **69**, 1902, 81, Plate IV, Fig. 4; Plate XI, Figs. 5, 5a.

This species is allied to *T. ornatus* Say, with which it agrees in color, granulation and rugosity of surface, but differs in its more robust form with wider and generally more projecting vertex, slightly more prominent mid-carina; in the generally more abruptly forked and wider facial costa, and notably in the enlarged middle femora; the expanded portion of the latter in the male being nearly or quite one-half as broad as long (in *ornatus* seldom more than one-third);

in the female the difference is less noticeable. The humeral angles of the pronotum are more pronounced and the mid-carina is a little more elevated in its anterior portion.

Forms with both long and short pronotum occur, the varietal name *abbreviatus* having been given to the shorter one. In the long examples the pronotum and wings pass the hind femora about 3.5 mm.

Measurements: Length of body, male, 8.3-12 mm., female, 9-13 mm.; of pronotum, male, 8.5-11 mm., female, 8-12 mm.; of hind femora, male, 5 mm., female, 5.5-6 mm.

This species has been taken only in Marion and Vigo counties. From the latter locality some of Morse's type specimens were secured. It frequents the same localities as *T. ornatus*, the species to which it is most closely allied. In the localities where it has been found, short forms have, up to the present, proven more abundant than the long ones. It will probably be found to occur more commonly in the northern half of the State, as its range is northerly, being given by Scudder as "Montreal to S. Dakota and Nebraska."

21. TETTIX ARENOSUS Burmeister. The Granulated Grouse Locust.
Tettrix arenosa Burm., **40**, II, 1838, 659.
Tettix arenosus, Bol., **19**, 1887, 95; Bl., **11**, XXVI, 1894, 219 (in part); Scudd., **188**, 1900, 16; Hanc., **69**, 1902, 68, 85, Plate III, Fig. 3; Plate IV, Figs. 5, 5b.
Tettix ornata Thom., **206**, V, 1873, 184 (in part).

Body rather slender; the pronotum everywhere minutely granulate but little rugose or wrinkled. Color grayish or blackish, often with a large squarish white spot on the dorsal surface between the humeral angles; this spot usually with traces of black on its hind margin. Vertex, viewed from above, nearly twice the width of one of the eyes, depressed in front; extending but little beyond the front of the eyes, its front margin subtruncate, the median carina indistinct, scarcely if at all projecting. Eyes, when viewed from above, prominent. Antennæ slender, the joints elongate. Pronotum with its front margin truncate, its posterior portion prolonged, and extending much beyond the hind femora, its dorsal surface flat, the median carina indistinct, scarcely or not at all elevated. Inner wings fully developed, a little surpassing the pronotum.

Measurements: Length of body, male, 8 mm., female, 9 mm.; of pronotum, male, 10.5 mm., female, 13 mm.; of hind femora, male, 5 mm., female, 5.5 mm.

This is a common insect in Indiana, especially in the southern half. Specimens in my collection are from Posey, Orange, Crawford, Monroe, Vigo, Putnam and Kosciusko counties. From *ornatus* it may be readily known by its more slender form, flatter pronotum with less prominent median carina, and by its evenly and finely granulated surface. The annulations of antennæ and legs are much less distinct than in *ornatus* and the general color is not so variable. It frequents upland woods which are dry and open, being seldom found in the vicinity of water. It was originally described from South Carolina, and its general range is southern.

22. TETTIX OBSCURUS Hancock. The Obscure Grouse Locust.

Tettix obscurus Hanc., **67**, XXIII, 1896, 239, Plate VII, Figs. 9, 9a, 10, 10a; Plate IX, Figs. 23, 25; Id., **69**, 1902, 87; Scudd., **188**, 1900, 17.

Tettix inflatus Hanc., **67**, XXIII, 1896, 238; Scudd., **188**, 1900, 17.

Tettix angustus Hanc., **67**, XXIII, 1896, 238; Scudd., **188**, 1900, 16.

Allied to *arenosus*, with which it agrees in color; body more robust. Vertex, viewed from above, twice the width of one of the eyes, but little depressed in front; extending beyond the front of eyes to a distance equal to one-fourth the diameter of one of them; its median carina but little distinct, not advanced beyond the sides. Frontal costa distinctly sinuate between the lower portions of the eyes, forming a small protuberance at the junction with the median carina of the vertex. Eyes of medium size. Pronotum truncate in front, strongly constricted before the shoulders, less prolonged backward than in *arenosus;* the median carina indistinct through most of its length, a little raised on anterior third. Inner wings extending slightly beyond tip of pronotum.

Measurements: Length of body, male, 11 mm., female, 13 mm.; of pronotum, male, 10.5 mm., female, 12 mm.; of hind femora, male, 5 mm., female, 5.5 mm.

Among a number of grouse locusts sent to Dr. Hancock were numerous examples from Vigo, Marion and Lake counties which he referred to this species. They were taken in company with *T. arenosus* and were by me considered that species. In my opinion time will show that *obscurus* is but a form of *arenosus*, as Dr. Hancock wrote me, when returning the specimens, that some of those labeled by him as *obscurus* "shade off into forms approaching *arenosus*."

Hancock's *T. gibbosus*, representatives of which he also found among the "lot of *arenosus*" I sent him from Vigo and Marion counties, I consider only a shorter and wider form of *arenosus*, having the pronotum a little more constricted than usual in front of the shoulders. The other characters given by him in his key to the species of Tettix are not distinctive.

XIV. NEOTETTIX Hancock (1898).

The members of this genus have the body short and thick set. Vertex wider than one of the eyes, the front margin convex or rounded; viewed from the side, a little advanced in front of the eyes. Frontal costa convex, their lower halves, viewed in front, strongly divergent or forked. Antennæ rather stout, short, composed of twelve or, rarely, thirteen segments. Pronotum with its front dorsal margin truncate, advanced over the head to the eyes, the sides of dorsal surface sloping a little downward between the shoulders; the median carina distinct, usually a little elevated between the shoulders. Hind femora enlarged, rather short. Hind tarsus with the first segment distinctly longer than the second and third together, the pad between the claws of last segment acute but more or less flat below.

Five species of this genus are known from the United States. One of these occurs in Indiana.

23. NEOTETTIX HANCOCKI sp. nov.

Body short, robust; color dark gray, the tibiæ and tarsi annulate with light and dark, the ovipositor brown. Vertex nearly twice as wide as one of the eyes; its median carina visible only on front half; its front border rounded. Frontal costa, viewed from the side, strongly convex between the bases of antennæ, the lower halves, as in other species of the genus, widely divergent. Eyes prominent, subglobose. Pronotum with its dorsal front margin truncate, reaching the eyes; the lateral carinæ on the portion in front of shoulders high and distinct; the posterior portion with the sides converging gradually to a rather sharp apex, which terminates just above the base of ovipositor; the median carina distinct throughout, more or less undulate, highest between the shoulders; the posterior lateral carina prominent throughout; the dorsal surface with a number of prominent oblong tubercles on its front half; those on posterior half shorter and more rounded; tegmina oblong, the apical half rounded. Wings abbreviated, three-fourths the length of posterior portion of pronotum.

Measurements: Length of body, female, 10 mm.; of pronotum, 8.5 mm.; of hind femora, 6 mm.

From *N. bolivari*, its nearest ally, this species is easily recognized by its more bulky form, by the more convex and prominent frontal costæ, the larger eyes, the higher lateral carinæ of pronotum behind the eyes, and especially by the prominent tubercles on the surface of the front dorsal half of pronotum. The tegmina are shorter and broader, the upper posterior notch of lateral lobe of pronotum is deeper and the median lobule more rounded than in *bolivari*.

A single female, now in the collection of Dr. Hancock, was taken from the border of a large cypress swamp in Knox County, on July 6, 1902. It was not recognized until Dr. Hancock made a careful examination of the Indiana material of the sub-family. A second visit was made to the place on April 23, 1903, but a careful search resulted only in the finding of four half-grown nymphs. The whole swamp was covered with water several feet in depth, and the young of *hancocki* were found in company with the young and adults of other Tettigids on the higher ground bordering the water, within ten feet of its margin, and only a few rods from the nearest cypress trees. All other known members of the genus are from the southern states, and it is interesting to note that this single northern species makes its home among the isolated cypress swamps of Indiana—the cypress being a tree whose main distribution is far to the south.*

XV. Paratettix Bolivar (1887).

From the other grouse locusts the members of this genus may be readily known by the short and narrow vertex which does not extend beyond the eyes, its front margin being truncate. Frontal costa more or less prominent between the antennæ, declined toward their base, rarely a little sinuate. Eyes prominent, sub-globose. Antennæ of 14 segments. Pronotum with its dorsal surface flat, its front margin truncate, and, in our species, advanced forward upon the head to the eyes; its posterior portion moderately prolonged; the median carina low. Tegmina oval or elongate, punctate. Inner wings usually fully developed, rarely abbreviated. Hind tibiæ with their apical third gradually enlarged, the pads between the spurs of last joint of hind tarsi covered with numerous fine points or spicules. Five species of the genus are known from the United States, one of which occurs in Indiana.

24. Paratettix cucullatus (Burmeister). The Hooded Grouse Locust.
Tetrix cucullata Burm., **40**, II, 1838, 658.
Tettix cucullata Scudd., **141**, VII, 1862, 475; Thom., **206**, V, 1873, 185.
Tettix cucullatus Bol., **19**, 1887, 259, 266; Fern., **53**, 1888, 47; Bl., **6**, XXIV, 1892, 33; Beut., **3**, VI, 1894, 309.
Paratettix cucullatus Morse, **94**, VII, 1894, 163, Plate 6, Figs. 4, 4a; Hanc., **67**, XXIII, 1896, 241, Plate VII, Figs. 11, 11a; Id., **69**, 1902, 111, Plate VIII, Figs. 6, 7; Lugg., **84**, 1898, 110, Fig. 65; Bl., **16**, 1899, 236, Fig. 62; Scudd., **188**, 1900, 17.

*Two additional females of *N. hancocki* were taken in the cypress swamp on July 1, 1903, by one of my assistants. The male has, however, not yet been discovered.

Color usually a uniform yellowish gray; sometimes a russet red or dull black, the tibiæ annulate with light and dark. Body rather long, depressed, smoothly and evenly granulate. Vertex viewed from above, but little wider than one of the large and prominent eyes; not advanced in front of them, its front margin slightly hollowed. Pronotum truncate in front, advanced upon the head to the eyes (whence the specific name), the medina carina wanting or indistinct on the front portion; low on the elongated posterior portion, which extends about 3 mm. beyond the apex of hind femora. Inner wings exceeding the pronotum by 2 mm.

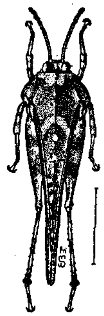


Fig. 41. *Paratettix cucullatus* (Burm.). (After Lugger.)

Measurements: Length of body, male, 9 mm., female, 12 mm.; of pronotum, male, 10.5 mm., female, 13 mm.; of hind femora, male, 5.5 mm., female, 7 mm.

The "hooded grouse locust" doubtless occurs throughout the State, having been noted in Spencer, Knox, Monroe, Vigo, Putnam, Marion and Marshall counties. It is most always found along the damp sandy or muddy banks of ponds, lakes and streams, usually in company with *Galgulus oculatus* and other semi-aquatic insects. Its modest hues agree admirably with such surroundings, thus furnishing the insect valuable protection against its foes. When disturbed it more often flies than leaps, its flight being more prolonged than any other of our Indiana Tettigians. It often alights upon the water, where it swims with ease, its dilated hind tibiæ being then of much aid to its onward progress.

XVI. TETTIGIDEA Scudder (1862).

The grouse locusts belonging to this genus are more robust and clumsy in form than those we have previously treated, and possess a larger head and less oblique face. They may also be readily distinguished by their 22-jointed antennæ and by the fore femora being sulcate or grooved along their upper margin. The crown of the head has a small lobe on each side which encroaches upon the upper inner border of the eye. The vertex is wider than one of the eyes and has its front border more or less rounded. Pronotum with its dorsal surface finely granulate and usually more or less rugose or wrinkled; its sides sloping downward between the shoulders, the posterior portion flat and either long drawn out or abbreviate; the anterior margin rounded, angulate or acute and more or less projected forward upon the head; the median carina distinct. As in the previous genera, the males are much more slender than the females and both the pronotum and inner wings vary much in length in the same species, much confusion of synonymy having therefore resulted. Eight nominal species have been described from the United States. Of these four occur in Indiana.

KEY TO INDIANA SPECIES OF TETTIGIDEA.

a. Front margin of the pronotum produced on the head and between the eyes nearly to their front in the form of an acute angle or sharp cusp.

b. Body rather stout; vertex but little projecting beyond the eyes; the pronotum broad across the shoulders, its dorsal surface strongly rugose or wrinkled, its median and lateral carinæ well developed..........................25 *armata*, p. 229

bb. Body slender; vertex more projecting, the pronotum narrow across the shoulders, its dorsal surface finely wrinkled, its carinæ but slightly developed..............26 *spicata*, p. 230

aa. Front margin of pronotum obtuse angulate or rounded, produced on the head only to front of posterior third of eyes.

c. Vertex of head rather strongly advanced in front of eyes, the union of its median carina and frontal costa, prominent; front margin of pronotum obtuse angulate; eyes of average size; antennæ stout........27 *parvipennis*, p. 230

cc. Vertex of head but little produced in front of eyes; the union of its median carina and frontal costa less prominent; front margin of pronotum broadly rounded; eyes prominent, antennæ more slender.....28 *lateralis*, p. 231

25. TETTIGIDEA ARMATA Morse.

Tettigidea armata Morse, 96, III, 1875, 107; Bl., 15, XXX, 1898, 60; Scudd., 188, 1900, 18; Hanc., 69, 1902, 142, Plate X, Fig. 6.

Tettigidea armata depressa Morse, 96, III, 1895, 107; Bl., 15, XXX, 1898, 60; Hanc., 69, 1902, 142.

Color dark gray or brown above, blackish on the sides, the tegmina with a white spot on their apical third; the hind femora usually more or less mottled with whitish on their outer face. Body rather robust; vertex but little projecting beyond the front of the eyes; the frontal costa, when viewed from the side, prominent. Pronotum with its front dorsal margin projecting forward between the eyes in the form of an acute tooth or cusp; its median carina distinct, sharp, nearly horizontal, its dorsal surface distinctly roughened with rather long wrinkles, the sides in front of the shoulders a little excavated. In the long form the wings and pronotum pass the hind femora. In the short form, *T. armata depressa*, the pronotum is abbreviated and the wings more or less abortive.

Measurements: Length of body, long form, male, 11 mm., female, 15 mm.; of pronotum, male, 11.5 mm., female, 14 mm.; of hind femora, male, 6 mm., female, 7.5 mm. Short form, length of body, male, 8.5 mm., female, 11.5 mm.; of pronotum, male, 7.5 mm., female, 11.5 mm.; of hind femora, male, 5.5 mm., female, 7.5 mm.

Morse's type specimens of this species were in part secured by me in Vigo County, where it occurred in small numbers along the wooded margins of a large lowland pond. It has also been taken in Monroe County, along the margins of a lake near Waterloo, Dekalb County, and by Dr. Hancock near Dune Park, Porter County, so that it probably occurs throughout the State in low, damp, wooded localities. Outside of Indiana it has been recorded from Louisiana, Texas, Florida and Illinois. In my experience the short winged form is much less common than the long winged.

26. TETTIGIDEA SPICATA Morse.

Tettigidea spicata Morse, 96, III, 1895, 108; Scudd., 188, 1900, 18; Hanc., 69, 1902, 144, Plate X, Fig. 5

Body small, slender; vertex more projecting than in *armata;* the body narrower between the shoulders; the lateral carinæ of pronotum but slightly developed; the median carina less distinct; the dorsal surface more finely rugulose.

Measurements: Length of body, female, 14.5 mm.; of pronotum, 14 mm.; of hind femora, 7.5 mm.

Among the specimens of this genus submitted to Dr. Hancock for examination he found a single female of this species, taken near Grand Chain, Posey County, April 26, 1901. Several additional specimens were taken along the margin of the Cypress Swamp, Knox County, April 23, 1903. *Spicata* is a form of southern range, having hitherto been recorded only from Georgia and Florida. Its presence in Posey and Knox counties is but another link in the chain of proof that the southern third of Indiana is a portion of the territory in which the sub-tropical and boreal forms of the eastern United States overlap and merge.

27. TETTIGIDEA PARVIPENNIS (Harris).

Tetrix parvipennis Harris 70, 1833, 583; Id., 72, 1862, 187, Fig. 82.

Tettigidea parvipennis Morse, 96, III, 1895, 108; Hanc., 67, XXIII, 1896, 242, Plate VII, Figs. 12, 12a; Id., 69, 1902, 148; Walk., 217, XXX, 1898, 124; Scudd., 188, 1900, 18.

Tettigidea parvipennis pennata Morse, 96, III, 1895, 109; Hanc., 69, 1902, 146, Plate X, Fig. 7.

Tettigidea polymorpha Scudd., 141, VII, 1862, 477; Fern., 53, 1888, 48; Bl., 4, XXIII, 1891, 100 (in part); Morse, 94, VII, 1894, 164 (nec. Burm.); and doubtless many other authors under the same name.

Tettigidea lateralis Scudd., 141, VII, 1862, 477; Fern., 53, 1888, 48; Bl., 4, XXIII, 1891, 100 (in part); Morse, 94, VII, 1894, 164, Fig. 5 (nec. Say); and other authors under the same name.

Color, grayish, light brown or fuscous above; the sides blackish, the tip of pronotum with a small white spot; the male with the lower part of face, mouth parts, and the lower sides of pronotum in front of legs, ivory white; the female with the last two joints of palpi, and often a spot on the upper outer half of hind femora, white. Body robust; vertex about twice the width of one of the eyes, projecting rather strongly in front of eyes. Frontal costa straight, the upper half, when viewed from the side, prominent; the lower half sloping gradually. Antennæ slightly flattened, the joints of the middle third not over two and a half times as long as broad. Pronotum with its front dorsal margin terminating in an obtuse angle which reaches opposite the posterior third of eyes; its dorsal surface rugose with distinct, branching vein-like wrinkles; its median carina distinct, but little elevated; its posterior portion slightly surpassing the tip of abdomen; or, in the long form, *T. parvipennis pennata*, passing the tip of hind femora. Inner wings either aborted or in the form *pennata* equaling or slightly exceeding the pronotum in length.

Measurements: Long form, length of body, male, 12.5 mm., female, 15 mm.; of pronotum, male, 10.5 mm., female, 14 mm.; of hind femora, male, 5.7 mm., female, 7.2 mm. Short form, length of body, male, 9.5 mm., female, 13 mm.; of pronotum, male, 8.5 mm., female, 12.5 mm.; of hind femora, male, 5.4 mm., female, 7 mm.

This is a very common grouse locust throughout Indiana, frequenting both dry upland woods, fence rows, and low marshy tracts. Its mating season appears to be the whole year round, as I have taken specimens in copulation in nearly every month, even on sunny days in mid-winter. It hibernates usually in small colonies or groups—as many as eleven having been found huddled together within the space of a few square inches on the under side of a log or chunk. E. M. Walker has found it hibernating in a beetle-boring in a log, the hole being completely hidden by the bark. The general color of the pronotum varies greatly in different examples, each insect seemingly seeking that local habitat which corresponds closely to its hue.

28. TETTIGIDEA LATERALIS (Say).

Acrydium laterale Say, **137**, I, 1824, 10, Plate 5; Id., **139**, I, 1859, 10, Plate 5.

Tettigidea lateralis Scudd., **141**, VII, 1862, 477 (in part); Id., **188**, 1900, 18; Thos., **206**, V, 1873, 187 (in part); Bl., **4**, XXIII, 1891, 100 (in part); Id., **16**, 1899, 236, Fig. 62; Hanc., **66**, XXVIII, 1894, 483, Plate XIII; Id., **69**, 1902, 149, Plate X, Fig. 9; Morse, **96**, III, 1895, 108; Lugg., **84**, 1898, III, Fig. 66 (in part).

Color as in *T. parvipennis;* vertex less projecting in front of eyes than in that species. Frontal costa, viewed from the side, less prominent. Eyes larger. Antennæ filiform, the joints of the middle third, three to four times as long as broad. Pronotum with its front dorsal margin more or less rounded, but little produced forward upon the head; its dorsal surface rugose as in *parvipennis;* its posterior portion surpassing the tip of hind femora in the long form; reaching the end of abdomen in the short form, *T. polymorpha* Burm. (?). Development of inner wings, as in other species, depending upon the length of pronotum.

Fig. 42. *Tettigidea lateralis* (Say). (After Lugger.)

Measurements: Length of body, male, 12 mm., female, 14.5 mm.; of pronotum, male, 9.5 mm., female, 12 mm.; hind femora, male, 5.5 mm., female, 7 mm.

This is a species of southern range which in Indiana has been taken so far only in Vigo, Putnam, Monroe, Crawford, Floyd, Knox and Posey counties—all in the southern half of the State. It frequents the same localities and has the same habits as *T. parvipennis.* Hancock has described a form as variety *medialis* to which he referred many of the specimens submitted to him from Indiana. This appears to be, in part, a connecting link between *parvipennis* and *lateralis,* and an examination of a large series of specimens from all parts of the Eastern United States will probably show that the two species are the same. In that case *lateralis* would have the priority in name.

Sub-family TRYXALINÆ.

In the members of this sub-family the vertex is horizontal or a little ascending; the face is decidedly oblique and usually meets the vertex at an acute angle; the lateral foveolæ are usually present and well developed, though in a few genera they are absent or invisible from above. The eyes are usually longer than that portion of the cheeks lying below their orbits. The antennæ are variable, being often depressed, acuminate or clavate, and inserted between the middle or below the middle of the eyes. The dorsal field of the pronotum has its front and hind margins of nearly equal width; the lateral carinæ usually distinct; the median carina cut by but one sulcus and never crested, and the surface smooth. The tegmina and wings are often short and imperfectly developed. Long and short winged forms of the same species are not uncommon. The wings are generally transparent, never bright colored or with a black band.

Our members of this sub-family for the most part frequent the borders of marshes and damp prairie meadows, making their homes among the tall rank grasses and sedges which there abound. They usually move by flying, making no noise while on the wing. One or two species, however, delight in sandy or clayey places, where clumps of bunch and wire grass furnish them protection and food. Their inner wings are never bright colored and showy as in the next sub-family, and their tegmina have remained a green or straw color in order to harmonize with their chosen abiding places. The males stridulate, or call the opposite sex to them, only when at rest by rubbing the inner surface of the hind thighs against the outer surface of the wing covers. No one of our species occurs in sufficient numbers to do much damage to vegetation, and some of them are among the least common of the Acrididæ. The winter of all is passed in the egg stage.

Thirty-eight genera and 90 species of *Tryxalinæ* are listed by Scudder from the United States, mostly from the region west of the Mississippi River, and one or two additional species have been described since his catalogue was issued. Of these, but nine species, representing eight genera, have as yet been taken in Indiana, though several others may in time be found to inhabit limited areas of the State. Our genera may be separated by the following table:

KEY TO INDIANA GENERA OF TRYXALINÆ.

a. Foveolæ of the vertex wanting or invisible from above; face very oblique.

b. Sides of the fastigium strongly rounded, so that the apex is in no way acuminate; antennæ strongly flattened at the base; pronotum with the lateral lobes vertical and straight and the lateral carinæ parallel; median carina of the pronotum cut much behind the middle; tegmina fully developed, acuminate or angulate at apex....................XVII. TRYXALIS, p. 234

bb. Sides of the fastigium straight or gently rounded so that the apex is more or less acuminate; antennæ variable; pronotum with the lateral lobes less distinctly vertical; the lateral carinæ gently or strongly sinuate near the middle (except in *Dicromorpha*); median carina of the pronotum cut in or but little behind the middle; tegmina rounded at apex.

c. Hind tibia armed with 18 to 21 spines on the outer margin..........................XVIII. SYRBULA, p. 236

cc. Hind tibia armed with not over 15 spines on outer margin.

d. Antennæ relatively short, at most but little longer than head and pronotum together; fastigium of vertex with no distinct median carina.

e. Pronotum with the sides elongate, the length on dorsal margin greater than the depth; the disk of one color; lateral carinæ parallel throughout ....XIX. Dicromorpha, p. 238

ee. Pronotum with the sides not elongate; the disk particolored; the lateral carinæ diverging both before and behind the middle................ XX. Orphulella, p. 239

dd. Antennæ long, about or more than half as long again as head and pronotum together; fastigium of vertex with a median carina..XXI. Chlœaltis, p. 243

aa. Foveola of the vertex always present; visible from above; face less oblique than in the preceding genera.

f. Tegmina without well developed elevated intercalary vein. Median carina of pronotum not high and sharp, never cut plainly in front of middle by the principal sulcus ....

g. Apical spurs on inner side of hind tibiæ equal in length; lateral carinæ of pronotum distinct throughout their full length; broadest part of male tegmina lying beyond the middle....XXII. Stenobothrus, p. 246

gg. Apical spurs on inner side of hind tibiæ very unequal in length, the inferior twice, or nearly twice as long as the superior; lateral carinæ of pronotum distinct only on metazona; broadest part of male tegmina lying at the middle.............. XXIII. Ageneotettix, p. 248

ff. Tegmina with strongly developed, elevated, intercalary vein. Median carina of pronotum rather high and sharp, cut plainly in front of middle by principal sulcus......XXIV. Mecostethus, p. 249

XVII. Tryxalis Fabricius (1775).

Vertex horizontal, semi-elliptical, projecting in front of the eyes to a distance about equal to that between the eyes; furnished with a delicate median carina. Lateral foveola wholly wanting. Face, viewed from the side, sloping strongly backward. Antennæ flattened at the base, acuminate, about as long as the head and pronotum. Disk of pronotum plain, the three carinæ parallel, distinct, the median cut by one sulcus much behind the middle. Lateral lobes of the pronotum perpendicular and parallel, a little longer than high, with both the front and hind margins oblique; the former straight, the latter sinuate. Tegmina much longer than the abdomen; acuminate or angulate at apex. Hind femora slender, the apex reaching (female) or exceeding by nearly half their length (male) the abdomen. But one species belongs to the genus as at present restricted.

29. TRYXALIS BREVICORNIS (Linnæus). The Short-horned Locust.
Gryllus (*Acrida*) *brevicornis* L., 81, II, 1767, 692.
Truxalis brevicornis Fabr., 50, 1775, 279; Thom., 211, 1880, 97; McN., 88, VI, 1891, 66; Id., 89, VI, 1897, 211, Plate I, Fig. 5; Bl., 4., XXIII, 1891, 75; Id., 11, XXVI, 1894, 221; Id., 15, XXX, 1898, 61; Beut., 3, VI, 1894, 291, Plate VIII, Figs. 1, 2.
Tryxalis brevicornis, Burm., 40, II, 1838, 607; Morse, 98, VII, 1896, 325, 382, Plate 7, Figs. A, Aa; Scudd., 188, 1900, 19.
Pyrgomorpha brevicornis Glov., 62, 1872, Plate IV, Fig. 14; Thom., 206, V., 1873, 67.
Opsomala punctipennis Serv., 196, 1838, 590; Thom., 202, V, 1865, 447.
Pyrgomorpha punctipennis Thom., 206, V, 1873, 68.
Opomala punctipennis Thom., 206, V, 1873, 196.

The females of this species are dimorphic as regards color, being either a pale green more or less dotted with brown on the tegmina, or a uniform rusty brown. The green form has the lateral carina of pronotum, antennæ and edges of vertex brown. The males, which

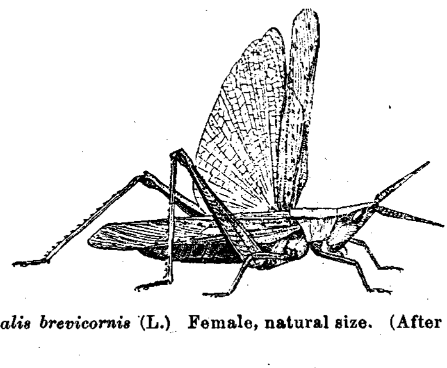


Fig. 43. *Tryxalis brevicornis* (L.) Female, natural size. (After Beutenmüller.)

are much smaller, usually have the dorsal surface, face and tibiæ of fore and middle legs, bright green, the remainder of the body dark brown. Inner wings transparent, with the veins greenish. The structural characters are given above under the generic heading.

Measurements: Length of body, male, 20 mm., female, 33 mm.; of antennæ, male, 10 mm., female, 11 mm.; of pronotum, male, 4.5 mm., female, 6.5 mm.; of tegmina, male, 20 mm., female, 31 mm.; of hind femora, male, 14 mm., female, 20 mm.

This curious long headed locust occurs in suitable localities throughout Indiana, though Scudder in his catalogue gives its range as the "southern United States." It has been taken both in Steuben and Lake counties, in the extreme northeastern and northwestern corners of the State, as well as in nearly every other county where collections have been made. Walker has recently taken a few specimens near Point Pelee, Ontario. It is found only in the tall grasses and sedges along the margins of lakes, ponds, streams and swales, and in such localities is usually locally abundant. It reaches maturity in central Indiana about July 20, and in the northern part of the State a fortnight later. The hind legs are very slender as the insect seldom leaps when disturbed, but uses the wings in strong, zig-zag, noiseless flight, usually alighting on a stem of grass or sedge a dozen rods away. Frank Hay, living on the north shore of Bass Lake, Starke County, reports a flight of this species after dark on the evening of August 13, 1901. Large numbers flew onto the porch and against the house and many were captured and used for fish bait.

XVIII. Syrbula Stal (1873).

Head nearly as long as the pronotum, the occiput moderately rounded and distinctly ascending. Vertex sub-triangular, the front margin sub-acuminate, the sides rather prominent, the median carina distinct. Lateral foveolæ very small or wanting; when present, invisible from above. Antennæ flattened at the base and acuminate in both sexes; expanded apically in the male. Pronotum with the three carinæ distinct; the lateral gently or strongly sinuate, so that the disk is plainly narrower in the middle; all the carinæ cut by one sulcus a little behind the middle. The lateral lobes of pronotum about as high as long, their front and hind margins moderately oblique, the latter a little sinuate; the lower margin more or less undulate. Tegmina and wings well developed, exceeding the abdomen in both sexes. Hind femora unusually long and slender, surpassing the tips of the tegmina in our species. Hind tibiæ armed on the outer margin with 19 to 21 rather small spines. Last ventral segment of male acutely conical. Three species are known from the United States. Of these, one occurs in Indiana.

30. Syrbula admirabilis (Uhler). The Handsome Locust.

Stenobothrus admirabilis Uhl., **212**, II, 1864, 553; Glov., **62**, 1872, Plate IV, Fig. 13; Thom., **206**, V, 1873, 84.

Syrbula admirabilis Thom., **211**, IX, 1880, 100; Bl., **4**, XXIII, 1891, 76; McN., **89**, VI, 1897, 222; Scudd., **188**, 1900, 19.

Syrbula leucocerca Stal., **200**, I, 1873, 102.

Male much smaller and more slender than the female; its general color olive brown and yellowish. Face yellowish, the corners of the mouth pitch brown. Antennæ with basal two-thirds yellowish, the apical club-shaped portion black on one side and pale on the other. A narrow line running obliquely backward from each eye to the pronotum and the lower third of lateral lobe of pronotum, yellowish. Tegmina brownish, the disk more or less dusky near the base. Hind femora yellowish with two or three oblique dusky bars on the upper outer face, apex black; hind tibiæ pale, the spines tipped with black.

Female: Face and sides of the head green; antennæ pale at base, the apical half dusky. A pale reddish brown stripe extends from the tip of vertex backward to the hind margin of the pronotum; this bordered on each side by a black stripe which is much narrower on the head. Sides of the pronotum green with a fuscous bar across the middle. Tegmina smoky brown, the dorsal and anal fields each with a bright green stripe; the latter notched above by the serrations of a fuscous stripe, which lies between the two green areas; the wings, smoky brown, tinged with greenish yellow at the base. Hind femora with the upper lateral carina whitish; the upper outer face green, the lower, reddish brown; hind tibiæ as in male. The ground color of the female is rarely brown, and that of the male rarely green. The structural characters are given above under the genus heading.

Measurements: Length of body, male, 22 mm., female, 35 mm.; antennæ,male, 9.5 mm., female, 10 mm.; of pronotum, male, 4.5 mm., female, 6 mm.; of tegmina, male, 18 mm., female, 27 mm.; of hind femora, male, 17.5 mm., female, 24 mm.

This prettily colored locust is nowhere common in Indiana, and as yet has been taken only in the southern half of the State, in Vigo, Putnam, Marion, Monroe, Crawford, Floyd, Knox and Posey counties. It frequents, for the most part, high, open uplands, where the soil is poor and covered with scant vegetation, though it is sometimes found in timothy meadows and along roadsides where the grass has been cropped short. But few individuals have been noted in any one locality. It reaches maturity about August 1. The males differ so much in size and color from the other sex that they are very apt to be considered a distinct species. As the slender legs indicate, the movements are made mostly by the wings, the flight being rapid and noiseless. The range of *admirabilis* is given by McNeill as "United States east of the Rocky Mountains, extending as far north as Nebraska and northern Illinois, and on the Atlantic coast to Maryland."

XIX. DICROMORPHA Morse (1896).

Vertex much shorter than broad; the lateral carinæ distinct, elevated, and meeting in front in a blunt point; median carina and lateral foveolæ wholly wanting. Antennæ about the length of the head and pronotum together, the joints moderately flattened. Disk of the pronotum flat, the carinæ distinct, straight and parallel, all cut behind the middle by the principal sulcus. Lateral lobes of the pronotum perpendicular, longer than deep, the front and hind margins strongly oblique; the latter plainly sinuate; the lower margin more strongly sinuate. Tegmina usually more or less aborted, rarely reaching the end of abdomen. Hind femora stout and not banded. Two species are known from the United States, one of which occurs in Indiana.

31. DICROMORPHA VIRIDIS (Scudder). The Short-winged Green Locust.

Chlœaltis viridis Scudd., 141, VII, 1862, 455; Glov., 62, 1872, Plate VI, Fig 11; Plate X, Fig. 5; Thom., 211, IX, 1880, 92, 99; Fern., 53, 1888, 36; McN., 88, VI, 1891, 64; Beut., 3, VI, 1894, 292, Plate VII, Fig. 10.

Chrysochraon viridis Thom., 206, V, 1873, 75; Bl., 4, XXIII, 1891, 75; Id., 11, XXVI, 1894, 221.

Dicromorpha viridis Morse 98, VII, 1896, 326, 383, Plate 7, Figs. 7, 7a; McN., 89, VI, 1897, 231; Lugg., 84, 1898, 124, Fig. 71; Bl., 16, 1899, 241, Fig. 67; Scudd., 188, 1900, 25.

Chlœaltis punctulata Scudd., 141, VII, 1862, 455; Fern., 53, 1888, 36.

Chrysochraon punctulata Thom., 206, V, 1873, 76.

Opsomala brevipennis Thom., 202, V, 1865, 451.

Truxalis angusticornis Stal., 200, I, 1873, 105.

Color of male dull brown, the top of head, disk of pronotum and dorsal field of tegmina usually bright green, rarely brown; face pale yellowish brown. Female, either bright green or dirty brown; often with a narrow dark line beginning behind the eye and running along the upper portion of lateral lobe of pronotum. Tegmina ovate lanceolate, about half the length of abdomen in the female, three-fourths its length in the male. Hind femora reaching tip of abdomen in the female, exceeding abdomen one-third their length in male. Very rarely the tegmina reach to or beyond the tip of abdomen; this form having been described as *punctulata*.

Measurements: Length of body, male, 16 mm., female 27; of antennæ, male and female, 8.5 mm.; of pronotum, male, 4 mm., female, 6 mm.; of tegmina, male, 8.5 mm., female, 9 mm.; of hind femora, male, 11.5 mm., female, 15 mm.

This is a common locust throughout the State, frequenting the fence rows, roadsides, and especially the borders of open woods, which grow along the margins of lakes, vicinity of the coarse grasses There, as long as mo- ponds and other wet places. T... ere they flourish tionless, they are invisible, and th... outhern Indi- in peace and countless numbers. In s... t, and the ana *D. viridis* reaches maturity by July 1... il after sexes may be found mating from then unt... the heavy frost. The brown female far outnumbers the green one in this State, especially during the autumn days, when their hues correspond so closely to the dead leaves which cover their haunts of the summer months. The green backed males are, however, the prevailing form of that sex at all seasons. The long winged form has not, as yet, been taken in Indiana. The wings of the other form are too short for flight, and it tries to escape when disturbed only by leaping clumsily.

Fig. 44. *Dicromorpha viridis* (Scudd.). Female, one and one-half times natural size. (After Lugger.)

When the late spring and early summer have been more than usually damp, hundreds of dead and dying specimens of this species and of *Melanoplus bivittatus* Say, are often to be seen in late July in the tops of iron weeds. They are principally females, and their death is probably due to the insect fungus, *Entomophthora calopteni* Bessey; an interesting account of which appeared in Bull. 22, U. S. Dept. Agr., 1890, 104. The disease is, perhaps, more abundant on account of the young being exposed to so much dampness in May and June. In two instances females of the lubberly locust, *Melanoplus differentialis* Thos., have been discovered feeding upon the dead bodies of *D. viridis*, the abdomen and soft portions of thorax having been wholly devoured.

XX. Orphulella Giglio-Tos. (1894).

Vertex nearly horizontal, never extending in front of the eyes a distance greater than its own width. Median carina, if present, very faint. Lateral foveola usually present on side margins of vertex, but small and not visible from above. Antennæ filiform, sometimes depressed and acuminate. Pronotum with the median carina sharp; cut in or behind the middle; the lateral carinæ generally diverging both before and behind the middle, so that the center of disk is noticeably narrower than the front and hind margins. Lateral lobes of pronotum no longer than broad, the front border decidedly oblique, and nearly straight; the hind border less oblique and more or less sinuate; the lower margin plainly angulate near the middle. Tegmina and wings well developed, a little shorter or much longer than the abdomen; the former very narrow, the intercalary vein wanting. Hind femora of medium size.

Twelve species are known from the United States, two of which have been taken in Indiana. These may be separated as follows:

KEY TO INDIANA SPECIES OF ORPHULELLA.

a. Vertex of head rectangular in female; a little acute in the male. Foveolæ distinct, narrowly triangular. Lateral carinæ of pronotum strongly incurved, the distance between them at hind margin much greater than at front margin. Prozona and metazona about equal. Tegmina passing hind femora....................30 *pelidna*, p. 240

aa. Vertex of head blunt, rounded, obtuse in female, rectangular in male; foveolæ indistinct. Lateral carinæ of pronotum less incurved, the distance between them at hind margin being but little greater than at front margin. Prozona longer than metazona. Tegmina rarely exceeding the abdomen........................31 *speciosa*, p. 242

32. ORPHULELLA PELIDNA (Burmeister). The Smaller Spotted-winged Locust.

Gomphocerus pelidnus Burm., **40**, II, 1838, 650.

Stenobothrus pelidnus Thom., **206**, V, 1873, 95; Morse, **98**, VII, 1894, 104.

Orphula pelidna McN., **89**, VI, 1897, 234, 235; Bl., **15**, XXX, 1898, 54; Lugg., **84**, 1898, 125, Fig. 72.

Orphulella pelidna Scudd., **185**, XXXI, 1899, 179, 187; Id., **188**, 1900, 24.

Stenobothrus maculipennis Scudd., **141**, VII, 1852, 458; Glov., **62**, 1872, Plate V, Fig. 14; Thom., **206**, V, 1873, 87; Id., **211**, IX, 1880, 88, 102, Figs. 12, 16; Riley, **122**, II, 1884, 202, Fig. 282; Lint., **82**, II, 1885, 196, Fig. 58; Fern., **53**, 1888, 37, Fig. 14; Morse, **92**, VI, 1893, 478, Figs. 3, 4; Beut., **3**, VI, 1894, 293, Fig. 7, Plate VIII, Fig. 4.

Orphula maculipennis Morse, **98**. VII, 1896, 326, 408, Plate 7, Figs. 8, 8a.

Stenobothrus propinquans Scudd, **141** VII, 1862, 461; Thom., **206**, V, 1873, 90.

Vertex with the margin distinctly raised above the disk; the median carina absent; its central depression removed from the apex one-third to one-fourth the width of the vertex. Antennæ but little depressed, slightly longer than head and pronotum, the middle joints three to four times as long as wide. Median carina of pronotum cut very near the middle by the principal sulcus. In the male the hind femora extend about 2 mm. beyond the end of the abdomen, and are slightly exceeded by the tegmina. In the female, both hind femora and tegmina are about equal, and exceed the abdomen less than in the male. Other structural characters are given in the key.

Color: Head and disk of pronotum either brown or green. A broad reddish brown or black band behind the eye reaches back to hind margin of pronotum; this limited above by the lateral carinæ of pronotum, which are whitish, but partially crossing the carinæ onto the posterior third of disk. Sides of pronotum below the band brownish. Tegmina either brown or green, with a median band of equidistant square black spots along their full length; in addition a few black spots below the median band. Abdomen reddish brown, the sides spotted with black. Hind femora brownish red, with traces of fuscous cross bars; hind tibiæ pale brown, annulate with whitish near the base.

Fig. 45. *Orphulella pelidna* (Burm.). Female, one and one-half times natural size. (After Lugger.)

Measurements: Length of body, male, 17 mm., female, 21 mm.; of antennæ, male and female, 7.5 mm.; of tegmina, male, 16 mm., female, 18 mm.; of hind femora, male, 10 mm., female, 12 mm.

Although this small spotted locust is said to occur in abundance in the United States east of the Rocky Mountains, I have met with it but once in Indiana during 15 years' collecting. This was July 27, 1897, when I found it in abundance about the margins of a small lake in one of the valleys among the sand dunes near Millers, Lake County.

It uses both the wings and legs in flight, and when close pressed often burrows into the fallen grass in an attempt to escape detection. Of 21 specimens taken, but three were females, and they were of the green variety. Five of the males were also partly green, the remainder being brown and fuscous. Morse states that in New England this species "begins to appear about the middle of July, being a week or two later than *speciosa*, and may be found during the remainder of the season. It is an active and alert species, leaping well and also flying freely and well, sometimes for two or three rods. It is found on the drier portions of the land adjoining salt marshes, on the more densely grassed portions of ground just inshore of the sandy beaches, and on sandy or loamy soil farther inland." It will probably be found to occur in isolated localities throughout northern Indiana.

33. ORPHULELLA SPECIOSA (Scudder).

Stenobothrus speciosus Scudd., 141, VII, 1862, 458; Thom., 206, V, 1873, 87.

Orphula speciosa McN., 89, VI, 1897, 235, 240, Plate 4, Fig. 17c; Lugg, 84, 1898, 126, Figs. 73, 74.

Orphulella speciosa Scudd., 185, XXXI, 1899, 178, 183; Id., 188, 1900, 24.

Stenobothrus æqualis Scudd., 141, VII, 1862, 459; Thom., 206, V, 1873, 89; Lint., 82, II, 1885, 196; Morse, 92, VI, 1893, 478, Figs. 5, 6; Beut., 3, VI, 1894, 294, Fig. 9.

Orphula æqualis Morse, 98, VII, 1896, 326, 409, Plate 7, Figs. 9, 9a; Brun., 34, 1897, 128, Fig. 28.

Stenobothrus bilineatus Scudd., 141, VII, 1862, 460; Thom., 206, V, 1873, 90.

Stenobothrus gracilis Scudd., 147, 1872, 250; Thom., 206, V, 1873, 94.

Vertex broader and blunter than in *pelidna;* the margins scarcely raised above the disk; a faint median carina on its front half; the central depression close to apex. Antennæ about as long as the head and pronotum, plainly flattened, the middle segments about twice as long as broad. Median carina of pronotum cut a little behind the middle by the principal sulcus. Tegmina reaching tip of abdomen in the female and tip of hind femora in the male; often shorter.

Color: Either green or brown, much as in *pelidna,* but the median row of spots on tegmina smaller and fewer in number, and sometimes wanting. The dark bar behind the eye is more faint than in that species, and seldom crosses onto the basal third of pronotal disk. Hind femora greenish or brownish, not banded. Hind tibiæ, dull brown or yellowish, without paler ring near their base.

Measurements: Length of body, male, 14 mm., female, 18 mm.; of antennæ, male and female, 6 mm.; of tegmina, male, 12 mm., female, 13 mm.; of hind femora, male, 9 mm., female 11 mm.

This species is also known in Indiana only from Lake County, a single pair having been taken July 24, 1902, from the side of a railway a mile southeast of Hammond. It is liable to be found anywhere in the State as its range is given as "Nova Scotia to Texas." In northern Illinois McNeill found it confined to the tops and sides of hills. Morse has written of it as reaching maturity in New England the first week in July, and being "one of the most plentiful and widespread of our locusts, but owing to its small size and non-migratory habits it does not attract the attention given to the larger and consequently more destructive species. While somewhat local, it is found nearly everywhere on dry, sandy or loamy soils. It moves chiefly by leaping, but readily takes wing on occasion, flying, however, but a few feet. Active and alert in the hot sunny weather of midsummer, it can best be secured by sweeping the net rapidly over the ground, a dozen or more specimens being the result of a few minutes' work."

XXI. CHLŒALTIS Harris (1841).

Vertex triangular, the lateral carina but little elevated; the median carina more or less distinct; the foveolæ wholly wanting. Antennæ long, those of male twice, and of female one and a half times the length of head and pronotum together; the joints of basal half strongly flattened. Pronotum with the three carinæ equally distinct, and cut much behind the middle by the principal sulcus; the lateral carinæ more or less curved, especially in the female, so that the middle of disk is plainly narrowed. Lateral lobes of pronotum a little longer than high, the fore and hind margins straight and strongly and equally oblique, the lower margin with its posterior half nearly horizontal, its anterior half strongly ascending. Tegmina of female abortive (rarely fully developed), those of male well developed, the costal area being dilated and strongly reticulate. Hind femora of medium size; banded on the upper outer face. Ovipositor short, little exserted, the upper valves enlarged and strongly toothed at base. Two species represent the genus in the United States. Of these, one occurs in Indiana.

34. CHLŒALTIS CONSPERSA Harris. The Sprinkled Locust.

Locusta (Chlœaltis) conspersa Harr., 71, 1841, 149; Id., 72, 1862, 184.

Chlœaltis conspersa Smith, 198, I, 1868, 145; Glov., 62, 1872, Plate VI, Fig. 10, Plate X, Fig. 12; Scudd., 148, I, 1874, 370, Figs., 55, 56; Id., 168, XXIII, 1893, 75, Figs. 50, 51; Id., 180, VIII, 1897, 99; Id., 188, 1900, 25; Thom., 211, IX, 1880, 99; Fern., 53, 1888, 36; McN., 88, VI, 1891, 65; Id., 89, VI, 1897, 228, Plate III, Figs. 14, 14a; Bl., 11, XXVI, 1894, 222; Beut., 3, VI, 1894, 293, Plate VII, Fig. 9; Morse, 98, VII, 1896, 327, 419, Plate 7, Figs. 11, 11a; Lugg., 84, 1898, 121, Figs. 69, 70; Walk, 217, XXX, 1898, 124.

Chrysochraon conspersum Thom., 206, V, 1873, 76; Coms., 41, 1888, 102, Fig. 92; Id., 42, 1895, 111, Fig. 122; Bl., 4, XXIII, 1891, 75.

Locusta (Chlœaltis) abortiva Harr., 71, 1841, 149; Id., 72, 1862, 184.

Stenobothrus melanopleurus Scudd., 141, VII, 1862, 456. (Male.)

Color of male usually light-brown above with always a broad shining black bar covering the entire lateral lobe of pronotum; the tegmina without spots or with a few faint dusky ones; the hind tibiæ red or yellowish, the knees black. The female varies from dull clay yellow to dark brown, with the tegmina usually more or less sprinkled with small black spots, and with only traces of the dark bar on sides of pronotum.

Tegmina of female covering half of the abdomen, those of male reaching nearly to its tip; inner wings shorter. The ovipositor is

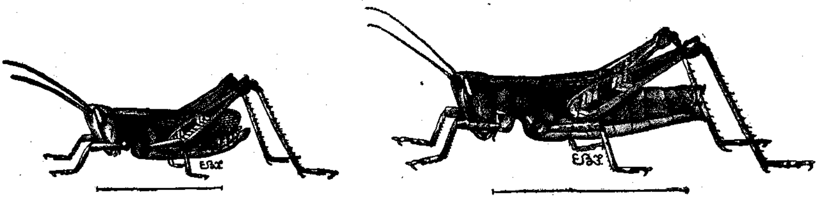


Fig. 46. *Chlœaltis conspersa* Harr. Male and female. One and one-half times natural size. (After Lugger.)

of peculiar structure, being fitted for boring in wood, its upper valves being short, broad and toothed like a saw on the posterior edge, while the lower ones bear a strong hooked tooth at the tip. For other structural characters see above under the genus heading.

Measurements: Length of body, male, 20 mm., female, 24 mm.; of antennæ, male and female, 11.5 mm.; of tegmina, male, 11 mm., female, 9 mm.; of hind femora, male, 13.5 mm., female, 16 mm.

This handsome wood brown locust occurs throughout Indiana, but nowhere in numbers. It makes its home in thickets, in the borders of open woods, in grassy plots alongside old rail fences, and oftentimes along the borders of streams in woodland pastures, but is seldom seen in damp localities. In such places its hues correspond so closely with those of the dead leaves, fallen grass stems and other surroundings that it is seldom the insect is noted until it leaps clumsily to one side. Mature males have been taken in Vigo County on June 19th, an early date for locusts which have hatched from the egg in spring. A single female with tegmina reaching slightly beyond tip of abdomen is in my collection from Vigo County. The ordinary short winged female is apt to be confused with the brown females of *Dicromorpha viridis*, but can be readily distinguished by the presence of the median carina of vertex, and the curved lateral carinæ of pronotum.

Interesting accounts of the egg-laying habits of the female of *conspersa* have been given by both Smith and Scudder. I have, on a number of occasions, noted the females with the abdomen inserted in soft or decaying wood, and on August 11, 1893, I discovered a female in the act of boring a hole in the upper edge of the topmost board of a six-plank fence. The abdomen was curved downward, and the toothed forcipate valves of the ovipositor used as pinchers with which small pieces of the wood were broken off. When discovered, the abdomen was inserted nearly one-half an inch in the pine board, and the upper edge of the opening about the sides of the abdomen was covered with small pieces of wood, just as the dust or borings will accumulate about the edge of a hole which a carpenter is boring.

I stood by and watched her work for ten or more minutes, when she suddenly stopped, withdrew her ovipositor and hopped away. Along the fence, within a distance of 30 feet, I found 15 other holes, 11 of which were fresh, while the others had evidently been bored the previous year. Most of these holes were on the upper edge of the top board, which was in all cases of pine and perfectly sound. None of the holes contained eggs, most of them being less than half an inch in depth.

On July 21st, and September 21st, I have found them with the abdomen inserted full length in stumps or logs, and when removed, eggs were found in the lower horizontal portion of each cavity. On the former date the female was ovipositing after dark in an oak log which served as part of a bridge across a stream. Smith has suggested that the reason for so few holes being finished is, that the wood proves too hard, and the insect tries for a softer place, or, many of them may be disturbed during the process of oviposition. Scudder says that "the wood must be firm enough to retain the eggs well in place, and soft enough to absorb much moisture in the spring. Upright pieces of timber are never chosen, but rather short sticks of decaying, charred or pithy wood, which can not easily be broken or blown against the rocks. Holes are frequently made three-quarters of an inch deep, and abandoned because the spot proves unsuitable. In a stick about a foot and a half long, and two or three inches wide, I counted 75 borings, only three or four of which had been used as nests. The number of imperfect to perfect holes must be as 25 to one. When a good piece of wood is discovered, the nests are crowded thickly together; and a stick less than two inches in diameter and five inches in length contained 13 completed nests. The holes are pierced at a slight angle to the perpendicular, away from the insect; they are straight for about a quarter of an inch, then turn abruptly and run horizontally along the grain for about an inch. The eggs (from 10 to 14 in number) are almost always laid in the horizontal portion of the nest; they are cylindrical, tapering toward the ends, but not at all pointed, and measure from five to five and a half millimeters in length, by one and one-eighth in breadth; the ends are equally and regularly rounded. They vary in tint, some being almost colorless, and others of a faint yellow. After the eggs have been carefully packed away in the sawdust made by the abrasion of the sides of the hole, they are covered above with a whitish froth, and the hole is sealed up just below the surface of the wood with a black glutinous secretion, excessively hard, smooth and shiny, and the upper surface slightly concave. In the spring the moisture doubtless softens these coverings so that the young grasshoppers can easily escape. Many old nests may be found uncovered and filled with the shells of the eggs, but none in which the cover is still retained."

XXII. Stenobothrus Fischer (1843).

Vertex triangular, obtuse in female, acute in male; the foveolæ visible from above, as narrow, oblong, or linear impressions; the median carina absent, or at most a colored line. Antennæ filiform; much longer than head and pronotum in the male. Pronotum with the median carina distinct, cut a little behind the middle by the principal sulcus; the lateral carinæ sinuate or curved, so that the middle of disk is narrower than the fore and hind margins. Lateral lobes of pronotum about as long as deep, the front margin straight, the hind and lower margins sinuate. Tegmina variable in length, usually fully developed in male. Wings a little shorter than tegmina. Hind femora rather slender; not transversely barred. Valves of ovipositor short, but plainly exserted.

This European genus formerly included a number of United States species, Thomas having described no less than 16 species (a number of them synonymous) under it in his Acrididæ of North America. As at present limited, but two are listed from the United States, one of which occurs in Indiana.

35. Stenobothrus curtipennis (Harris). The Short-winged Brown Locust.

Locusta (Chlœaltis) curtipennis Harr., 71, 1841, 49; Id., 72, 1862, 184, Plate III, Fig. 1; Rathv. 109, 1862, 386, Fig. 28.

Stenobothrus curtipennis Scudd., 141, VII, 1862, 456; Id., 142, II, 1868, 118; Id., 148, I, 1874, 372, Fig. 57; Id., 168, XXIII, 1893, 76, Fig. 52; Id., 180, VIII, 1897, 99; Id., 186, XXXV, 1899, 50; Id., 188, 1900, 26; Smith, 198, I, 1868, 147; Glov., 62, 1872, Plate VI, Fig. 15; Plate VII, Fig. 10; Plate X, Fig. 4; Plate XII, Fig. 18; Thom., 206, V, 1873, 91 (in part), Id., 211, IX, 1880, 104; Riley, 122, II, 1884, 202; Lint., 82, II, 1885, 196; Comst., 41, 1888, 102; Fern., 53, 1888, 37; McN., 88, VI, 1891, 65; Id., 89, VI, 1897, 260; Beut., 3, VI, 1894, 294; Morse, 98, VII, 1896, 327, 420 Plate 7, Fig. 12; Lugg., 84, 1898, 128, Figs. 75, 76.

Chlœaltis curtipennis Bl., 4, XXIII, 1891, 76; Id., 11, XXVI, 1894, 222.

Stenobothrus longipennis Scudd., 141, VII, 1862, 457; Glov., 62, 1872, Plate V, Fig. 15.

Color exceedingly variable, but in Indiana specimens usually a light brown above, with a black bar extending back from the eye along the upper half of the lateral lobe of pronotum; beneath yellowish, the sides of abdomen spotted with black and the hind knees of the same color. Sometimes the face and lower sides of pronotum are gray, or even green. Antennæ brownish yellow at base, the apical halves brown or black.

The tegmina of *curtipennis* are, in most females, about three-fourths the length of the abdomen, while in the males they usually reach to the tip of the abdomen; though they may be longer or shorter in either sex. The males are apt to be mistaken for those of *Chlœaltis conspersa*, but may be distinguished by the presence of the foveolæ, by the narrower black bar on sides of pronotum and by the smaller and more slender body.

Measurements: Length of body, male, 14.5 mm., female, 21 mm.; of antennæ, male, 9.5 mm., female, 7.5 mm.; of tegmina, male, 11 mm., female, 10 mm.; of hind femora, male, 11 mm., female, 13 mm.

This is a very common locust throughout northern Indiana, but as yet has not been taken south of Putnam and Vigo counties. It abides in low, wet prairies, swales, damp meadows, and especially in the vicinity of tamarack swamps. These conditions of local habitat are common in the northern half of the State, but scarce or wanting in the southern half, except in the extensive lowlands along the Wabash River in Knox and Gibson counties, but there the locust seems to be wanting. In Putnam County it occurs in blue-grass pastures along the banks of streams in open woodland. It begins to reach maturity about June 20th. By July 1st, it has become fairly common, and it may be taken until mid-October or even later, if the frosts are not too severe. The males seem everywhere less abundant than the females. The former is an active and noiseless flier, but the female, being usually shorter winged, endeavors to escape by leaping and tumbling, and, says McNeill, "its astonishing facility as a tumbler and contortionist generally discourages all but the most determined efforts for its capture." Scudder has given a description of the song habits of *curtipennis* as follows: "When about to stridulate, these insects place themselves in a nearly horizontal position, with the head a little elevated; they then raise both hind legs together, the hind tibiæ bent back snugly against the femora during the movement, and grate the thighs against the outer surface of the tegmina. The first one or two movements are frequently noiseless or faint. In sunny weather the notes are produced at the rate of about six a second, are continued from one and a half to two and a half seconds, and when undisturbed are repeated with intermissions of from five to six seconds. When the sky is overcast the movements are less rapid."

XXIII. Ageneotettix McNeill (1897).

Vertex, somewhat declivent, the sides sharp and meeting in front almost at a right angle; the median carina wanting; lateral foveolæ rectangular or four sided, about twice as long as broad, very distinct. Face moderately oblique. Antennæ filiform, longer than head and pronotum together. Pronotum with the median carina distinct, cut once behind the middle by the principal sulcus; the lateral carinæ indistinct; strongly sinuate or curved inward; the hind margin of disk broadly rounded. Lateral lobes of pronotum higher than long, their front and hind margins nearly straight and vertical, the lower margin with its front half inclined strongly upward. Tegmina and wings well developed, equaling the abdomen in the female, usually slightly surpassing its tip in the male. Hind femora rather stout, surpassing the tip of abdomen in the male, equaling it in the female. Hind tibiæ with the spurs on the inner side at apex, much elongated and very unequal. Valves of ovipositor but little exserted, the tip only being visible. Two species are known from the United States, one of which has been taken in Indiana.

36. Ageneotettix scudderi (Bruner).

Aulocara scudderi Brun., **24**, XII, 1890, 63; Bl., **11**, XXVI, 1894, 217.
Eremnus scudderi McN., **89**, VI, 1897, 268; Lugg., **84**, 1898, 132, Fig. 77.
Ageneotettix scudderi Scudd., **188**, 1900, 28.
Philobostroma parva McN., **88**, VI, 1891, 64.

General color, dull brown, the tegmina with numerous small darker brown, quadrate spots, sometimes almost confined to a median band. In most specimens a dull yellowish band reaches from the vertex backward across the middle of occiput and pronotum to the tips of the tegmina. An indistinct blackish bar extends from eye back across the upper half of lateral lobes of pronotum; and a triangular spot of black on each side of basal third of pronotal disk, plainest in the male. Hind femora dull reddish brown with three blackish cross-bars on the upper outer face. Hind tibiæ bright coral red, with a whitish basal ring; the knees deep black. Antennæ dull reddish, sometimes lighter. Lower surface, dirty yellowish white.

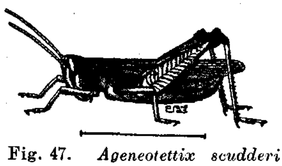


Fig. 47. *Ageneotettix scudderi* (Bruner). Male. (After Lugger.)

Measurements: Length of body, male, 15 mm., female, 20 mm.; of antennæ, male 10 mm., female, 7.5 mm.; of tegmina, male, 9 mm., female, 13 mm.; of hind femora, male, 10.5 mm., female, 11.5 mm.

This small dull colored locust has been taken in Indiana only from the sandy bed of the old Wabash and Erie Canal, five miles north of Terre Haute, Vigo County. Here it was first taken on July 6, 1892, and afterward in September and October, 1893. On one side of the canal, at the point mentioned, is a large pond, occupying perhaps 50 acres of the Wabash River bottoms, and on the other side is a sandy hill or bluff of the river, which is covered with typical prairie grasses and plants. The locust has been found only in an area of about five acres, on the side of the hill, and in the bed of the canal. When disturbed it leaps vigorously, and without noise, for several times in succession; then settling down on a sandy spot, it will allow a close approach, evidently relying upon the similarity of color between its body and the sand to shield it from observation. According to Bruner, *loc. cit.*, it is a very common species west of the Mississippi; but east of that stream has been taken only at Moline and Cordova, Illinois; and in Vigo County, this State. It will probably be found to occur over the sand-covered portions of southwestern Indiana.

XXIV. Mecostethus Fieber (1853).

Vertex horizontal; the lateral carinæ distinct, straight, the apex truncate or slightly rounded; median carina distinct; lateral foveolæ small, shallow, triangular. Antennæ filiform, longer in the male than the head and pronotum together. Pronotum with all the carinæ distinct, the median rather sharp, and cut in front of the middle by the principal sulcus; the lateral (in our species) with their posterior halves distinctly divergent; the disk rugose, the metazona longer than the prozona; the hind margin of the former obtusely angled. Lateral lobes of pronotum about as high as long, their front margins perpendicular, the hind ones a little oblique, the lower margin with its front half oblique. Tegmina and wings well developed, surpassing the abdomen in both sexes, the discoidal area furnished with a very prominent intercalary vein, which in the male is provided with a rasp for stridulating. Hind femora, rather long and slender, exceeding the abdomen in the male. The sub-anal plate of male is acutely produced, being at least twice as long as its greatest depth. Valves of ovipositor strongly exserted, the upper pair, with minute teeth along their upper margins.

Three species are known from the United States, one of which occurs in Indiana.

37. Mecostethus lineatus (Scudder).

Arcyptera lineata Scudd., 141, VII, 1862, 462; Id., 142, II, 1868, 118 (song of); Id., 143, XI, 1868, 313 (note of, set to music); Smith, 119, 1872, 381; McN., 88, VI, 1891, 66.

Stetheophyma lineata Thom., 206, V, 1873, 98; Id., 211, 1880, 104; Glov., 62, 1874, Plate XVIII, Fig. 9; Fern., 53, 1888, 38.

Mecostethus lineatus Morse, 98, VII, 1896, 327, 444, Figs. 13–13b; McN., 89, 1897, 254, Figs. 22a, 22b; Bl., 15, XXX, 1898, 55; Scudd., 188, 1900, 29.

General color, dark brown. A narrow yellowish line extends from the upper border of the eye to the pronotum, bordered below by an indistinct dark band which extends along the upper half of lateral

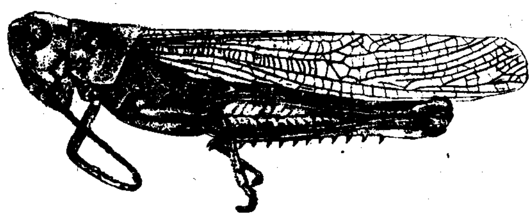


Fig. 48. *Mecostethus lineatus* (Scudd.). (After McNeill.)

lobes of the pronotum. The tegmina with a distinct pale or yellowish streak two-thirds their length, along the scapular area. Hind femora with the outer face yellowish or reddish brown, darker above, the lower face either yellowish or bright coral red, the knees black. Hind tibiæ yellowish, annulate with paler near their base, the spines black. The females usually much darker than the males with the yellow line on head and tegmina often obscure. The structural characters are given above under the genus heading.

Measurements: Length of body, male, 26 mm., female, 35 mm.; of antennæ, male, 11.5 mm., female, 10.5 mm.; of tegmina, male, 25 mm., female, 30 mm.; of hind femora, male, 17 mm., female, 20 mm.

This large and handsome locust occurs in isolated areas in the northern third of the State, having been taken in Fulton, Lake, Starke, Marshall, Kosciusko and Steuben counties. It is found only in low boggy meadows bordering lakes or tamarack swamps. The males seem to far outnumber the females, and are much more wild and active, taking to flight when a person is a dozen yards distant. They use the wings only in escaping, flying swiftly and noiselessly for 50 to 100 feet and alighting on the stems of the tall grasses and sedges among which they have their homes. The only way in which I have been able to effect their capture was by running after them and swooping them with the net as they arose or before they had time to arrange their legs for the upward impetus at the beginning of a new flight. The females are more bulky and lubberly than the males, and are usually seen in more open places, where the grass is shorter, and hence are more easily taken. The earliest date at which mature specimens have been seen was July 13th, in Fulton County, and the latest, October 25th, near Bass Lake, Starke County, though they may occur both before and after these dates. In the United States *lineatus* has been recorded only from Maine, Massachusetts, Connecticut, northern Illinois and eastern Nebraska.

Sub-family ŒDIPODINÆ.

This sub-family includes those genera of Indiana locusts which have the prosternum unarmed with tubercle or spine, the face nearly vertical, instead of oblique, and the head rounded at the point of union with the vertex and face. The fastigium or front of vertex slopes sharply downward; the foveolæ are present but are usually small and shallow. The antennæ are linear or sub-linear and are usually inserted above the middle of the eyes, sometimes almost above the eyes themselves. The eyes are shorter than in the sub-family *Tryxalinæ*, being rarely longer than that portion of the cheeks below their orbits. The dorsal field of the pronotum has its hind margin much wider than the front margin; the lateral carinæ usually wanting; the median carina (except in the genus *Arphia*) cut by one or two sulci, and often raised in a sharp ridge or crest, and the surface generally wrinkled or covered with small tubercles. The tegmina and wings are always fully developed and the latter, in most species, are brightly colored. All of our genera belong to the division or tribe *Œdipodini* of Saussure, in which the ocelli are placed near the eyes and in which the outer margin of hind tibiæ lacks an apical spine next the spurs.

Our members of this sub-family are, when at rest with the tegmina closed, dull brown or grayish in color, and hence dwell, for the most part on bare clayey slopes, or stretches of sand; along roadsides and railways, or in closely cropped timothy meadows. Twelve of our 16 species have the inner wings black, yellow or red and hence are very conspicuous objects when in flight, being often taken for butterflies by persons who have given little attention to nature. These bright colors, are, says Morse, "in no sense protective and bear no relation to the environment of the insects, but are probably of value in the mating of the sexes." The color of the inner wings often varies much in the same species, shading from dull white, through yellow and orange to vermilion red. The greater intensity of color is in part due to age, and perhaps in part to higher temperature, though other factors doubtless enter into its cause.

The members of this sub-family are peculiar in that the males of most of them and the females of a few stridulate while on the wing; a rather harsh, crackling or rattling note being produced by rubbing the under surface of the tegmina against certain veins on the upper surface of the inner wings. The sound seems to be under control of the insect, for they often make it when suddenly alarmed, or cease making it if too greatly frightened. Some of them produce a uniform rattling note during the entire period of flight, which is generally in a straight course. Others make the call only during certain intervals of flight. These change the direction of flight at will, and at every turn emit two or three short, rattling sounds. A number of species also sound a different call when at rest, in the same manner as do the *Tryxalinæ*, by rubbing the hind femora against the intercalary vein of the tegmina, which is toothed or roughened to aid as a sounding organ.

This sub-family is also notable among our Indiana Acrididæ by having three or four species which pass the winter as nymphs or half grown young. These nymphs reach maturity about mid-April and are the first Acridians of large size to be seen in the spring. The majority of our species, however, pass the winter, as do most other locusts, in the egg stage.

Twenty-six genera and 154 species were listed by Scudder in his "Catalogue," and about 40 species have since been described. Of these, ten genera and sixteen species have been taken in Indiana. These genera may be separated by the following table in which, however, I have made use of many characters not of generic importance, in order that the beginner may the more readily determine the specimens in hand.

KEY TO GENERA OF INDIANA ŒDIPODINÆ.

a. Median carina of pronotum raised in a distinct crest, which is entire, or not cut by the principal sulcus; tegmina sub-coriaceous, or leathery, in texture, densely and irregularly reticulate; inner wings brightly colored, red or yellow at base.......XXV. ARPHIA, p. 254

aa. Median carina of pronotum less prominent and in female always cut by one or more sulci; tegmina with the apical half membranaceous and regularly reticulate.

b. Median carina of pronotum cut by but one sulcus.

c. Disk of inner wings pellucid or transparent, not distinctly bounded by a blackish border.

d. Pronotum with its disk roof shaped, the sides sloping downward; its dorsal front margin plainly angulate. Hind femora without dark cross bars....... XXVI. CHORTOPHAGA, p. 257

dd. Pronotum with its disk flat; its dorsal front margin truncate. Hind femora with dusky cross bars on their outer face.

e. Frontal costa of male strongly sulcate throughout their full length; median carina of pronotum distinct, higher on prozona than on metazona, distinctly cut by the principal sulcus..........XXVII. ENCOPTOLOPHUS, p. 260

ee. Frontal costa of male but slightly sulcate just below the ocellus; median carina of pronotum low, of equal height throughout, faintly cut by principal sulcus....XXVIII. CAMNULA, p. 261

cc. Disk of inner wings opaque, red, orange, black or yellow in color; when not black, distinctly bounded with a blackish border.

f. Body, especially that of female, robust. Pronotum with the lateral carinæ extending in front of the principal sulcus and not cut by that sulcus; its disk often with numerous tubercles; inner wings red or yellow; tegmina usually with a number of large dark colored spots...... XXIX. HIPPISCUS, p. 263

ff. Body more slender, often compressed. Pronotum with the lateral carinæ extending only to the principal sulcus and cut by it; its disk with but few if any tubercles; inner wings black or pale yellow; tegmina with numerous small dark spots which are sometimes united into cross bars.

g. Inner wings black with a yellow border......XXX. DISSOSTEIRA, p. 272

gg. Inner wings yellow, with a fuscous curved median band.............. XXXI. SPHARAGEMON, p. 275

bb. Median carina of pronotum cut by two sulci, the front notch often less distinct than the hind one...................

h. Antennæ of male shorter than hind femora, the basal joints not strongly flattened. Frontal costa at all points above the ocellus, wider than the basal joints of antennæ.

i. Lower margin of lateral lobe of pronotum straight, its front half not curved upward. Median carina of pronotum about as high on metazona as on prozona; its hind notch but little in front of the middle of pronotum.....XXXII. MESTOBREGMA, p. 279

ii. Lower margin of lateral lobe of pronotum with its front half curved upward. Median carina of pronotum very faint on metazona; its hind notch much in front of the middle, the metazona at least one and a half times as long as the prozona........ XXXIII. TRIMEROTROPIS, p. 280

hh. Antennæ of male longer than hind femora, the basal joints strongly flattened. Frontal costa at its widest point above the ocellus narrower, and at the vertex much narrower, than the basal joints of antennæ................ XXXIV. PSINIDIA, p. 283

XXV. ARPHIA Stal (1873).

Vertex horizontal, either sub-pentagonal or triangular, its disk with a distinct, usually deep, transverse curved impression a little behind the middle; lateral carinæ distinct; the median carina present, but terminating at the impression; the foveolæ present, rather large, but shallow and more or less rhomboidal. Frontal costa rather broad, strongly sulcate in the region of and below the ocellus. Antennæ about as long as head and pronotum together. Pronotum with its front margin bluntly angulate, produced forward upon the posterior third of occiput; the median carina compressed, and higher than usual, not notched by the transverse sulcus; the lateral carinæ rounded, distinct only on the metazona. Lateral lobe of pronotum deeper than long, the front margin a little sinuate, the hind margin more or less oblique, the lower margin with its front half curved upward, the posterior angle rather broadly rounded. Tegmina somewhat leathery in texture, densely and irregularly reticulate, the apical third only with the cells, or spaces between the venules, distinct; the intercalary vein closer to the median than to the ulnar vein. Inner wings brightly colored, yellow or red at base. Hind femora stout, their basal halves depressed and dilated. Ovipositor with its valves moderately exserted; the upper ones with their apical halves a little inturned and narrowly spoon-shaped.

Sixteen species are accredited by Scudder to the United States. Of these but two have, as yet, been taken in Indiana. These may be separated by the following:

KEY TO INDIANA SPECIES OF ARPHIA.

a. Upper third of frontal costa with the sides converging, meeting at the point of union with the front of vertex; median carina of pronotum lower and less curved; hind margin of pronotum ending in a right angle, or obtuse angle .... 38 *sulphurea*, p. 255

aa. Upper third of frontal costa with the sides scarcely converging; distinct at the point of meeting with the front of vertex; median carina of pronotum, viewed from the side, high and arched, crest-like; hind margin of pronotum ending in an acute angle. .... 39 *xanthoptera*, p. 256

38. ARPHIA SULPHUREA (Fabricius). The Sulphur-winged Locust.

Gryllus sulphureus Fab., 51, I, 1781, 369.

Locusta sulphurea Harr., 70, 1833, 583; Id., 72, 1862, 177, Plate I, Fig. 6; Emm., 49, V, 1854, 146; Rathv., 109, 1862, 386, Fig. 27.

Œdipoda sulphurea Burm., 40, II, 1838, 643; Scudd., 141, VII, 1862, 470; Glov., 62, 1872, Plate V, Fig. 6.

Tomonotus sulphureus Thom., 206, V, 1873, 105; Id., 211, IX, 1880, 89, 107.

Arphia sulphurea Stal., 200, I, 1873, 119; Sauss., 134, 1884, 71; Fern., 53, 1888, 39; Bl., 4, XXIII, 1891, 77; Beut., 3, VI, 1894, 296, Plate VIII, Fig. 10; Morse, 99, VIII, 1897, 36, 51, Plate 2, Fig. 17; Lugg., 84, 1898, 136, Figs. 78, 79; Scudd., 188, 1900, 30.

Color, varying from dark brown, almost blackish in some males, to pale yellowish brown. The tegmina of males often with a pale yellowish band along the dorsal or hind margin; those of the lighter colored females often thickly sprinkled with small fuscous spots. Inner wings with their basal two-thirds a bright sulphur yellow. A dusky curved band covers the outer third; from which a distinct dark ray runs nearly to the base of the wing, near the front or costal margin. Hind femora with the outer face either uniform dark brown with a pale ring near the knee, or with alternating bands of black and white, which are more plainly visible on the inner face. Hind tibiæ dusky black, or blue black, with a pale ring near the base. Abdomen reddish brown or yellowish. Many of the young and a few of the adults which appear in spring, or those which live on high, rocky woodland slopes where lichens are abundant, often have the pronotum and hind femora prettily marked or spotted with grayish and greenish in imitation of those lowly plants.

Measurements: Length of body, male 22 mm., female 32 mm.; of antennæ, male and female, 7 mm.; of tegmina, male 23 mm., female 26 mm.; of hind femora, male 14.5 mm.; female, 18 mm.

The yellow winged locust is a common insect throughout Indiana, making its home in dry upland pastures and meadows, along roadsides and on gravelly and rocky slopes. It passes the winter in the nymph stage sheltered beneath logs, chunks and rubbish and begins to reach maturity in central Indiana about May 1st (May 3d being the earliest date it has come to my notice), being preceded only by *Chortophaga viridifasciata.* It is most abundant in June, and about July 15th begins to be replaced by its congener, *A. xanthoptera.* However, examples have been taken in Marion County as late as September 10th. The male, when disturbed, moves in short, jerky flights, sounding its cymbals while in the air, at every turn. The sound is a sharp crackling note, and is seemingly under the control of the insect.

39. ARPHIA XANTHOPTERA (Germar.)

Œdipoda xanthoptera Germ., **58**, II, 1838, 643; Scudd., **141**, VII, 1862, 469; Smith, **199**, 1872, 372, 381, Fig. 10.

Tomonotus xanthopterus Thom., **206**, V, 1873, 105.

Tomonotus sulphureus xanthopterus Thom., **211**, IX, 1880, 107.

Arphia xanthoptera Sauss., **134**, 1884, 67; Fern., **53**, 1888, 39; Bl., **4**, XXIII, 1891, 77; Beut., **3**, VI, 1894, 297, Plate VIII, Fig. 11; Morse, **99**, VIII, 1897, 36, 50, Plate 2, Figs. 16, 16a; Lugg., **84**, 1898, 138, Fig. 80; Scudd., **188**, 1900, 31.

Arphia xanthoptera carinata Bl., **4**, XXIII, 1891, 78 (not *A. carinata* Scudd.)

Color varying from a very dark to a bright reddish brown, the head and pronotum usually lighter than the tegmina; the latter in the female often sprinkled with numerous darker brown spots. Inner wings with the basal two-thirds either deep yellow or orange red, the

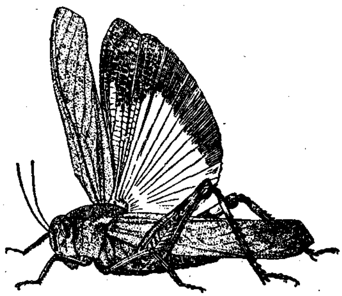


Fig. 49. *Arphia xanthoptera* (Germar). Male. Natural Size. (After Beutenmüller).

outer third with the curved fuscous bar as in *sulphurea,* but the dark ray near costal margin not much longer than the width of the fuscous band, and always extending less than one-half the distance to base of wing. Hind femora dull grayish brown, the upper outer face with two or three oblique blackish bars; a pale ring near the knee. Hind tibiæ dusky, the spines black.

This species differs from *sulphurea* by having the disk of the vertex truncate in front, its lateral carinæ not meeting, but continuous with the frontal costa; the latter with the sides not converging to an acuminate apex. The median carina of pronotum is higher and more distinctly arched and the posterior margin of pronotum is more acute. It is usually larger than *sulphurea*.

Measurements: Length of body, male 27 mm., female 34 mm.; of antennæ, male and female, 10.5; of tegmina, male, 26 mm., female, 30 mm.; of hind femora, male, 18 mm., female, 19 mm.

This is also a common locust throughout Indiana, beginning to reach maturity in the central part of the State, from eggs hatched in the spring, about July 30th, and existing until November 1st, or later. It frequents the stubble of wheat, clover and timothy fields, the banks along railways and the borders of high, dry, open woodlands and roadsides. One-third or more of the males have the inner wings a deep orange yellow, but not more than one-sixth of the females have the wings so colored. The orange winged males are usually darker in color, and their stridulation is seemingly louder and more prolonged than in the yellow winged forms. The sound is made as the insect rises from the ground, and at times at the points of turning in its zigzag flight. *Xanthoptera* is a stronger and more active flier than *sulphurea* and its note is louder and readily distinguished from that of the latter.

XXVI. Chortophaga Saussure (1884).

Body rather slim, compressed, punctate or fine wrinkled, green or brown in color. Vertex horizontal, triangular; the apex truncate; the lateral carinæ not prominent, the median carina wanting; the foveolæ very shallow, elongate, triangular. Frontal costa prominent, rather narrow, punctate, sulcate below the ocellus, the margins of upper fourth slightly converging to meet those of the vertex. Antennæ no longer than head and pronotum together, the joints short and somewhat flattened. Pronotum with its disk roof shaped, its front margin bluntly angulate, projected slightly forward on the occiput, the hind margin acute angled; the median carina not prominent, straight and but faintly notched a little before the middle by the principal sulcus; the lateral carinæ visible only on the metazona, rounded and indistinct in the female, plainly visible in the male. Lateral lobes of the pronotum as in *Arphia*, the posterior angle less rounded. Tegmina narrow, extending beyond the abdomen; the apical half membranaceous, the intercalary vein running midway between the median and ulnar veins. Inner wings pellucid, the veins but slightly swollen. Hind femora of medium size, surpassing the abdomen in the male, a little shorter in the female. Ovipositor as in *Arphia*.

Two species of the genus occur in the United States, one of which inhabits Indiana.

40. CHORTOPHAGA VIRIDIFASCIATA (DeGeer). The Green-striped Locust.

Acrydium viridifasciatum DeG., 57, III, 1773, 498, Plate 42, Fig. 6.

Locusta (Tragocephala) viridifasciata Harr., 71, 1841, 147; Id., 72, 1862, 182, Plate III, Fig. 2.

Tragocephala viridifasciata Scudd., 141, VII, 1862, 461; Id., 150, XVII, 1875, 481; Id., 153, IV, 1875, 80; Glov., 62, 1872, Plate V, Fig. 9; Thom., 206, V, 1873, 103, Plate I, Fig. 3; Id., 211, IX, 1880, 105, Figs. 13, 17; Stal., 200, I, 1873, 119; Riley, 117, VIII, 1876, 149, Fig. 46; Id., 214, I, 1878, 255, Fig. 94; Id., 122, II, 1884, 203, Fig. 285.

Chortophaga viridifasciata Sauss., 134, 1884, 72, Plate I, Figs. 7, 12; Fern., 53, 1888, 40, Fig. 15; Bl., 4, XXIII, 1891, 76; McN., 88, VI, 1891, 62; Beut., 3, VI, 1894, 295, Plate VIII, Fig. 9; Morse, VIII, 99, 1897, 35, 64, Plate 2, Fig. 18; Lugg., 84, 1898, 144, 147, Figs. 83–85; Scudd., 188, 1900, 31.

Locusta (Tragocephala) infuscata Harr., 72, 1862, 181.

Tragocephala infuscata Scudd., 141, VII, 1862, 461; Glov., 62, 1872, Plate X, Fig. 10; Thom., 206, V, 1873, 102, Plate I, Fig. 7.

Tragocephala viridifasciata infuscata Scudd., 150, XVIII, 1875, 481; Thom., 211, IX, 1880, 106.

Chortophaga viridifasciata infuscata Bl., 4, XXIII, 1891, 76.

Locusta (Tragocephala) radiata Harr., 72, 1862, 183.

Tomonotus zimmermanni Sauss., 128, II, 1861, 23.

Color dimorphic, either largely green with a small amount of brown upon the tegmina *(viridifasciata)* or wholly brown *(infuscata)*. Specimens are common, however, which can be referred to either

Fig. 50. *Chortophaga viridifasciata* (DeGeer). Nymph and adult female. (After Riley).

form, the color being a mixture. In the more pronounced green examples, the head, pronotum, outer face of hind femora and the basal two thirds of the median field of the tegmina are grass green; the upper dorsal field, and apical third of tegmina, as well as a narrow stripe along their lower or costal margin are ash brown; the abdomen reddish brown. Rarely the head, pronotum and hind femora are reddish purple instead of green. In the brown form the apical halves of the tegmina are darker and their sides often contain a few light spots. The inner wings of both forms are transparent and yellow at base, the apical two-thirds fuliginous or smoky, the apex paler; an opaque dark bar is present along the middle of front margin. Hind tibiæ brown or pale blue with a white ring near the base.

Measurements: Length of body, male, 20 mm., female, 26 mm.; of antennæ, male, 8 mm., female, 7 mm.; of tegmina, male, 18.5 mm., female, 23 mm.; of hind femora, male, 13 mm., female, 15 mm.

This is the first locust to reach maturity in spring from hibernating nymphs, specimens having been taken in Vigo County as early as April 15th. It is a common species throughout the State, making its home in blue-grass pastures, and especially in the grassy tracts along rail fences between upland woods and cultivated fields and meadows. It also occurs on sunny sloping hillsides and railway embankments. In fact, mature individuals may occur anywhere in dry grassy places from mid-April till November 1st. In such localities the young, in company with those of *Arphia sulphurea*, may be seen on all sunny winter days when the mercury is above the freezing point. At such times they often climb or leap upon the lower rails of fences or sides of stumps, there resting in and apparently enjoying the sunshine. The species is said to be double brooded in some localities, but in Indiana, as far as known, it is single brooded, the young hatching in August and September and undergoing three or four moults before winter.

In this State, as elsewhere throughout its range, which includes the United States and Canada east of the Rocky Mountains, green females and brown males are the predominating forms, not more than 20 per cent. of the females in Indiana being brown, and a much smaller proportion of the males being green. The male of *viridifasciata*, when disturbed, usually flies but a few rods, moving in a circling or zigzag course, and producing a low but distinct shuffling or rattling noise during the whole of its flight. The female moves noiselessly and more directly to a greater distance.

XXVII. Encoptolophus Scudder (1875).

Body a little shorter and stouter than in *Chortophaga*, but compressed as there; the head more swollen. Vertex broadly triangular, the apical half sloping a little downward, the disk noticeably lower than the occiput, the lateral carinæ low; the median present but terminating at middle of disk; the foveolæ distinct, elongate triangular. Frontal costa narrow, strongly sulcate throughout in the male, but only above ocellus in the female. Antennæ equaling the head and pronotum together in the female, a third longer in the male; the joints of apical half moderately flattened. Pronotum with its disk nearly flat, the front margin truncate, the hind margin forming a rather sharply marked right angle; the median carina distinct, a little higher on the prozona, cut into two nearly equal halves, by a distinct notch; the lateral carinæ plainly visible only on the metazona. Lateral lobes of pronotum deeper than long, their disks concave and much wrinkled, their front and hind margins nearly vertical, the lower margin with its posterior half rounded, the anterior oblique, ascending. Tegmina rather broad and short, the apex broadly rounded, slightly surpassing the abdomen in both sexes; the intercalary vein distinctly nearer the ulnar than the median vein. Inner wings short and broad, pellucid or nearly so, the veins next the costal margin distinctly swollen. Hind femora a little shorter than the abdomen in the female; slightly surpassing it in the male.

Four species of *Encoptolophus* are known from the United States. Of these, one occurs in Indiana.

41. **Encoptolophus sordidus** (Burmeister). The Clouded Locust.

Œdipoda sordida Burm., 40, II, 1838, 643; Glov., 62, 1872, Plate X, Fig. 11; Thom., 206, V, 1873, 116; Pack., 215, II, 1880, 179, Plate I, Fig. 4.

Tragocephala sordida Stal, 200, I, 1873, 119; Thom., 211, IX, 1880, 107.

Encoptolophus sordidus Scudd., 150, XVII, 1875, 479; Id., 153, IV, 1875, 78; Id., 188, 1900, 32; Sauss., 134, 1884, 77; Comst., 41, 1888, 103, Fig. 93; Id., 42, 1895, 110, Fig. 121; Fern., 53, 1888, 41, Fig. 16; Bl., 4, XXIII, 1891, 77; Beut., 3, VI, 1894, 296, Plate X, Fig. 2; Morse, 99, VIII, 1897, 35, 66, Plate 2, Fig. 19; Lugg., 84, 1898, 147, Fig. 86.

Locusta nebulosa Harr., 71, 1841, 146; Id., 72, 1862, 181; Emm., 49, V, 1854, 146, Plate 9, Fig. 7.

Color, dull rusty, yellowish or smoky brown, varied with small mottlings of the darker and lighter shades. Pronotum in living specimens often with a distinct pinkish buff X-shaped mark on its disk. Antennæ pale brown at base, the apical half darker. Tegmina with two pale transverse bars on the middle of sides, which contrast plainly with the larger dark patches between and on either side of them. Inner wings transparent yellowish at base; the apical half smoky brown, the apex darker. Hind femora indistinctly banded with dull yellowish and dark brown. Hind tibiæ dusky brown with a pale ring near the base.

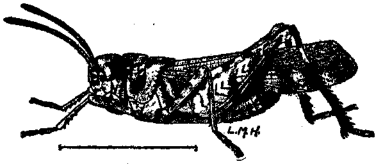


Fig. 51. *Encoptolophus sordidus* (Burm.). Male. (After Lugger.)

Measurements: Length of body, male, 22 mm., female, 29 mm.; of antennæ, male, 10 mm., female, 9 mm.; of tegmina, male, 19 mm., female, 24 mm.; of hind femora, male, 13.5 mm., female, 16 mm.

The clouded locust is common throughout the State, maturing in the central portion about August 1st, from eggs hatched in the spring, and existing till December 1st, provided the autumn is a favorable one. It frequents only dry upland timothy and clover meadows, blue-grass pastures, roadsides, etc. When living in woodland pastures it frequents the sunny spots, seldom alighting in the shade when flushed. The male stridulates on the wing during short flights, seldom, if ever, in the more prolonged ones, which it makes when frightened. The note is a harsh droning or buzzing sound, somewhat resembling that of a bumblebee, but louder. It is begun after the insect has risen three or four feet above the ground, and is continued until it begins to descend, being kept up continuously while it is flying horizontally. The females usually leap for the first two or three times they are disturbed, but if flushed a number of times they use the wings in endeavoring to escape.

XXVIII. Camnula Stal (1873).

Body short, the size below the average for the *Oedipodinæ*, the head compressed. Vertex with its disk ovate-oblong in male, broader in female, its front half sloping downward, the apex rounded, the lateral carinæ distinct, the median carina very faint in the female, absent in the male; the foveolæ indistinct, narrowly triangular. Frontal costa, not prominent, flat or nearly so, a little sulcate just below the ocellus. Antennæ short, filiform. Pronotum with its disk flat, not rugose, the front margin truncate, the hind margin obtuse angled, the median carina low, of equal height throughout, cut with a small notch a little in front of the middle; the lateral carinæ distinct on both prozona and metazona. Lateral lobes of pronotum, deeper than long, the front margin nearly vertical, the hind margin oblique, the lower margin as in *Encoptolophus*. Tegmina narrow, surpassing the abdomen; the apical third remotely reticulate, the cells quadrate. Inner wings pellucid with dusky venules. Hind femora equaling or slightly exceeding the abdomen; their upper margin sharp and somewhat crested. Valves of ovipositor strongly exserted. One species is found throughout the northernmost United States and Canada from the Atlantic to the Pacific. It occurs rarely in northern Indiana.

42. CAMNULA PELLUCIDA (Scudder). The Clear-winged Locust.

Œdipoda pellucida Scudd., 141, VII, 1862, 472; Glov., 60, 1870, 78; Id., 62, 1872, Plate XII, Fig. 20; Thom., 206, V, 1873, 137.

Camnula pellucida Scudd., 148, I, 1874, 378; Id., 188, 1900, 32; Thom., 211, IX, 1880, 118; Id., 215, II, 1880, 242, Fig. 10; Riley, 127, XXV, 1891, 32, Fig. 10; Sauss., 134, 1884, 81; Fern, 53, 1888, 41, Fig. 17; Brun., 26, XXVII, 1892, 12; Id., 28, XXVIII, 1893, 34, Fig. 18; Id., 30, 1893, 463, Fig. 107; Id., 34, 1896, 123, Figs. 25, 26; Morse, VIII, 99, 1897, 35, 80, Plate 2, Fig. 20; Lugg., 84, 1898, 148, Figs. 87, 88.

Œdipoda atrox Scudd., 147, 1872, 253; Glov., 60, 1871, 77, Fig. 10; Id., 62, 1872, Plate VIII, Fig. 3; Id., 63, 1874, 137, Fig. 10; Thom., 206, V, 1873, 136; Riley, 214, I, 1878, 454, Fig. 109.

General color, light brown; face, reddish brown. Antennæ yellowish at base, the apical half dusky. A dark triangular spot behind eye, and an oblong vertical black spot on the front half of lateral lobe of pronotum. Tegmina smoky brown, with several darker rounded spots on sides; these separated by lighter yellowish blotches; the dorsal surface dark brown, with a yellowish brown stripe along each humeral angle. Inner wings transparent, with dark nervules. Hind femora yellowish brown, with two or three blackish bars on the outer face; the knees fuscous. Hind tibiæ yellowish brown; the basal fourth lighter. Abdomen yellowish beneath, the sides darker.

"In the markings of the tegmina, form and color, *pellucida* looks like a diminutive *Hippiscus*. It varies much in size and tegminal markings."

Measurements: Length of body, male, 19 mm., female, 22 mm.; of antennæ, male and female, 7 mm.; of tegmina, male, 17 mm., female, 20 mm.; of hind femora, male, 12 mm., female, 13 mm.

As noted above, this is a species of northern range. It has been taken in Indiana but once, near Bass Lake, Starke County, on August 21, 1902. Here a half dozen specimens, all that could be found during a two-hours' search, were secured from a low, marshy tract, on which the grass had been cropped short. When flushed, the males flew noiselessly 30 to 50 feet, then dropped down and squatted low between the grass blades. The single female was more clumsy and did not take to wing; all were found within an area of 100 square feet. It is probable that the species occurs in isolated localities throughout the northern third of the State. In New England Morse says that it begins to mature about July 1st, and may be found during the rest of the season. "It is extremely common, even abundant locally, throughout the northern part of New England, being probably the most numerous in point of individuals of any of our *Oedipodinæ*. It is found in dry grassy pastures and other untilled lands, preferably on high ground. Its flight is silent or slightly rustling, usually low, short and direct, resembling that of a large Melanoplus; when with the wind, however, it is occasionally prolonged for several rods in a straight line."

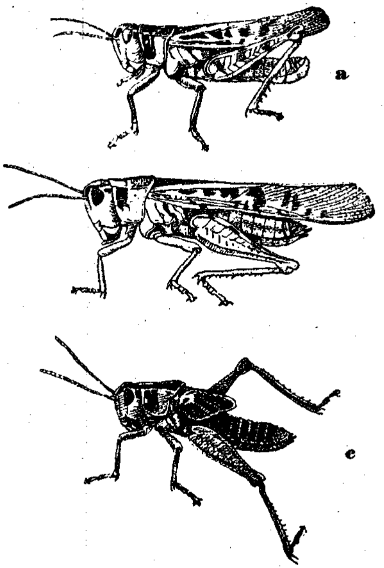


Fig. 52. *Camnula pellucida* (Scudd.). *a*, adult male; *b*, female; *c*, nymph; slightly enlarged. (After Simpson.)

XXIX. Hippiscus Saussure (1861).

Species of large size and robust form. Head large, sub-globose, the cheeks swollen. Vertex with the disk usually broadly triangular, the apex rounded or obtusely angulate and sloping more or less downward; the lateral carinæ distinct, but not sharp; the median carina present, at least on posterior half, and continued back over the occiput in the form of a small central ridge; the foveolæ present, but not prominent, usually triangular in form. Antennæ but little, if any, longer than head and pronotum together, filiform, the joints of apical halves a little flattened. Pronotum with its disk flat, usually rugose and bearing a number of rounded or oblong tubercles; the front margin truncate, the hind margin usually obtuse, or right angled; the median carina rather prominent, and cut once by the principal sulcus; the lateral carinæ extending a short distance in front of this sulcus, but not cut by it. Lateral lobes of the pronotum about as long as deep, constricted near the middle; the front margin a little sinuate, the hind margin oblique; the lower margin with its posterior half rounded, the anterior half oblique, directed upward, the posterior angle usually broadly rounded. Tegmina considerably exceeding the abdomen; their sides usually with a number of large rounded or squarish dark spots. Inner wings with their basal halves red or yellow, the apical halves with a broad fuscous arcuate band, narrowing toward the anal angle. Hind femora stout, depressed, dilated.

Thirty-seven of these heavy bodied locusts are catalogued by Scudder as occurring in the United States, most of them being found only west of the Mississippi River. Four are known from Indiana, and probably one or two others will, in time, be found to inhabit the State.

KEY TO INDIANA SPECIES OF HIPPISCUS.

a. Hind margin of pronotum acutely angled; the prozona much shorter than the metazona; vertex with the front half of disk prolonged, narrowing gradually; the ulnar area of tegmina dark, but without distinct spots; inner wings pinkish red at base.................... 43 *tuberculatus*, p. 265

aa. Hind margin of pronotum right angled or obtuse angled; the prozona nearly as long as the metazona; vertex with the front half of disk not prolonged, narrowing rapidly; the ulnar area of tegmina distinctly spotted; the inner wings (except rarely in *haldemanii*) yellow or orange red at base.

b. Frontal costal strongly sulcate below the ocellus, and distinctly narrowed at its upper extremity; vertex with the disk, not or but faintly divided by cross carinæ into four sub-equal parts; spurs at opposite sides of apex of hind tibiæ nearly equal.

c. Tubercles on disk of metazona rounded or oblong, not forming ridges parallel to the hind margins; inner face of hind femora banded with black, blue at base......... 44 *phœnicopterus*, p. 267

cc. Tubercles on disk of metazona more or less united to form oblique ridges parallel to the hind margin; inner face of hind femora uniform yellowish.....45 *haldemanii*, p. 269

bb. Frontal costa but little sulcate below the ocellus and not narrowed at the upper extremity; vertex with the disk divided by transverse and lengthwise carinæ into four sub-equal parts; spurs at opposite sides of the apex of hind tibiæ very unequal in length. A distinct broad, buff X-shaped mark usually present on disk of pronotum........46 *rugosus*, p. 270

43. HIPPISCUS TUBERCULATUS (Palisot de Beauvois). The Coral-winged Locust.

Acrydium tuberculatum Pal. de Beauv., 108, 1805, 200, Plate 4, Fig. 1.
Hippiscus tuberculatus Sauss., 134, 1884, 87; Fern., 53, 1888, 42; Scudd., 167, VI, 1892, 269, 303; Id., 188, 1900, 33; Beut., 3, VI, 1894, 297, Plate X, Fig. 3; Morse, 99, VIII, 1897, 36, 81, Plate 2, Fig. 21; Brun., 34, 1897, 131, Fig. 31; Bl., 15, XXX, 1898, 61; Id., 16, 1899, 235, Fig. 61; Lugg., 84, 1898, 153, Figs., 89–91.
Locusta corallina Harr., 71, 1841, 142; Id., 72, 1862, 176; Emm., 49, V, 1854, 146.
Œdipoda phœnicoptera Scudd., 141, VII, 1862, 468; Glov., 62, 1872, Plate V, Fig. 4; Thom., 206, V, 1873, 135; Riley, 117, VIII, 1876. 104, Fig. 41; Id. 214, I, 1877, 228, Fig. 7.
Hippiscus phœnicopterus Scudd., 148, 1874, 377; Thom., 211, 1880, 95, 117, Fig. 18; Bl., 4, XXIII, 1891, 79.
Œdipoda obliterata Burm., 40, II, 1838, 643.

Vertex prominent, its front half prolonged, the lateral carinæ distinct, not uniting, but continuous with those of the frontal costa; the median carina reaching center of disk; the foveolæ triangular, very small. Frontal costa sulcate below the ocellus; the upper third a little narrowed. Antennæ short, equaling the length of head and pronotum; the joints a little flattened. Pronotum with its disk flat, but little wrinkled; granulate and bearing a few small rounded black tubercles; the hind margin acute angled, sometimes right angled in the male; the median carina low, but distinct, cut much in front of the middle by the principal sulcus; lateral carinæ distinct. Hind femora very broad, the upper and lower carinæ prominent and arcuate.

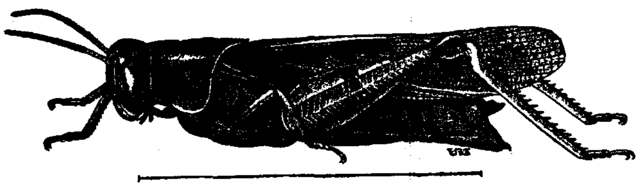


Fig. 53. *Hippiscus tuberculatus* (Pal. de Beauv). Female. (After Lugger).

General color, ash brown, darker above; the cheeks paler. Antennæ yellowish at base, the apical two-thirds gradually darkening to fuscous. Pronotum with a short, dark brown, lengthwise bar on middle of lateral lobes, below which the lobe is usually lighter than above. Tegmina blotched with fuscous and black, the humeral angle light brown; the dark color of discoidal and ulnar areas usually unbroken; some scattered dark blotches on apical third. Wings bright coral red (rarely yellow) at base, bordered without by an arcuate fuscous band which reaches the anal angle; a broad marginal ray of fuscous extends long the front or costal margin, nearly to base. Hind femora with the basal half of inner face black (prussian blue in life), the apical half yellow with a median black bar; the outer face with indistinct bars of black. Hind tibiæ dull yellow, sometimes with an orange tint.

Measurements: Length of body, male, 30 mm., female, 43 mm.; of antennæ, male, 13 mm., female, 14 mm.; of pronotum, male, 8 mm., female, 11 mm.; of tegmina, male, 31 mm., female, 41 mm.; of hind femora, male, 18 mm., female, 23 mm.

The female of the coral-winged locust is the largest and most bulky of our Indiana *Oedipodinæ.* The males, as the measurements show, are much smaller. This locust probably occurs throughout the State, but is most abundant in the southern or driftless portion, where the soil is poor and the hills high; and in the northwest portion, where the sand-covered area is extensive. It has not been noted

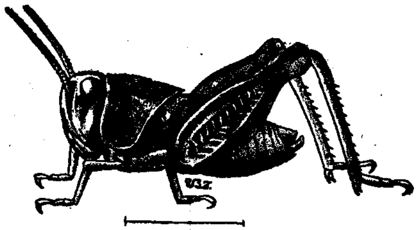


Fig. 54. *Hippiscus tuberculatus.* Young. (After Lugger).

by me in the richer and more level regions of the central and eastern portions of the State. The winter is passed in the nymph stage, the young being "curious little depressed, toad-like objects" of a dull leaden color. Mature examples have been taken in Monroe County as early as April 20th, and in Crawford County as late as July 10th. The northern examples are smaller, darker colored, and may probably be found a month later.

This locust frequents, for the most part, timothy meadows, upland pastures, roadsides, and especially bare or scantily vegetated slopes and sandy plains. When in flight it is very conspicuous, owing to its large size and bright-colored inner wings. The males are ready and active flyers, moving rapidly for quite a distance, making, meanwhile, a loud rattling note which can be heard at a distance of several rods. The females seldom take to wing, but leap clumsily when approached, and are more readily captured. The general range of *tuberculatus* is given by Scudder as "North America, east of the Rocky Mountains, rare southwardly."

44. HIPPISCUS PHŒNICOPTERUS (Germar). The Orange-winged Locust.
Œdipoda phœnicoptera Germ., 58, II, 1838, 643.
Hippiscus phœnicopterus Sauss., 134, 1884, 87; McN., 88, VI, 1891, 63; Scudd., 167, VI, 1892, 267, 274, 285; Id., 188, 1900, 33; Beut., 3, VII, 1894, 298, Plate IX, Fig. 4.
Œdipoda discoidea Serv., 196, 1839, 724; Glov., 62, 1872, Plate III, Figs. 3, 7; Thom., 206, V, 1873, 133.
Hippiscus discoideus Stal, 200, I, 1873, 121; Thom., 211, IX, 1880, 89, 116; Comst., 41, 1888, 104.

Vertex prominent, the basal two-thirds broad, the lateral carinæ distinct, suddenly converging opposite the front half of eyes, but not uniting in front; the median carina low, reaching center of disk; traces of a cross carina on posterior half of disk in female; foveolæ small, elongate U-shaped. Frontal costa rather narrow, sulcate from a little above the ocellus to the base; the upper third narrower, punctate. Antennæ a little shorter than head and pronotum in the female; equaling their length in the male; filiform, the joints a little flattened. Pronotum with its disk flat, a little wrinkled on the prozona, covered somewhat regularly with small rounded tubercles, these more prominent in the female; the hind margin right-angled in the male, obtuse-angled in the female; the median carina low but distinct, cut in front of middle by the principal sulcus, the lateral carinæ distinct only on metazona. Tegmina of both sexes surpassing the abdomen; the basal lobe of lower margin noticeably expanded, especially in the female. Hind femora broadly dilated; the upper and lower carinæ much elevated and sharp.

General color, ash or reddish brown; the males darker. Face ash brown or clay yellow. Occiput and disk of pronotum dark brown. All of these parts, as well as the upper and lower outer faces of the hind femora are often prettily tinged with greenish. Tegmina, ash brown, with numerous large dark brown or blackish spots; those of the female more distinct, the light interspaces being wider; the largest of these spots on the lower third being just behind the expansion noted above. Wings deep orange (rarely yellow) at base; outside of this and just beyond the middle a curved black band crosses from the costal margin to the anal angle; the apical fourth transparent and smoky, the extreme tip with one or two fuscous blotches in the male; a humeral bar or stripe of black reaches nearly to the base of the front portion. Inner face of hind femora deep blue, with an orange bar near the apex; outer face reddish or yellowish brown, with three black bars on the upper half. Hind tibiæ yellowish, often tinged with orange, the spines tipped with black.

Measurements: Length of body, male, 31 mm., female 44 mm.; of antennæ, male, 12.5 mm., female, 13.5 mm.; of pronotum, male, 8.5 mm., female, 11 mm.; of tegmina, male, 31 mm., female, 40 mm.; of hind femora, male, 18 mm., female, 23 mm.

This is a locust of southern range which has been taken in Indiana only in Crawford, Lawrence and Jennings counties. In the vicinity of Wyandotte Cave, Crawford County, it is, in the latter half of June and first part of July, one of the most common of the *Oedipodinæ*. It occurs only on the uplands, where it frequents grain fields, open bare places in the woods, roadsides and timothy meadows. The male, when flushed, flies rapidly for a long distance, making a low rattling note while in the air; the female, as in kindred species, is too heavy bodied to take to wing gracefully, and therefore more often moves by leaping. In the vicinity of North Vernon and Mitchell, males only were seen. This locust probably occurs throughout the southern third of the State, and perhaps winters in the nymph stage. Its general range includes the southern United States east of the Great Plains.

45. HIPPISCUS HALDEMANII (Scudder). Haldeman's Locust.

Œdipoda haldemanii Scudd., **147**, 1872, 251; Glov., **62**, 1872, Plate XIII, Fig. 3; Thom., **206**, V, 1873, 130.

Hippiscus haldemanii Scudd., **156**, II, 1876, 264; Id., **167**, VI, 1892, 267, 286; Id., **188**, 1900, 32; Lugg., **84**, 1898, 156, Fig. 93.

Hippicus nanus Sauss., **134**, 1884, 86.

Vertex broad, its disk sub-quadrate, often containing several minute tubercles, the lateral carinæ low, distinctly rounded; the median carina reaching the center, with sometimes traces of a cross carina; the foveolæ small but distinct, triangular. Face nearly vertical, the frontal costa broad, sulcate from a little above the ocellus downward, less so in the female, the upper third distinctly narrowed. Antennæ slender, about the length of head and pronotum together. Pronotum short; the prozona sub-cylindrical, constricted; the disk much wrinkled and rugose, bearing numerous elongate tubercles which lie obliquely and more or less parallel to the hind margin; the latter right-angled in the male, obtuse-angled in the female; the median carina low, indistinct on the prozona, cut a little in front of the middle by the principal sulcus; lateral carinæ distinct on hind part of prozona and front half of metazona. Tegmina surpassing the abdomen about one-fourth their length. Hind femora relatively slender, much narrower proportionally than in any other of our species of Hippiscus, reaching the tip of the abdomen in the female, slightly passing it in the male.

General color, grayish brown varied with numerous dark spots. Face, ash gray, the cheeks and a spot back of the eye, lighter; the vertex, occiput and disk of pronotum darker. A black bar on middle of lateral lobe of pronotum. Tegmina with a narrow yellowish line along each humeral angle, the dorsal area, brownish, unbroken; the sides with a number of oblong dark brown spots, separated by irregu-

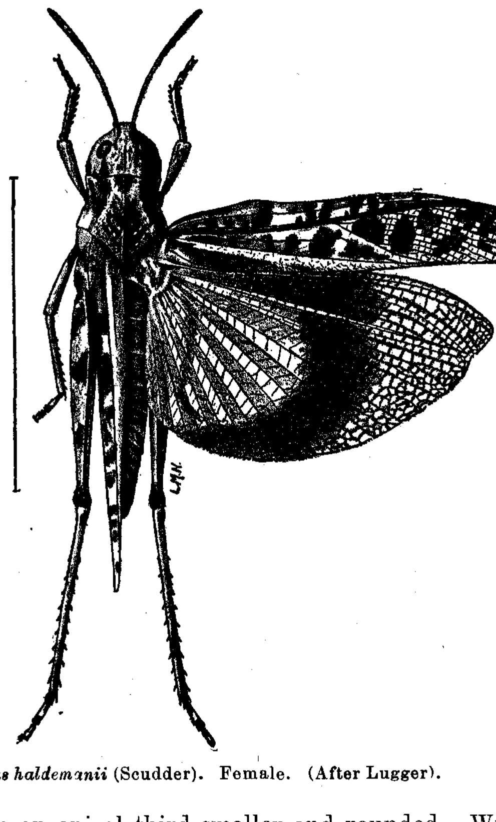


Fig. 55. *Hippiscus haldemanii* (Scudder). Female. (After Lugger).

lar grayish bars; those on apical third smaller and rounded. Wings with the basal half lemon yellow, orange red, or, rarely, pinkish; the remaining portion as in *phœnicopterus*. Hind femora with the inner face bright yellow;* the outer face brownish yellow with traces of three very oblique cross bars. Hind tibiæ light yellow, tinged with orange in the male.

* Thomas says: "Inside of posterior femora and the posterior tibiæ a bright coral red," but this does not hold good of Indiana specimens.

Measurements: Length of body, male, 27 mm., female, 44 mm.; of antennæ, male, 12 mm., female, 14 mm.; of pronotum, male, 7 mm., female, 10 mm.; of tegmina, male, 27 mm., female, 38 mm.; of hind femora, male, 16 mm., female, 22 mm.

This species has been taken in Indiana only near Pine, Lake County, where my assistant, Mr. L. E. Daniels, took eight specimens on June 20, 1902. They were found on open, sparsely vegetated sandy tracts, about a fourth of a mile back from the shore of Lake Michigan. Nothing distinctive of their habits was noted. One of the females taken has the inner wings pinkish or coral red, as in *tuberculatus;* two have them orange red, the others, yellow. Of the four males, two have yellow and two orange colored wings. This is the most eastern record for the species, its range, according to Scudder, being from Moline, Illinois, westward to the Rocky Mountains. It probably occurs in this State only in the sand-covered area of the northwestern portion.

46. HIPPISCUS RUGOSUS (Scudder). The Lubberly Locust.

Œdipoda rugosa Scudd., 141, VII, 1862, 469; Glov., 62, 1872, Plate XII, Fig. 8; Thom., 206, V, 1873, 132.

Hippiscus rugosus Scudd., 148, I, 1874, 377; Id., 167, VI, 1892, 268, 287; Id., 188, 1900, 33; Sauss., 134, 1884, 85; Fern., 53, 1888, 42; Bl., 4, XXIII, 1891, 78; Morse, 99, VIII, 1897, 36, 81, Plate 2, Fig. 22; Lugg., 84, 1898, 149.

Hippiscus corallipes rugosus Thom., 211, IX, 1880, 89, 115.

Hippiscus variegatus Scudd., 167, VI, 1892, 268, 301; Id., 188, 1900, 33; Brun., 34, 1896, 131; Id., 36, 1899, 271; Lugg., 84, 1898, 157, Fig. 94.

A rather bulky and short-bodied form. Vertex convex, the disk indistinct, and sloping downward, broader than long in both sexes, the lateral carinæ dull, low; the median carina extending to front border, and with a cross carina dividing the disk into four sub-equal portions, the front pair being the more distinct; lateral foveolæ, shallow, elongate triangular. Frontal costa broad, flat, punctate, slightly sulcate just below the ocellus. Antennæ about as long as head and pronotum in the female, a third longer in the male. Pronotum with the disk flat or nearly so, the metazonal portion not greatly widened, the hind margin obtuse-angled, the surface bearing numerous low, oblong or longitudinal, glistening tubercles; the median carina low, cut very near the middle by the principal sulcus; the lateral carinæ distinct on the metazona; the lateral lobes of metazona densely punctate. Tegmina relatively broad, exceeding the abdomen in both sexes. Hind femora moderately slender, equaling or surpassing the abdomen by one-fourth their length, the basal half depressed, dilated.

General color, light to dark brown, the face and abdomen brownish yellow; the disk of pronotum with a pale, X-shaped stripe, not always present in the female. Antennæ yellow at base, the apical half reddish fuscous. Tegmina ash gray, often darker in the male, the sides and dorsal area with numerous dark brown or fuscous oblong or rounded spots, those on center of sides larger; the apical third often semi-transparent, with the spots much smaller and more irregular in shape. Wings with the basal half varying from a pallid tint through pale lemon yellow to deep orange; the outer half with the curved black band and transparent apex as in *phœnicopterus.* Hind femora bright yellow within, with three transverse bars of black; dull clay yellow without, with three more or less distinct, very oblique fuscous bars. Hind tibiæ yellow, with a paler ring near the base.

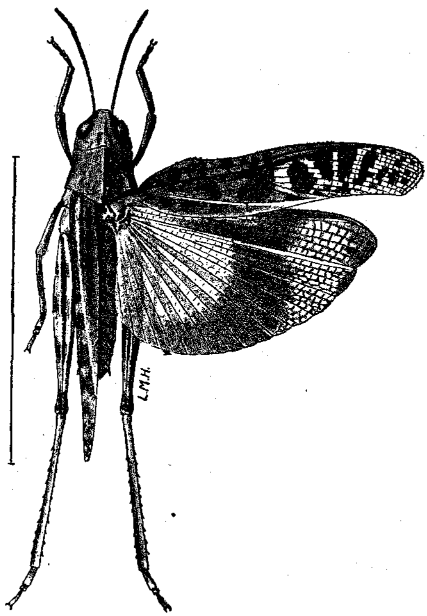


Fig. 56. *Hippiscus rugosus* (Scudder). Male. (After Lugger.)

Measurements: Length of body, male, 28 mm., female, 37 mm.; of antennæ, male, 13 mm., female, 12 mm.; of pronotum, male, 7 mm., female, 9 mm.; of tegmina, male, 27 mm., female, 34 mm.; of hind femora, male, 18 mm., female, 22 mm.

This is the most common species of *Hippiscus* in the State, being especially abundant in the central and southern portions, but scarce in the north, where it has been collected only in Fulton and Marshall counties. In central Indiana it begins to reach maturity about July 20th, from eggs hatched in the spring. Like others of its kind, it frequents only dry, upland localities, being especially abundant in open woodland pastures, timothy and clover meadows, along roadsides and rail fences. The males are shy, usually taking to flight when an intruder is a rod away and moving in a straight line in the direction they happen to be headed, without noise, save the rustling of their wings. The females are very clumsy, being readily picked up with the fingers. I have often placed one of them on the palm of one hand and with the other stroked gently its back and antennæ without having it attempt to escape.

Mating takes place in late August and September, and the males then mostly perish, while the females are to be found much longer, sometimes as late as November 5th. Orange-winged females of *rugosus* are more common than males; probably one third of them having the wings of that hue. It ranges over the eastern United States east of the Rocky Mountains.

From the study of type specimens of Scudder's so-called *H. variegatus* and of a large number of examples taken in the field, I have concluded that it is but a little stouter bodied, lighter colored form of *rugosus*, and have therefore combined the two species under the latter name. Intermediate specimens, varying in length of tegmina and size and position of tegminal spots are common. With numerous examples at hand it is impossible to separate the two forms.

XXX. DISSOSTEIRA Scudder (1876).

Body slender, compressed. Vertex with the disk sub-pentagonal or ovate; the front half a little downward sloping, its front margin angulate; the lateral carinæ low; the median carina present but indistinct; the foveolæ short, triangular. Frontal costa sulcate, a little narrowed below the ocellus. Pronotum with disk of prozona sloping, that of metazona flat; the front margin truncate, the hind margin obtuse-angled; the median carina high and sharp, and on the metazona strongly arched, cut in front of the middle by a deep but narrow notch; lateral carinæ rounded, cut by the principal sulcus and obsolete in front of it. Lateral lobes of pronotum deeper than long, the front margin vertical, the hind margin oblique, the lower margin with its posterior half rounded, the anterior half oblique. Tegmina broad, much exceeding the abdomen; the whole of apical third membranaceous; the intercalary vein very distinct and nearly intermediate between the median and ulnar veins. Inner wings long and wide, black, with a narrow yellowish outer border; the apex fuscous. Hind femora slender, a little shorter than abdomen in both sexes.

Four species of the genus are accredited to the United States. Of these, one occurs in Indiana.

47. **Dissosteira carolina** (Linnæus). The Carolina Locust. The Black-winged Locust.

Gryllus (*Locusta*) *carolinus* L., 81, I, 1758, 433.

Locusta carolina Harr., 70, 1833, 583; Id., 72, 1862, 176, Plate 3, Fig. 3; Emm., 49, V, 1854, 145, Plate 9, Fig. 9; Rathv., 109, 1862, 386, Figs. 26, 26a.

Œdipoda carolina Burm., 40, II, 1838, 643; Serv., 196, 1839, 722; Glov., 62, 1872, Plate V, Fig. 3; Thom., 206, V, 1873, 117; Id., 211, IX, 1880, 88, 111.

Dissosteira carolina Scudd., 159, 1876, 511; Id., 180, VIII, 1897, 100; Id., 188, 1900, 36; Sauss., 134, 1884, 137; McNeill, 87, XIX, 1887, 58; Fern., 53, 1888, 43; Bl. 4, XXIII, 1891, 78; Id., 16, 1899, 242, Fig. 69; Smith, 197, XC, 1892, 6, 12, 34, Plate 1, Fig. 4k; Beut., 3, VI, 1894, 298, Plate X, Fig. 6; Morse 99, VIII, 1897, 35, 87; Lugg., 84, 1898, 158, Fig. 95.

General color varying from light grayish yellow through bright reddish brown to dark fuscous; usually dull ashy brown, sprinkled with numerous small dusky spots; these most numerous on the pronotum and tegmina, on the latter sometimes forming three more or less distinct cross bands. Wings deep black except the outer border,

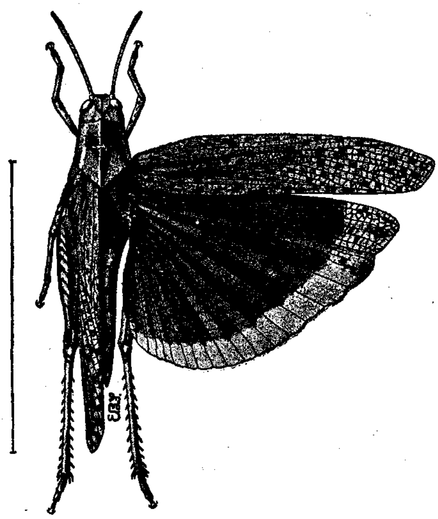


Fig. 57. *Dissosteira carolina* (Linn.). Female. (After Lugger.)

which is pale greenish yellow; the apex smoky gray with a few darker spots. Hind femora with three broad black bands on the inner face. Hind tibiæ yellowish or dusky.

Measurements: Length of body, male, 30 mm., female, 35 mm.; of antennæ, male, 11 mm., female, 13 mm.; of pronotum, male, 7 mm., female, 10 mm.; of tegmina, male, 34 mm., female, 41 mm.; of hind femora, male, 16 mm., female, 18 mm.

The black winged locust occurs everywhere throughout the State and to the casual observer appears to be our most common species, but there are a dozen which are more abundant. Its numbers appear multiplied because it frequents the highways and by-ways of man rather than the pastures and meadows where other grasshoppers are wont to congregate. Moreover, when disturbed, it more often betakes itself to the bare earth than to the green grass. Why this absurd taste? asks the person uninitiated in the doings of nature's objects. For the simple reason that the dust of the roadside and the gravel ballast of the railway correspond so closely with the color of its back that its best friends and worst enemies will overlook it if it will only remain quiet. Yea, even that sharp-eyed connoisseur of grasshopper tid-bits, the turkey gobbler, oftentimes walks right over it, mistaking it for a wayside pebble.

Mature specimens of this "carolina locust," hatched from eggs in spring, have been taken in Vigo County as early as June 14th and as late as November 22d. It is usually common and mating by July 5th. Either there are two broods each year, or else the eggs hatch at irregular intervals, as freshly moulted individuals have been observed on a number of dates in September, and as late as October 14th. On one occasion, while passing through a wheat field in late September, I observed clinging to the stems of weeds, several specimens of what appeared to be the bodies of grasshoppers with the wings of the common sulphur-yellow butterfly attached to them. Such a combination aroused my curiosity, but a closer examination proved them to be specimens of this common black-winged locust which had just moulted for the last time, and spread out their soft wings to dry. The inner wings, instead of being black, were light yellow, but in three or four hours thereafter had changed to their usual color.

This locust is often seen along the walks and in the yards of our larger cities and I have seen specimens about the base of the Soldiers' Monument in the very center of the city of Indianapolis. Both sexes use the wings almost wholly in their travels, and fly in a noiseless zigzag manner for quite a distance when flushed. Their hind legs are used only in giving themselves an upward impetus from the ground, and hence are much smaller proportionally than are those of such locusts as leap rather than fly, while their wings are much longer and stronger.

The range of *D. carolina* is a most extensive one, embracing the United States and Canada from ocean to ocean.

XXXI. Spharagemon Scudder (1875).

Body slender, more or less compressed. Head rather swollen above, the vertex shaped much as in *Dissosteira,* but the lateral carinæ converging more rapidly; the median carina and angled front margin absent, the foveolæ wider and more distinct. Frontal costa narrow, sulcate, at least below the ocellus. Antennæ in both sexes about as long as hind femora; filiform, the joints of basal third a little flattened. Pronotum with the disk of metazona flat, that of prozona with the sides sloping; the median carina high and strongly compressed, cut a little in front of the middle by a deep but narrow notch; the lateral lobes as in *Dissosteira.* Tegmina relatively shorter than in *Dissosteira,* the intercalary vein less distinct and nearer the median than the ulnar vein. Inner wings yellow, with a dark curved median band. Hind femora rather stout and short, equaling, or a little exceeding, the tip of abdomen. Hind tibiæ, in our species, with at least the apical half red. Valves of ovipositor short; but little exserted.

This genus is closely related to *Dissosteira,* and Saussure, in his Prodromus, has placed it as a sub-genus under that one. Eight species are known from the United States. Of these, two have been taken in Indiana.

KEY TO INDIANA SPECIES OF SPHARAGEMON.

a. Size, large; the notch of median carina of pronotum vertical. Hind tibiæ with a distinct pale ring on basal third, followed by a black one of equal width, the apical half coral red........48 *bolli,* p. 275

aa. Size, small; notch of median carina of pronotum distinctly oblique. Hind tibiæ coral red, sometimes paler at base, but without distinct white and black rings......................49 *wyomingianum,* p. 277

48. Spharagemon bolli Scudder. Boll's Locust.

Spharagemon bolli Scudd., 149, XVII, 1875, 469; Id., 153, IV, 1875, 68; Id., 168, XXIII, 1893, 77; Id., 188, 1900, 37; McN., 88, VI, 1891, 64; Bl., 6, XXIV, 1892, 30; Morse, 95, XXVI, 1894, 227, 236, Figs. 6, 7; Id., 97, VII, 1895, 290; Id., 99, VIII, 1897, 37, 88, Plate 2, Fig. 26; Beut., 3, VI, 1894, 300, Plate X, Fig. 1; Lugg., 84, 1898, 163, Fig. 98.

Dissosteira (*Spharagemon*) *bolli* Sauss., 134, 1884, 140.

Dissosteira bolli Fern., 53, 1888, 43.

Spharagemon balteatum Scudd., 149, XVII, 1875, 469; Id., 153, IV, 1875, 68; Bl., 4, XXIII, 1891, 78.

Ground color variable, that of the male being usually grayish or fuscous, that of the female rusty brown or pale buff; the face grayish or yellowish. Antennæ brownish or grayish at base, fuscous at apex. Tegmina sprinkled throughout with minute blackish spots. In the males these spots are aggregated into three more or less distinct dark cross bars; in the female only faint traces of these bars are visible. Inner wings light greenish yellow at the base, with a broad median curved band of blackish or piceous which stops a little short of the anal angle; from this band near the front margin a black bar reaches

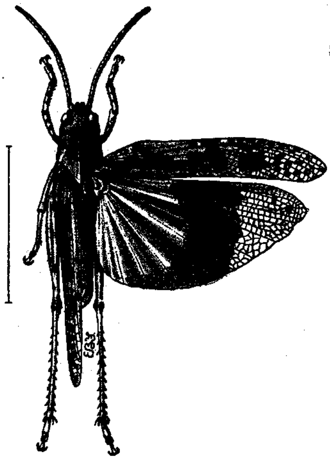


Fig. 58. *Spharagemon bolli* **Scudder. Male. (After Lugger.)**

back half way through the yellow. Apical third of wing transparent smoky, the extreme tip in the male being often of the same hue as the median band. Hind femora with alternating bars of black and yellow, three each, on the inner face; the outer face dull yellowish or grayish brown with three or four oblique indistinct dark brown bands.

The median carina of pronotum in the male is higher than in the female, that portion on the metazona being more elevated in front than behind. Other structural characters are given under the generic heading.

Measurements: Length of body, male, 25 mm., female, 33 mm.; of antennæ, male, 14 mm., female, 16 mm.; of pronotum, male, 7 mm., female, 9 mm.; of tegmina, male, 27 mm., female, 32 mm.; of hind femora, male, 16 mm., female, 19 mm.

This is a common locust throughout the central and southern thirds of the State, but is less numerous northward, where it seems to be replaced in part by the next species, though it has been taken in Starke and Lake counties. It frequents paths and bare places in dry upland woodland pastures, especially those which include the slopes of high hills, roadsides and stubble fields. In the northern counties it is found most abundantly along the sandy edges of woodlands and in old fields. In Crawford County mature specimens from eggs hatched in spring, have been taken on June 25th; in Vigo County, on June 30th. The males fly much farther than the females and on arising from the ground emit a short and rather low rattling note. The females are clumsy in their movements, and prefer, after being flushed once or twice, to lie still when approached, as close to the ground as possible, relying upon their protective coloration to prevent discovery.

Individuals of both this species and *D. carolina* have, in late summer, a peculiar habit of sustaining themselves in the air, about three feet above the ground, for several minutes. While poising in this manner above one spot, they make a dry, rustling note, which is perhaps a call to some nearby member of the opposite sex. *S. bolli* ranges from New England to Georgia, Texas and Nebraska.

49. **Spharagemon wyomingianum (Thomas). The Mottled Sand Locust.**

Œdipoda wyomingiana Thom., **205**, 1872, 462; Id., **206**, V, 1873, 113; Glov., **62**, 1874, Plate XIV, Fig. 1; Plate XV, Fig. 2.

Spharagemon wyomingianum Scudd., **149**, XVII, 1875, 468; Id., **153**, IV, 1875, 67, 69; Id., **188**, 1900, 38; Bl., **15**, XXX, 1898, 61.

Spharagemon collare wyomingianum Morse, **97**, VII, 1895, 298.

Spharagemon collare McN., **88**, VI, 1891, 64.

Spharagemon oculatum Morse, **95**, XXVI, 1894, 232, 239, Fig. 8; Bl., **11**, XXVI, 1894, 218; Scudd., **188**, 1900, 37.

General color, pale yellowish or pinkish brown, everywhere sprinkled and spotted with darker brown or fuscous. Face ash gray or yellowish, sprinkled with minute darker spots. Antennæ fuscous at tip, lighter toward base. Sides of pronotum with two indistinct dusky bands, the upper in the place of the lateral carinæ on the prozona. Tegmina with three transverse bars of fuscous spots; the dorsal field often brownish red. Inner wings similar to those of *bolli*, the median black band narrower toward the anal angle which it reaches. Hind femora pale brown or gray on outer face with traces of four fuscous cross bars; within sulphur yellow, with four more or less complete black bars. Hind tibiæ coral red or pinkish, paler at base; spines with extreme tips black.

The eyes of male of this species are larger and more prominent than usual. The vertex, viewed from above, is about as broad as the eye, with a faint trace of median carina on the posterior half. Pronotum with the disk flat on metazona, somewhat sloping on prozona, slightly angulate in front, acute angled behind; median carina high, compressed, arched, especially on metazona, the prozona in the male with crest of carina distinctly sloping toward the head; the notch plainly oblique and very narrow. Tegmina surpassing the femora by about one-third their own length. In most specimens the legs and the ventral portion of body are very pubescent, with rather long, grayish hairs.

Measurements: Length of body, male, 19 mm., female, 24 mm.; of antennæ, male, 12 mm., female, 11.5 mm.; of pronotum, male, 5 mm., female, 6.5 mm.; of tegmina, male, 19 mm., female, 23 mm.; of hind femora, male, 11 mm., female, 13 mm.

This small but handsome locust is quite common in the sand covered areas of the northern third of the State, having been taken in Fulton, Marshall, Lake, Porter, LaPorte, Starke, Kosciusko and Steuben counties. The earliest date at which it has been taken is July 14th, in Fulton County, when it was found in numbers and had probably been mature for a week or longer. It occurs most abundantly along the thinly vegetated sandy tracts twenty rods or more back from the water margin of lakes, in old sandy cultivated fields and along railways and roadsides. In such localities it is often found in company with *Psinidia fenestralis* and less frequently with *S. bolli*. It seldom leaps when disturbed, but uses the wings to propel itself in a flight of about 30 yards; the males making a faint crackling noise as they clear themselves from the earth, while the females are noiseless. In a corn field near Lake Maxinkuckee, I found *wyomingianum* very common on August 17, 1893, over about two acres of the most sandy portion. Resting on the soil between the rows, they were very difficult of detection, and eight times out of ten were not seen until flushed, unless they had previously been "marked down" as they alighted. A few were also taken from the sandy margin of the lake, but careful search over a wide extent of territory failed to reveal them elsewhere. It will probably be found in the vicinity of most of the lakes of the State. It is more frequent northward and westward, but has been taken in Maryland and New York, and may possibly occur in the sand covered area of southwestern Indiana.

XXXII. Mestobregma Scudder (1876).

Size small. Body slender, compressed. Disk of vertex with its posterior portion short and broad, the front portion narrowing rapidly and sloping strongly downward to form the sides of the frontal costa; the lateral carinæ high and sharp, the median carina wanting; the foveolæ, in our species, rather prominent, triangular. Frontal costa narrow, sulcate throughout, a little constricted above the ocellus. Antennæ about as long as hind femora, the basal joints so depressed as to form one sharp edge. Pronotum moderately constricted in the middle, the front margin truncate, the hind margin right-angled, the disk wrinkled, and bearing a number of small, oblique tubercles; the median carina sharp, slightly higher on the prozona, notched twice in front of the middle; the lateral carinæ rounded, visible only on the metazona. Lateral lobes of pronotum deeper than long, the front margin almost vertical, the hind one a little concave, the lower margin oblique but straight, the posterior angle thereby enlarged. Tegmina narrow, the apical half membranaceous and transparent. Inner wings with the basal half yellow. Hind femora slender, reaching tip of abdomen in female, much surpassing it in male.

Nine species of the genus occur in the United States, one of which has been taken in Indiana.

50. Mestobregma cinctum (Thomas). The Ash-brown Locust.

Œdipoda cincta Thom., **203**, 1870, 80; Id., **204**, II, 1871, 275; Id., **205**, 1872, 464; Id, **206**, V, 1873, 122; Glov., **62**, 1872, Plate XII, Fig. 13.

Mestobregma cinctum Thom., **211**, IX, 1880, 90, 113; Lugg., **84**, 1898, 164, Fig. 99; Scudd., **188**, 1900, 39.

General color ash gray, or yellowish brown, spotted with fuscous. Face ash gray, with minute dark spots. Occiput and disk of pronotum darker, with often a yellowish line extending back from eye along the sides of the disk. Lateral lobes of pronotum with traces of alternate lengthwise bars of pale and fuscous, the former the narrower. Tegmina yellowish brown or grayish, often darker in the male, the lower field with two squarish dark spots separated by an oblong whitish spot; the apical half transparent, often with a few small dark spots along the costal margin. Inner wings with the basal third greenish or lemon yellow; a narrow curved fuscous band on middle third; the apical third smoky transparent, with a few fuscous dots near the tip. Outer face of hind femora ash gray or yellowish with three more or less distinct black spots on the upper margin.

Inner face black with two narrow yellow crossbars. Hind tibiæ pale blue, sometimes dusky, with a whitish ring near the base, the spines black except at extreme base. Lower side of body yellow.

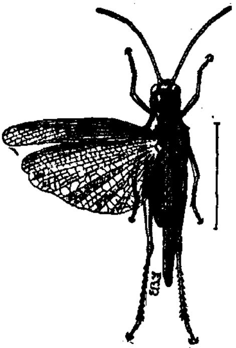


Fig. 59. *Mestobregma cinctum* (Thos.). Male. (After Lugger).

Measurements: Length of body, male, 18 mm., female, 25 mm.; of antennæ, male, 11.5, female, 12 mm.; of pronotum, male, 4.5 m., female, 6 mm.; of tegmina, male, 19 mm., female, 25 mm.; of hind femora, male, 11.5 mm., female, 14 mm.

This locust inhabits, as far as known, only the southern third of the State, having been taken in Crawford, Floyd, Lawrence and Jennings counties. It frequents old, abandoned fields, roadsides and bare places, especially those on high wooded slopes. On the hills about Wyandotte Cave, and the Knobs back of New Albany, it is especially common. The earliest date on which it has been taken was July 7, when it was found in numbers, and had doubtless been mature for some time. Both sexes fly actively when flushed, the males making a low, whirring noise as they rise from the ground. The general range of *M. cinctum* is given as "Upper Mississippi Valley and Colorado." Thomas has recorded it from southern Illinois, and Garman from Bowling Green and Glasgow Junction, Kentucky.

XXXIII. Trimerotropis Stal (1873).

Body of medium size; compressed. Head slightly exceeding the prozona in width, but always narrower than the metazona, which is considerably expanded. Vertex longer than broad, the lateral carinæ distinct, gradually converging, and continuous with the sides of the frontal costa; the median carina, if present, faint; the foveolæ small, but distinct and triangular. Frontal costa a little narrower just below the ocellus and at the point of union with the vertex; in our species with at least the lower two-thirds strongly sulcate. Antennæ, filiform. Pronotum with the disk nearly flat, either smooth or with minute tubercles on the metazona; the front margin truncate, the hind margin either acute, right or obtuse angled; the median carina, low, especially on the metazona; cut by two notches, the hindmost of which is much in advance of the middle; the lateral carinæ, rounded, indistinct. Lateral lobes of pronotum, with the front and hind margins nearly vertical, the lower margin with its front half directed upward, the posterior half arcuate, the angle well rounded. Tegmina much exceeding the abdomen in both sexes, in our species grayish or light brown in color, sprinkled with many small dark spots. Inner wings with the basal half light yellow; the apical third transparent; a narrow curved black band intervening. Hind femora of average width, reaching or exceeding the tip of abdomen in both sexes.

McNeill, in the latest monograph of this genus, describes and gives keys to 54 nominal species belonging to it. Of these, 49 are from the United States, 16 of which are confined to California; while but three occur east of the Mississippi River. Of these, two have been taken in Indiana.

KEY TO INDIANA SPECIES OF TRIMEROTROPIS.

a. Hind tibiæ yellow or greenish yellow; width of dark band of inner wing seldom more than one-sixth the length of wing.............. 51 *maritima*, p. 281

aa. Hind tibiæ red; width of dark band of inner wing, broader, about one-fourth the length of wing.....................52 *citrina*, p. 282

51. TRIMEROTROPIS MARITIMA (Harris). The Maritime Locust.

Locusta maritima Harr., 71, 1841, 143; Id., 72, 1862, 178.

Œdipoda maritima Uhl., 213, 1862, 178; Glov., 62, 1872, Plate XII, Fig. 17; Thom., 206, V, 1873, 124.

Trimerotropis maritima Stal, 200, I, 1873, 135; Scudd., 148, 1874, 378; Id., 188, 1900, 42; Thom., 211, 1880, 113; Sauss., 134, 1884, 172; Fern., 53, 1888, 45; Bl., 11, XXVI, 1894, 218; Id., 15, XXX, 1898, 61; Beut., 3, VI, 1894, 299, Plate X, Fig. 5; Morse, 99, VIII, 1897, 37, 112, Plate 2, Fig. 29; Lugg., 84, 1898, 168, Figs. 101, 102; McN., 91, XXIII, 1901, 399, 410; Walk., 218, XXXIV, 1902, 2.

Size, medium. Pronotum with the median carina low throughout; the metazona about twice as long as the prozona, its disk flat, with a number of scattered minute rounded tubercles, the hind margin obtuse angulate. Inner wings twice as long as wide.

General color, light to dark gray or reddish brown mottled with brown or fuscous; the sides of head, lower parts of thorax and abdomen and the legs, often nearly white. Tegmina brownish yellow, sprinkled with fuscous dots, which are sometimes, especially in the darker male, arranged so as to form three irregular but distinct transverse bands; more often the spots are scattered along the sides, being most abundant on the basal third. Inner wings with disk light yellow; the width of curved black band rarely more than one-sixth the length of wing; the apex transparent. Inner face of hind femora pale yellow with three black bands; the lower sulcus pale with a black spot near the apex; the outer face without distinct spots or bands. Hind tibiæ obscure yellowish.

Measurements: Length of body, male, 21 mm., female, 28 mm.; of antennæ, male, 10 mm., female, 11 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 24 mm., female, 28 mm.; of hind femora, male, 11.5 mm., female, 15 mm.

This species has been taken in Indiana only along the south shore of Lake Michigan, in Lake, Porter and Laporte counties, where it is common. It flies rapidly and noiselessly for long distances and, unless carefully marked down, is very difficult to detect. The darker specimens are always found at some distance from the lake, where there is a scattering vegetation; the light colored ones on the pure sand of the immediate shore. It has been seen nowhere more than a half mile back from the water margin, and then only on the bare crests of the highest sand ridges and dunes. The earliest date on which mature specimens have been taken was July 25th, and the latest October 15th, though they are doubtless to be found both before and after those dates. Its general range is given by McNeill as "Atlantic States from Virginia northward and along the shores of the Great Lakes west to Illinois."

52. TRIMEROTROPIS CITRINA Scudder.

Trimerotropis citrina Scudd., **147**, II, 1876, 265; Id., **168**, XXIII, 1893, 77; Id., **188**, 1900, 41; Sauss., **134**, 1884, 169; McN., IX, 1900, 31, 35; Id., **91**, XXIII, 1901, 401, 426; Walk., **218**, XXXIV, 1902, 1, 4.

Size, medium or large. Pronotum with the median carina very low; the metazona but little more than one and a half times as long as prozona; the disk flat, except on the prozona, where the sides are raised moderately, and smooth or nearly so; the hind margin decidedly obtuse angled, the tip rounded. Wings one and three-fourths times as long as broad.

General color ash gray or yellowish brown, sprinkled more or less with fuscous. The face usually light gray; the tegmina yellowish brown, the dark spots aggregated into three dark crossbars, indistinct in the female, plainly visible in the male. Wings pale lemon yellow at base, the fuscous band broad, the width being from one-fourth to one-fifth the length of wing; the sub-marginal ray short, extending less than half way to base. Inner face of hind femora yellow, with three fuscous bands; the lower sulcus yellow with a distinct sub-apical fuscous spot and traces of two others; the outer face plain yellowish brown or gray. Hind tibiæ pinkish red, paler at base.

Measurements: Length of body, male, 22 mm., female, 30 mm.; of antennæ, male, 11 mm., female, 12 mm.; of pronotum, male, 5 mm., female, 6.5 mm.; of tegmina, male, 27 mm., female, 34 mm.; of hind femora, male, 13 mm., female, 15.5 mm.

This is a somewhat larger and more bulky insect than Indiana examples of *T. maritima,* the male being nearly as large as the female of the latter. In general appearance the two closely resemble one another and are apt to be confounded when they occur together.

I have taken this species in but one locality in Indiana. This was on a long sand and gravel bar, along the north shore of the Ohio River, a half mile below Vevay, Switzerland County. Here it was common on September 23, 1898, but having no net, I was able to capture but three specimens. Its flight along this gravelly bank was much less prolonged than that of *maritima* on the more extensive sand beach of Lake Michigan. When approached it would rise straight upward a few feet, and then move lazily and without noise eight to 15 feet, and alight again, always on the bare sand or gravel. The gravel bar was at the foot of a terrace 30 feet or more in height and a quarter of a mile wide, the surface of which was cultivated. No trace of *citrina* was found on this area, though other locusts were abundant. It has been recorded heretofore from Maryland, Arkansas, Texas, Colorado and Nebraska, and therefore is to be regarded as a southern form, which may be found all along the gravelly banks of the Ohio River.

XXXIV. Psinidia Stal (1873).

This genus is closely allied to *Mestobregma,* the general appearance of our species being very similar. Head with the occiput much elevated, the vertex much as in *Mestobregma,* but the lateral carinæ more nearly converging in front; the foveolæ smaller, sub-circular. Frontal costa sulcate throughout, the upper half very narrow, the lower half gradually expanding. Antennæ, especially those of the male, long; the joints of basal half strongly flattened, the edges higher than the center. Pronotum strongly constricted in the middle, the disk nearly smooth, the front margin truncate, the hind margin acute angled; the median carina sharp, straight and of equal height throughout, cut by two notches in front of the middle; the lateral carinæ rather sharp and distinct on the metazona; sub-distinct on the prozona. Lateral lobes of pronotum with the front and hind margins as in *Mestobregma,* the lower margin with its front half arcuate, strongly directed upward. Tegmina narrowed, exceeding the abdomen about one-fourth their length; their basal half densely coriaceous; many of the cells in the front half of the middle third two to four times as long as wide. Inner wings with the basal third usually orange red; otherwise as in *Mestobregma,* except that the black curved median band is broader. Hind femora reaching tip of abdomen in female, slightly exceeding it in male. Hind tibiæ ringed with dusky and yellowish white.

One species of *Psinidia* occurs in the United States and Canada east of the Mississippi River.

53. PSINIDIA FENESTRALIS (Serville). The Long-horned Locust.

Œdipoda fenestralis Serv., 196, 1839, 726; Thom., 206, V, 1873, 118.

Psinidia fenestralis Stal, 200, I, 1873, 133; Sauss., 134, 1884, 161; Fern., 53, 1888, 44; Beut., 3, VI, 1894, 303, Plate VIII, Fig. 3: Morse, 99, VIII, 1897, 37, 111, Plate 2, Fig. 28; Bl., 15, XXX, 1898, 56; Lugg., 84, 1898, 166, Fig. 100; Scudd., 188, 1900, 40.

Locusta eucerata Harr., 70, 1833, 583; Id., 72, 1862, 180.

Œdipoda eucerata Scudd., 141, VII, 1862, 472; Glov., 62, 1872, Plate III, Figs. 1, 2; Plate V, Fig. 13; Plate VI, Fig. 23; Thom., 206, V, 1873, 119.

General color varying widely according to environment, from pale clay yellow to bright reddish brown or even blackish. Face yellowish brown, the cheeks grayish, the occiput and disk of pronotum darker. A narrow yellowish stripe extends back from eye on to disk of pronotum; the sides of latter with a fuscous bar near the middle. Teg-

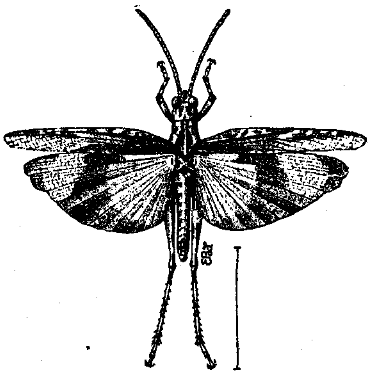


Fig. 60. *Psinidia fenestralis* (Serv.). Male. One and one-half times natural size. (After Lugger.)

mina yellowish or reddish brown, the lower half of sides with numerous small alternating light and dark spots; the upper half unspotted. Wings with the basal third usually orange or vermilion red, sometimes yellow; the middle third with a broad curved black band which reaches nearly to the anal angle; the front margin with a dusky bar reaching nearly to the base; the apical third pellucid. Outer face of hind femora reddish brown, with three dark, oblique bars on the upper half; inner face with alternating bands of black and yellow. Hind tibiæ whitish, with a dark ring at each end, and a broad one of the same color just above the middle; the apical halves of spines black.

Measurements: Length of body, male, 17 mm., female, 22 mm.; of antennæ, male, 12.3 mm., female, 11 mm.; of pronotum, male, 4.5 mm., female, 5.5 mm.; of tegmina, male, 19 mm., female, 21 mm.; of hind femora, male, 11.5 mm., female, 12.5 mm.

In Indiana the "long-horned locust" has been noted only in Lake, Porter and Laporte counties in the sandy area bordering Lake Michigan, where it was first taken July 27, 1897. It is most common along the beach within one-half mile of the lake, in company with *Trimerotropis maritima* (Harris) and *Spharagemon wyomingianum* (Thom.), though a few specimens were taken on sandy ridges five miles from the lake shore. It has a quick, short flight, and always chooses a bare, sandy spot on which to alight. Unless it is carefully "marked down" it is then very difficult to distinguish, since its colors harmonize so perfectly with its surroundings. By keeping an eye on it, and stealthily approaching it can readily be taken by throwing the net quickly over it just as it is in the act of rising. The male makes a slight rattling sound as it flies, but the movement of the female is noiseless. The majority of the specimens taken had the inner wings a bright red at base, though variations in color, from light yellow to deep red, were frequent. It may possibly be found to occur on the sand covered areas throughout the northern third of Indiana, though it is probable that it is limited to the area immediately adjoining Lake Michigan.

Sub-family ACRIDINÆ.

The Indiana species of this sub-family may be easily recognized by the presence of a distinct spine or tubercle on the prosternum between the front pair of legs. They vary much in size and general appearance, and among them are found our most injurious insects of the order Orthoptera.

The head is, in general, smaller and less swollen than in the two preceding sub-families. The face (except in *Leptysma*) is rarely very oblique, often nearly perpendicular. The disk of vertex is never sunken or concave, the lateral carinæ being low and rounded, or often obsolete. The foveolæ are often wanting or indistinct. The disk of pronotum is always free from tubercles and prominent wrinkles; has its hind margin usually broadly rounded, and never acute angled; the median carina always low and of nearly equal height throughout; and the lateral carinæ, with few exceptions rounded or obsolete. The tegmina are usually well developed, but in a number of species are very short, and in some extra-limital forms wholly wanting. The inner wings are never brightly colored as in the *Oedipodinæ*, but are usually transparent.

The prevailing color of most species of the sub-family is dull olivaceous brown; though a number of them are so striped or mottled with yellow, green or fuscous as to be decidedly handsome. Among the members of the principal genus (*Melanoplus*) there is considerable variation in color locally, "according to the character of the station where found, and also seasonably, whether collected early or late in the fall. As a rule specimens collected after a number of hard frosts are duller, darker and more suffused than summer examples, the coloration of the individual being apparently considerably modified by such exposure."

With one or two exceptions, all of our species pass the winter in the egg stage, and begin to reach maturity about June 1st, though most of them are not common until July. The Kentucky blue-grass and the different kinds of meadow grasses are then a darker green and, when rank, turn brown early in the autumn. The different species of *Melanoplus* and other locusts whose hues are olive green or brown, find in the fallen clumps of these grasses places of hiding well suiting their color, as well as an abundance of food well suiting their taste.

The males of *Acridinæ* rarely stridulate, and then only when at rest, by rubbing the inner surface of the hind femora against the outer surface of the tegmina.

Scudder, in his recent Catalogue of United States Orthoptera, lists 32 genera and 241 species as belonging to this sub-family. Of these, six genera and 26 species have been taken in Indiana. The genera may be distinguished by the following key:

KEY TO GENERA OF INDIANA ACRIDINÆ.

a. Face very oblique. Head as long as or longer than the pronotum; the vertex being prolonged and more or less acuminate. Antennæ acuminate, the joints flattened..............XXXV. LEPTYSMA, p. 287

aa. Face nearly vertical. Head shorter than the pronotum, the vertex advanced but little in front of the eyes. Antennæ filiform, the joints cylindrical.

b. Size large, the length of tegmina of female 27 or more mm. Lobes of mesosternum longer than broad, the inner margin straight. Sub-genital plate of male with a distinct U or V-shaped notch on its upper side. . XXXVI. SCHISTOCERCA, p. 289

bb. Size small or medium, the tegmina never over 25 mm. in length. Lobes of mesosternum transverse or equally long and broad, the inner margin usually rounded. Apex of sub-genital plate of male without a notch on its upper side.

c. General color when living, a bright, pale green, with a conspicuous purple line along the top of pronotum and dorsal part of closed tegmina. Vertex at its narrowest point between the eyes less than one and one-half times the width of second joint of antennæ. Sub-genital plate of the male with a more or less distinct sub-apical tubercle .... XXXVII. HESPEROTETTIX, p. 297

cc. Color usually dull, chiefly brownish or olivaceous. Vertex at its narrowest point between the eyes more than twice the width of second joint of antennæ. Sub-genital plate of male without a sub-apical tubercle.

d. Dorsal surface of pronotum never twice as long as the average breadth, generally only half as long again; the sides more or less constricted in the middle. Antennæ of male, less than twice the length of pronotum. Sub-genital plate of male with the apex rounded.

e. Head not large in proportion to pronotum, but little longer than the prozona. Pronotum not enlarged in front to receive the head. Cerci of male exceedingly variable, but very rarely styliform ..... XXXVIII. MELANOPLUS, p. 298

ee. Head swollen; large in proportion to the pronotum, nearly half as long again as the long prozona. Pronotum feebly flaring in front to receive the head. Cerci of male styliform.... XXXIX. PHŒTALIOTES, p. 334

dd. Dorsal surface of pronotum twice as long as average breadth; the sides parallel. Antennæ of male twice or more times as long as pronotum. Sub-genital plate of male broad, the apex truncate............ XL. PAROXYA, p. 335

XXXV. LEPTYSMA Stal (1873).

Body slender, sub-cylindrical. Head as long as pronotum; the vertex prominent, projected in front of the eyes in the form of an equilateral triangle; the lateral carinæ low, the median carina wanting. Face very oblique, the frontal costa low, a little narrowed below the ocellus, shallowly sulcate throughout; eyes longer than wide, set very obliquely on the head. Antennæ shorter than head and pronotum, tapering; the joints flattened. Pronotum almost cylindrical, the metazona a little the wider, the front margin truncate, the hind margin broadly rounded; the median carina very low; distinct only on the metazona; lateral carinæ obsolete. Lateral lobes of pronotum longer than wide; the front margin oblique, the hind margin concave, the lower margin sinuate. Prosternal spine short and rounded. Tegmina fully developed, the apical third gradually narrowed. Hind femora very slender, a little shorter than abdomen in both sexes. Cerci of male slender, tapering and bent abruptly upward and forward near the base. Sub-genital plate narrow, upturned and tapering to a point. Upper valves of ovipositor much longer than lower ones, their upper margins with a row of prominent teeth.

But one species of the genus occurs in the United States.

54. **Leptysma marginicollis** (Serville). **The Slender-bodied Locust.**
Opsomala marginicollis Serv., **196**, 1839, 591.
Opomala marginicollis Thom., **206**, V, 1873, 66, 196.
Leptysma marginicollis Stal, **200**, 1873, 86; Comst., **41**, 1888, 111, Fig. 102; Id., **42**, 1895, 111, Fig. 123; Bl., **6**, XXIV, 1892, 28; Id., **11**, XXVI, 1894, 221; Id., **16**, 1899, 241, Fig. 68; Scudd., **188**, 1900, 47; Id., **190**, IX, 1900, 116.

Ground color of living specimens light yellowish brown or fawn; unbroken except by a narrow, yellowish stripe, extending from the hind border of eye along the lower edge of pronotum to coxa of hind leg. In living specimens this line is bordered above by one of dark brown. When the insect is dried the brown and the tips of tegmina become darker.

Face, vertex, occiput and pronotum, densely punctured. Tegmina exceeding the abdomen by 3 to 5 mms. Wings transparent, equal to tegmina in male, slightly shorter in the female.

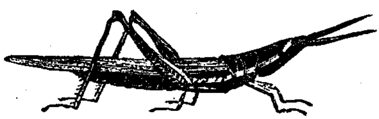


Fig. 61. *Leptysma marginicollis* (Serv.). (After Comstock).

Measurements: Length of body, male, 28 mm., female, 32 mm.; of antennæ, male, 8 mm., female 6 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 20 mm., female, 26; of hind femora, male, 14 mm., female, 17.5 mm.

This slender bodied, graceful species, has as yet been taken only in Vigo County, where, in October, 1892, it was found to be common on the tall sedges and rushes which grew near the margin of a large pond in the Wabash River bottoms, nine miles below Terre Haute. Its range before that time had been supposed to be a strictly southern one, it having been recorded only from Florida and North Carolina. Since then it has been found to extend across the southern United States from the Atlantic to the Pacific. Its occurrence in numbers as far north as central Indiana is, therefore, of especial interest, and can only be accounted for by the presence of the broad and sheltering valley of the Wabash, within the confines of which it finds a climate and a vegetation congenial to its taste.

In 1893 and 1894 the insect was still present, though in rapidly decreasing numbers as the pond was partially drained. I was much surprised to find, on May 21, 1893, a fully developed male with soft flabby wings, as though just moulted, though no others of any age were seen on that date. In October, 1902, I again visited the former site of the pond, but found only a vast cornfield, with no signs of this or other rare *Orthoptera*, which formerly dwelt in numbers in that locality. If still a member of the Indiana fauna, *marginicollis* will probably be found only about the margins of the larger ponds in the lower Wabash Valley.

At the locality mentioned, *marginicollis* was never seen on the grass or ground and never hopped when disturbed, but moved with a quick and noiseless flight for 20 or more feet to a stem of sedge or rush, on which it alighted. The instant it grasped the stem, it dodged quickly around to the side opposite the intruder. Then holding the stem firmly with its short front and middle legs, it drew its slender hind femora close up against the body, and folding the tibiæ into position, hugged its support as closely as possible, and remained perfectly motionless. Its body is almost cylindrical, and being of the same general color as the stalk of the plant on which it rested, it was almost impossible to detect it, unless one saw exactly where it alighted. Eight times out of ten a person, by approaching quietly, could reach his hand about the plant stem and grasp the insect. Its habits excellently illustrated the so-called "protective mimicry" of form and coloring, as it always seemed to choose a cylindrical object, and one similar to its own color before alighting.

XXXVI. Schistocerca Stal (1873).

Locusts of large size. Vertex with the front sloping downward and passing insensibly into the frontal costa; the lateral carinæ low and indistinct, the median carina wanting, the foveolæ very small, often obsolete. Face nearly vertical. Eyes oblong, oval, prominent. Antennæ of medium length, filiform. Disk of pronotum with the sides sloping on the prozona, the metazona usually flat or nearly so; the front margin truncate, the hind margin either broadly rounded or, in some males, obtuse angled; the median carina low but distinct, cut three times by the transverse sulci; the lateral carinæ wanting. Lobes of mesosternum longer than broad. Tegmina always fully developed. Inner wings of large expanse, transparent or nearly so. Hind femora slender, usually equaling or exceeding tip of abdomen. Hind tibiæ with smooth margins, and with numerous spines in regular rows on each side, but with no apical spine on the outer margin. Second tarsal joint only half as long as the first. Male with cerci oblong and of nearly equal breadth throughout; the sub-genital plate strongly upcurved, its apex deeply notched. Valves of ovipositor strongly exserted.

Eleven species of the genus occur in the United States. Of these, four have been taken in Indiana.

KEY TO INDIANA SPECIES OF SCHISTOCERCA.

a. Antennæ of male not more than one-fourth longer than head and pronotum together.

- *b.* Size very large. Tegmina of female much exceeding the abdomen: Disk of pronotum flat or nearly so, the median stripe broad ....55 *americana*, p. 290
- *bb.* Size small. Tegmina of female but little if any exceeding the abdomen. Disk of pronotum with sides distinctly sloping, the median stripe confined to the carina.......56 *damnifica*, p. 293

aa. Size, medium. Antennæ of male one-third or more longer than the head and pronotum together.

- *c.* General color yellowish brown or olive green; a distinct pale yellow mid-dorsal stripe on head, pronotum and closed tegmina ....57 *alutacea*, p. 294
- *cc.* General color rusty brown. No yellow stripe on dorsal surface ....58 *rubiginosa*, p. 296

55. SCHISTOCERCA AMERICANA (Drury). The American Locust.

Gryllus americanus (Drury), 48, I, 1770, 128, Plate 49, Fig. 2.

Acridium americanum Scudd., 141, VII, 1862, 466; Rathv., 109, 1862, 385, Fig. 25; Thom., 202, V, 1865, 448, 452; Id., 206, V, 1873, 172, Fig. 8; Id., 211, IX, 1880, 91, 129, Fig. 10; Glov., 62, 1872, Plate I, Fig. 15; Riley, 117, VIII, 1876, 103, Fig. 40; Id., 118, IX, 1877, 84, Fig. 17; Id., 214, I, 1878, 236, 448, Fig. 6; Id., 122, II, 1884, 194, Fig. 269; Comst., 41, 1888, 106, Fig. 96; Beut., 3, VI, 1894, 304, Plate IX, Fig. 3.

Acridium (*Schistocerca*) *americanum* Stal, 200 I, 1873, 66.

Schistocerca americana Brun., 22, I, 1885, 136; Id., 28, XXVIII, 1893, 10, Fig. 1; Id., 30, 1893, 462, Fig. 106; Id., 31, 1894, 163, 204, Fig. 66; Id., 34, 1896, 122, Fig. 24; Id., 35, 1899, 133, Fig. 75; Id., 36, 1899, 270, Fig. 63; Bl., 4, XXIII, 1891, 79; Id., 9, VI, 1893, 465; Id., 16, 1899, 238, Fig. 63; How., 75, VII, 1895, 220, 429, Figs. 19-22; Weed, 222, 1897, 67, Figs. 21-25; Lugg., 84, 1898, 174, Figs. 105, 106; Morse, 100, VIII, 1898, 255, 271; Scudd., 184, XXXIV, 1899, 447, 474; Id., 188, 1900, 47.

Size large, the female often two inches or more in length. Vertex hexagonal, the disk a little depressed. Frontal costa prominent, sulcate in the middle below the ocellus; a little narrowed below point

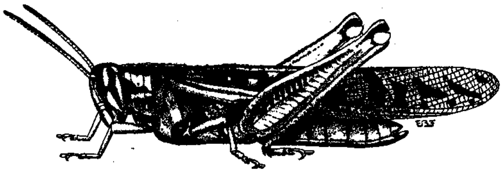


Fig. 62. *Schistocerca americana* (Drury). Male. (After Lugger).

of union with the vertex. Antennæ but little, if any, longer than head and pronotum together. Disk of pronotum flat on metazona, the sides rounded and sloping on prozona, the surface marked with minute shallow cells, or densely punctate, the hind margin broadly rounded. Tegmina exceeding the abdomen one-fourth or more their length in both sexes. Hind femora slender, reaching tip of abdomen. Spine of prosternum large, curved somewhat backward. Notch of sub-genital plate of male narrow but deep.

Color, reddish brown, often with a slight vermilion tint. A yellow stripe extends from the vertex along the middle of head, pronotum and closed tegmina as far as the tip of the abdomen. A dark brown line runs from the lower side of eye down the cheek. Sides of pronotum with a broad yellowish stripe on upper third and a short and narrow yellow dash near the center; the lower margin yellowish. Tegmina with numerous large dark brown spots, separated by light interspaces; the costal or lower margin whitish yellow, mottled with darker. Wings transparent, the nerves of basal portion yellowish. Outer face of hind femora reddish brown, with one or two dark streaks along the upper third. Hind tibiæ vermilion red, duller in dried specimens; the spines yellow, tipped with black.

Measurements: Length of body, male, 42 mm., female, 50 mm.; of antennæ, male, 13 mm., female, 14 mm.; of pronotum, male, 9 mm., female, 11 mm.; of tegmina, male, 43 mm., female, 53 mm.; of hind femora, male, 24 mm., female, 30 mm.

This is the largest locust found in the State, and when freshly moulted, one of the most handsome. It probably occurs in all the counties but is much less common in the northern half, though I have taken it in Fulton, Starke, Lake and Porter. Freshly moulted, mature specimens, from eggs hatched in spring, have been taken in Vigo County on June 18th, and on three different occasions numerous specimens have been seen as late as November 22d. On this date, in Marion County, when the government thermometer registered 17° in the morning, several were flushed in the afternoon, though a cold raw wind was blowing. In central and southern Indiana it is more abundant in mid-autumn than in summer. There occasionally may be two broods in one season, as I have found the nymphs common in Vigo County on October 15th and 21st.

This species is noted for its extended migrations and when a second brood appears, they are doubtless from eggs laid by mature specimens which have entered the State in early spring. About 3 o'clock in the morning of April 11, 1893, the city of Terre Haute, Indiana, was visited with a severe storm of rain and wind from the southwest. A number of buildings were unroofed and many shade and forest trees twisted and broken off. While on my way to the High School building several persons informed me that they had, that morning, seen specimens of "gigantic grasshoppers" on the street, but were unable to capture them. About 10 o'clock one of my former pupils brought me two living specimens of *S. americana* which she had picked up from the sidewalk near her home. They had come sailing in on the wings of the wind from some distant point in the southwest, where they had passed the winter in the mature state or as an advanced form of the young. Mature individuals which had doubtless migrated have also been taken in Lake County on May 13th.*

In the southern portion of Indiana, *americana* is always found in dry, upland localities, such as the borders of roads, old meadows, weed and stubble fields, prairies, and especially in old abandoned fields which have grown up to oak and other shrubs. In the northern portion it occurs in damper localities, being found in the tall grasses and sedges along the borders of sloughs and marshes and in the meadows bordering lakes and tamarack marshes. When flushed it rises quickly and with a fluttering noise, makes a long, wavering, jerky flight, and alights upon the bole or branch of tree or shrub, a fence, or some other object some distance above the earth; seldom,

*At Ormond, Florida, this locust was abundant and mature in early March, 1899, and it may pass the winter in the mature stage in some of the States much farther north.

if ever, settling on the ground. If then approached, it dodges around the object upon which it rests, much as does a squirrel under the same circumstances.

Of the distribution of the American locust Scudder has written: "Excepting *S. peregrina,* which has crossed the ocean and colonized another world, *S. americana* is the most widely distributed member of the genus, and merits its name, ranging as it does from North America east of the Great Plains and south to about latitude 40°; through the West Indies, Mexico and Central America to South America, where it occurs as far as Columbia in the west and Argentina in the east, though the records of its occurrence in South America are few. North of north latitude 40° or thereabouts, sporadic cases of its appearance are recorded, notably in Massachusetts and southern Ontario; these are doubtless accidental visitants, flying from their proper home farther south."

56. SCHISTOCERCA DAMNIFICA (Saussure).

Acridium damnificum Sauss., 128, II, 1861, 14.

Schistocerca damnifica Scudd., 184, XXXIV, 447, 475; Id., 188, 1900, 47; Bl., 18, 1902, 48, 222.

Cyrtacanthacris unilineata Walk., 219, IV, 1870, 611.

Acridium unilineatum Thom., 188, V, 1873, 170.

Acridium appendiculatum Scudd., 162, XIX, 1877, 86; Id., 161, VI, 1878, 27.

Acridium rubiginosum Thom., 206, V, 1873, 170; Id., 211, IX, 1880, 91, 128 (not Harris).

Size of male small; of the females medium and more bulky. Head small; the disk of vertex hexagonal. Frontal costa sulcate, and with the sides parallel below the ocellus, a little expanded and flat just above, then narrowed at point of union with vertex. Antennæ of male stout, but little, if any, longer than head and pronotum together. Disk of pronotum with the surface very rough with small pits and impressions, the sides strongly sloping, the median carina relatively high, and a little arched, the hind margin right angled in the male, obtuse angled in the female. Tegmina of male usually equaling or slightly exceeding the abdomen; those of female a little shorter; broader than in *alutacea.* Hind femora of female shorter than abdomen. Notch of sub-genital plate of male deep and narrowly V-shaped.

Color, a nearly uniform dark rust red. A narrow brownish yellow line on occiput and carina of pronotum. Tegmina often with small, dim dusky spots. Outer face of hind femora sometimes whitish, with dark narrow oblique lines arranged herring-bone fashion.

Measurements: Length of body, male, 25 mm., female, 42 mm.; of antennæ, male, 10 mm., female, 11 mm.; of pronotum, male, 7 mm., female, 9.5 mm.; of tegmina, male, 22 mm., female, 27 mm.; of hind femora, male, 16 mm., female, 19 mm.

This is a locust of southern range, which in Indiana has been taken only in Crawford County. A single female was secured May 10, 1899. This was probably a migrant, as this is a very early date for eggs hatched in spring to mature, and it is not known that the species winters in the nymph stage. Other specimens were taken in June and July, 1902. It frequents old fields and roadsides on the crests of the higher hills near Wyandotte, and is probably to be found in similar localities in the southern third of the State. When flushed they fly long distances and often alight on the limbs of trees or fence posts, around which they dodge, and from which they may often be taken with the hand.

Thomas has taken *damnifica* in southern Illinois, and Scudder says that it "is a common southern species, occurring in the United States east of the Great Plains, from Pennsylvania, Indiana, Illinois and Arkansas to the Gulf." He gives no Indiana locality. In 1899 I found it abundant at Ormond, Florida, on March 11th and later.

57. SCHISTOCERCA ALUTACEA (Harris). The Leather-colored Locust.

Acridium alutaceum Harr., 71, 1841, 139; Id., 72, 1862, 173; Scudd., 141, VII, 1862, 466; Rathv., 109, 1862, 384, Fig. 25; Glov., 62, 1872, Plate VIII, Fig. 13; Plate X, Fig. 13; Thom., 206, V, 1873, 171; Comst., 41, I, 1888, 106; Fern., 53, 1888, 30; Bl., 4, XXIII, 1891, 79; Beut., 3, VI, 1894, 304, Plate IX, Fig. 2.

Schistocerca alutacea Brun., 29, III, 1893, 26; Lugg., 84, 1898, 172; Morse, 100, VIII, 1898, 255, 270, Plate 7, Fig. 32; Scudd., 184, XXXIV, 1899, 445, 464; Id., 188, 1900, 47.

Acridium emarginatum Dodge, 44, IV, 1872, 15; Scudd., 147, 1872, 250; Thom., 206, V, 1873, 172; Id., 211, IX, 1880, 91, 128.

Schistocerca amarginata Brun., 29, III, 1893, 26; Id., 33, II, 1895, 7, Fig. 46; Lugg., 84, 1898, 173, Fig. 104.

Size medium, the female much the larger, with more robust body. Vertex rather prominent, narrow, the disk sub-rhomboidal, but little depressed, the lateral carinæ low, distinct only on front half. Frontal costa narrow, sulcate below the ocellus. Antennæ of male one and a half times as long as head and pronotum together, the joints a little flattened. Disk of pronotum flat on metazona, the sides higher and sloping on prozona, the hind margin broadly obtuse angled; the surface densely punctate; the median carina low but distinct. Prosternal spine large, cylindrical, the apex rounded.

Tegmina exceeding the abdomen about one-fourth their length in both sexes. Hind femora slender, reaching the tip of abdomen in female, exceeding it slightly in male. Cerci of male short oblong, the upper edge concave or broadly notched; the notch of sub-genital plate U-shaped, about as broad as deep.

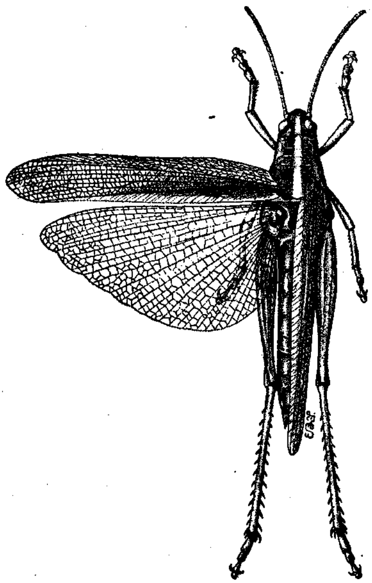


Fig. 63. *Schistocerca alutacea* Harris. Female. (After Lugger.)

Color, yellowish brown to olive green, darker in old or dried specimens. A narrow bright yellow line runs from the front of vertex back over head, pronotum and middle of closed tegmina. Sides of tegmina with often a few minute fuscous spots. Wings transparent yellowish, the veins darker. Sides of abdomen with a row of black dots on the hind margin of each segment. Outer face of hind femora reddish brown or yellowish with a row of black dots along the upper and lower margins. Hind tibiæ reddish; the spines yellowish, tipped with black.

Measurements: Length of body, male, 30 mm., female, 45 mm.; of antennæ, male and female, 16 mm.; of pronotum, male, 7 mm., female, 10 mm.; of tegmina, male, 26 mm., female, 38 mm.; of hind femora, male, 18 mm., female, 25 mm.

This species has been taken only in the western half of the State from Monroe County northward. It is abundant about the marshy meadows and sloughs in Fulton, Lake and Starke counties, where it has been taken on August 15th in numbers. There it makes its home in the rank grasses, weeds and rushes which grow in such places. The males are everywhere much more abundant and more active than the females, though they usually fly a shorter distance. In Vigo County it is frequent in patches of raw prairie and along the edges of thickets bordering them; also in many places along the railways, especially where they pass through prairie regions. Both sexes, when flushed, arise with a whirring noise which, however, is not a true stridulation. The males usually fly about 50 feet and settle down on the grass or on a low shrub. This locust will doubtless be found to inhabit suitable localities throughout the State, as it has been taken from New England to California.

58. **Schistocerca rubiginosa (Harris-Scudder). The Rusty Locust.**

Acridium rubiginosum Scudd., **141**, VII, 1862, 467; Glov., **62**, 1872, Plate V, Fig. 5; Riley, **122**, II, 1884, 194; Comst., **41**, 1888, 106; Fern., **53**, 1888, 30; Beut., 3, VI, 1894, 304, Plate IX, Fig. 1.

Schistocerca rubiginosa Morse, **93**, VII, 1894, 105; Id., **100**, VIII, 255, 269, Plate 7, Fig. 31; Scudd., **184**, XXXIV, 1899, 445, 462; Id., **188**, 1900, 48.

Schistocerca alutacea Rehn., **111**, XIII, 1902, 89; Id., **112**, 312.

Size, medium; the body of the female especially bulky. Head and pronotum wider than in *alutacea*, but the vertex less prominent. Frontal costa wider and flatter than in *alutacea*, sulcate below the ocellus. Antennæ of male a third longer than head and pronotum together. Pronotum with the sides sloping on both prozona and metazona; the median carina more prominent than in *alutacea*, otherwise the same. Tegmina exceeding the abdomen in both sexes. Notch at apex of cerci of male less evident than in preceding species; that of sub-genital plate narrower, more V-shaped.

Color a nearly uniform rusty brown, without median yellow stripe on head and pronotum; the tegmina usually with numerous dim, rounded fuscous spots on the sides. Wings transparent and glassy, slightly reddish toward the tip.

Measurements: Length of body, male, 30 mm., female, 43 mm.; of antennæ, male, 13 mm., female, 15 mm.; of pronotum, male, 7 mm., female, 10 mm.; of tegmina, male, 27 mm., female, 37 mm.; of hind femora, male, 17 mm., female, 22 mm.

This seems to be a scarce locust in Indiana, having been taken only in Porter County. It prefers dry upland pastures and woodland, especially those with a soil of sand, where scrub oaks abound. Its habits are the same as those of *alutacea*. Rehn, *loc. cit.* has placed it as a synonym of that species; but, aside from the color, the shorter antennæ, less prominent vertex and frontal costa, and more sloping disk of pronotum are sufficient to show its distinctness. The mere fact that on one or two occasions, opposite sexes of it and *alutacea* were found in copulation is no proof of their identity in species, for such widely diversified forms as *Melanoplus bivittatus* and *Melanoplus differentialis* have been noted thus. *Rubiginosa* ranges over the United States east of the Great Plains and will doubtless be found to inhabit dry sandy localities in many portions of the State.

XXXVII. Hesperotettix Scudder (1876).

Size small; the sides nearly parallel; not greatly compressed. Head small, the vertex opposite the middle of eyes but little wider than second joint of antennæ; the portion in front with a slight median furrow or depression. Face but little oblique, the frontal costa narrow, sulcate throughout, punctate. Antennæ of female equaling the head and pronotum together; a fourth longer in the male. Pronotum longer than in allied genera except *Paroxya,* the prozona half as long again as metazona, the sides of disk broadly sloping; the median carina low, not cut by the first and second sulci; the hind margin very obtusely angulate. Lateral lobes of pronotum with the front and hind margins nearly straight, oblique; the lower margin with its front half directed upward. Tegmina usually equaling or slightly exceeding the tip of abdomen. Fore and middle femora of male swollen; hind femora slender, much surpassing the abdomen. Subgenital plate of male entire, but with a more or less distinct subapical tubercle.

Seven nominal species are known from the United States, mostly from west of the Mississippi River. One has been taken sparingly in northern Indiana.

59. Hesperotettix pratensis Scudder.

Hesperotettix pratensis Scudd., 181, 1897, 57, 64, Plate V, Fig. 3; Id., 188, 1900, 50; Lugg., 84, 1898, 177, Fig. 107; Brun., 36, 1899, 247, 271.

Ommatolampis viridis Thom., 206, V, 1873, 156 (in part).

Pronotum slightly increasing in size from in front backward. Tegmina equaling or slightly exceeding the abdomen in both sexes. Supra-anal plate of male triangular, the middle of either half with a distinct ridge, which converge and enclose a basal groove, in which lie the minute, rounded furcula. Cerci, shorter than supra-anal plate, conical, tapering to a rather sharp point. Tubercle on subgenital plate indistinct. (See Fig. 1, Plate I.)

Color, bright pale green. A short fuscous bar below each eye and on middle of sides of pronotum; also one along middle of occiput. Antennæ pinkish. Disk of pronotum with a pinkish or purplish stripe along its middle, extending back along median line of closed tegmina, and fading insensibly into the green of their sides. Hind femora green, more or less tinged with purplish. Hind tibiæ, pale bluish green; the spines whitish, tipped with black. Abdomen greenish yellow.

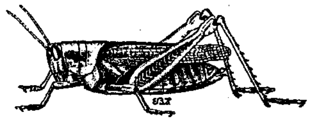


Fig. 64. *Hesperotettix pratensis* Scudd. Female. Natural size. (After Lugger).

Measurements: Length of body, male, 17 mm., female, 24 mm.; of antennæ, male, 8 mm., female, 9 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 12 mm., female, 17 mm.; of hind femora, male, 11 mm., female, 13.5 mm.

This dainty and prettily colored species has been noted only in Lake County, where it has been taken in two localities. On September 19, 1898, a single pair were secured from the long grasses bordering the margin of a swale north of Millers. Though careful search was made there and elsewhere in the northern counties, no others were secured until July 24, 1902, when I found them rather common in a long, low, marshy tract, a mile southeast of Hammond. Here the males were especially active, leaping from one grass stem to another several times in succession, and dodging around the stem the instant they clasped it with their legs. The females were oftentimes easily picked up by the fingers from their resting places. No attempt was made by either sex to use the wings in escaping.

Pratensis ranges, according to Scudder, from the "Mississippi River westward to California;" though he also names southern Illinois as one of its localities. It should be looked for along the edges of prairies and marshes throughout the western half of Indiana.

XXXVIII. Melanoplus Stal (1873).

Body moderately stout; generally feebly compressed. Head not prominent,* but little if any longer than the prozona. Face almost vertical. Vertex between the eyes but little wider than the frontal costa; the front half sloping downward, and always more or less sulcate, especially in the male. Frontal costa of average width and

* Except in *punctulatus*.

prominence, usually sulcate below the ocellus. Antennæ slender, filiform, never more than twice as long as the pronotum. Disk of pronotum usually only half as long again as the average breadth; the prozona distinctly longer than the metazona, its edges parallel, its surface a little convex and faintly punctate; metazona with its edges more or less diverging backward, its surface flat and densely punctate; front margin truncate, hind margin obtuse angulate; the median carina low but distinct on the metazona, often faint or obsolete on the prozona; the lateral carinæ obsolete. Lateral lobes of pronotum vertical or nearly so, and usually marked on their upper half with a blackish band. Tegmina always present, in some species being mere oval or lanceolate scales, but little, if any, longer than the pronotum; in others fully developed and then attaining or a little surpassing the tips of the hind femora.* Wings either represented by minute scales or fully developed, transparent, colorless. Hind femora moderately long and slender, usually equaling the tip of abdomen in the female and surpassing it in the male. Cerci of male exceedingly variable in form, often enlarged at apex, never styliform, and usually about the length of the sub-genital plate. Furcula usually developed and to a variable extent and also variable in form; so that they and the cerci furnish characters much used in separating the species one from another.

This genus comprises more species than does any other of the North American Orthoptera, no less than 146 being listed by Scudder from the United States and Canada. Of these 17 have been taken in Indiana. Some of these, to the casual observer, may seem very similar in size, color and general appearance, but a close examination of the abdominal appendages of the male will at once prove their distinctness. The tyro will probably have much difficulty in separating the females of the different species; in fact, he can only do so by taking the two sexes in the field, where they are usually to be found associated together. While dull colored and uninteresting to most people, the members of this genus form the most characteristic group of our Acrididæ. To it belong our most common locusts and the ones which do the most injury. From mid-May until late November they leap from our pathway in numbers, whether we stroll through open woodland, sunny meadow, or along the roadside; while in the back yards and on the lawns of our city homes they swarm in great profusion.

*None of our species, unless it be *fasciatus*, are dimorphic as regards wing length. I have seen only the short winged form of *fasciatus*, in Indiana, though a long winged one is known.

The Kansas or Rocky Mountain grasshopper, *Melanoplus spretus* (Uhler), belongs to this genus, but does not occur in Indiana. Contrary to the general belief, it is not a large, robust species, being but about the same size as our red-legged grasshopper, *M. femur-rubrum* (DeG.), and bearing to the latter a close general resemblance; so close, in fact, that only specialists can readily tell them apart. Millions of dollars of damage was done in the Western States by these small insects in the summers of 1873 and 1875. Migrating in vast clouds from one part of the country to another they would fall upon a cornfield and convert, in a few hours, the green and promising acres into a desolate stretch of bare, spindling stalks and stubs. In the words of the prophet Joel: "The land was as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing did escape them."

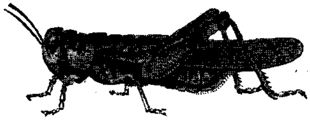


Fig. 64½. *Melanoplus spretus* (Uhler). Male. Natural size.

The following key will aid in the separation of the 17 Indiana species of the genus:

KEY TO THE INDIANA SPECIES OF MELANOPLUS.

a. Tegmina much shorter than the abdomen; often no longer than the pronotum. Furcula of male almost always feebly developed, usually no longer than the last dorsal segment to which they are joined.

b. Cerci of male either equal or tapering beyond the middle, no broader at apex than at the middle, usually laminate. Tegmina ovate, about the length of the pronotum.

c. Lateral lobe of pronotum a uniform wood brown in the female; with a faint dusky bar on upper half in male. Hind femora of male not barred with blackish. Hind tibiæ red ....60 *scudderi*, p. 302

cc. Lateral lobe of pronotum in both sexes with a broad shining black bar along the upper half; the lower half yellowish white. Hind femora of male with two distinct oblique blackish bars. Hind tibiæ pale green........... 61 *viridipes*, p. 305

bb. Cerci of male with the apex more or less expanded, broader at obovate or narrowly oblong, or longer than pronotum and lanceolate.

d. Tegmina shorter than pronotum, and with a wide interval between their inner edges.

e. Hind margin of pronotum without a trace of median notch. Cerci of male truncate at tip. Furcula cylindrical, tapering .... 62 *obovatipennis*, p. 306

ee. Hind margin of pronotum with a minute but distinct notch in the middle. Cerci of male rounded at tip. Furcula not cylindrical or tapering.

f. Tegmina narrowly oblong. All the femora green. Furcula minute, rounded........ 63 *gracilis*, p. 308

ff. Tegmina broadly ovate. All the femora brown. Furcula well developed, very broad at base, more or less angled or bifid at middle ....64 *morsei*, p. 309

dd. Tegmina lanceolate, longer than pronotum, their inner edges overlapping.

g. Subgenital plate of male distinctly narrower than long, its extremity strongly elevated. Middle of male cerci but little narrower than base. Tegmina covering two-thirds or more of abdomen .... 65 *fasciatus*, p. 311

gg. Sub-genital plate of male short and broad, its extremity but little elevated. Middle of male cerci distinctly narrower than the base. Tegmina covering but one-half the abdomen ....66 *blatchleyi*, p. 313

aa. Tegmina (except in the female of *extremus*) as long as or longer than the abdomen. Furcula usually either well developed or obsolete.

h. Cerci of male either equal or tapering beyond the middle, the tip usually slender or acuminate, never forked.

i. Apex of sub-genital plate of male with a median notch. Cerci short and nearly equally broad throughout, their length not more than twice as much as the middle breadth ....67 *atlanis*, p. 314

ii. Apex of sub-genital plate of male entire. Cerci at least three times as long as the middle breadth, generally slender, the apical half sometimes much narrower than the basal.

j. Sub-genital plate of the male nearly as broad at apex as at base; the apex elevated above the lateral margins, and terminating in a tubercle. Cerci of male narrowing but little in apical half................. 68 *impudicus*, p. 316

jj. Sub-genital plate of male distinctly narrower at apex than at base, the apex not elevated above the lateral margins. Apical half of cerci distinctly narrower than the basal half.

k. Tegmina much surpassing the hind femora; hind tibiæ bright red. Apical half of male cerci much less than half as broad as the extreme base ....69 *femur-rubrum*, p. 317

kk. Tegmina shorter than hind femora; those of female shorter than abdomen. Hind tibiæ pale red or yellowish. Apical half of male cerci distinctly more than half as broad as the extreme base .... 70 *extremus*, p. 319

hh. Cerci of male with the apex more or less expanded so as to be broader at some point beyond the middle than at the middle; the tip spatulate or sub-spatulate or forked.

l. Cerci of male not forked, the tip no broader than the base. Furcula well developed, at least a third as long as supra-anal plate .... 71 *angustipennis*, p. 321

ll. Cerci of male either distinctly forked or with a sub-median process or angle; or else expanded so as to be very much broader at the tip than at the base. Furcula wanting or minute.

m. Size small, the male being less than 20 mm. in length. Cerci always forked or with a sub-median angulation.

n. Lower fork of cerci merely an angle or median process. Furcula consisting of slender spines. Bases of lateral margins of sub-genital plate incurved .... 72 *minor*, p. 322

nn. Forks of cerci nearly equal, distinct. Furcula consisting of short triangular lobes. Lateral margins of sub-genital plate nowhere incurved .... 73 *luridus*, p. 324

mm. Size larger, the length of male being more than 20 mm. Cerci with the apical half much enlarged, but never distinctly forked.

o. Tegmina without distinct roundish fuscous spots. Length of body of male more than 25 mm. Front margin of pronotum not flaring to receive the head.

p. Pronotum without light colored lateral stripes. Hind tibiæ yellow. Furcula of male wholly absent.................... 74 *differentialis*, p. 326

pp. Pronotum with light colored lateral stripes along the margin of the disk. Hind tibiæ red or purplish. Furcula present but small .... 75 *bivitattus*, p. 329

oo. Tegmina with distinct roundish fuscous spots. Length of body of male less than 23 mm. Front margin of pronotum slightly flaring to receive the prominent head................ 76 *punctulatus*, p. 331

60. MELANOPLUS SCUDDERI (Uhler). Scudder's Short-winged Locust.

Pezotettix scudderi Uhl., 2 1 2, II, 1864, 555; Thom., 2 0 6, V, 1873, 152; Id., 2 1 1, IX, 1880, 95, 121; Comst., 4 1, 1888, 107; Bl., 4, XXIII, 1891, 80; Beut., 3, VI, 1894, 309, Plate VIII, Fig. 6.

Melanoplus scudderi Scudd., **179**, XXXVI, 1897, pp. 8, 33; Id., **181**, 1897, 125, 212, Plate 14, Figs. 5, 6; Id., **188**, 1900, 63; Lugg., **84**, 1898, 184, Fig., 108; Morse, **100**, VIII, 1898, 256, 280, Plate 7, Fig. 37.

Pezotettix unicolor Thom., **206**, V, 1873, 151; Id., **208**, V, 1875, 888, Plate XLV, Fig. 4; Id., **211**, IX, 1880, 95, 118; Glov., **62**, 1873, Plate XIII, Fig. 9.

Size medium or small. Vertex but little elevated above the pronotum, the interspace between the eyes of the female, about as broad as frontal costa, narrower in the male; its front half strongly sloping downward; the median sulcus shallow. Frontal costa feebly sulcate at and below the ocellus. Antennæ about three-fourths (male) or less than two-thirds (female) as long as hind femora. Pronotum with the disk broadly convex; the prozona from a fourth to a half longer than the densely punctate metazona, the median carina distinct, but low and equal throughout; front margin truncate or nearly so, and often faintly notched in the middle; hind margin obtuse-angled. Tegmina about as long as the pronotum, broad ovate in shape, their inner edges a little separated or just touching in the male, often overlapping in the female. Wings not half the length of the tegmina. Cerci of male sub-falcate, about twice as long as their basal breadth; the rounded apex about half as broad as the base. Furcula minute, triangular. (See Fig. 2, Plate I.)

Color: Dull reddish or wood brown, nearly uniform in the female. The male, and sometimes the female, with an indistinct dusky bar reaching from the eye back along the upper half of each lateral lobe of pronotum as far as the metazona. Hind femora with two faint dark bars on their upper face, the knees blackish. Hind tibiæ bright red, often paler at base, the spines black.

Measurements: Length of body, male, 19 mm., female, 24 mm.; of antennæ, male and female, 8 mm.; of pronotum, male, 6 mm., female, 7 mm.; of tegmina, male, 6 mm., female 7 mm.; of hind femora, male, 11 mm., female, 13 mm.

This short-winged, dull colored locust occurs throughout the State, but is more common southward. On account of its short tegmina, persons who are interested in Orthoptera are very apt at first to regard it as a nymph of some other species. In the central counties it begins to reach maturity about August 5th, and has been taken as late as November 22d. It is one of the most common of the late autumn locusts, frequenting the borders of open woods, fence rows and roadsides, especially in dry situations where blue-grass abounds. On warm sunny afternoons in November, it may often be seen resting quietly on the sides of logs, or the lower part of rail or board fences,

EXPLANATION OF PLATES I AND II.

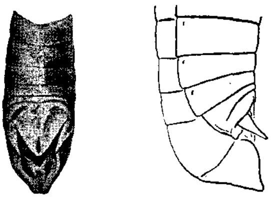
PLATE I.

Fig. 1. *Hesperotettix pratensis* Scudder.
2. *Melanoplus scudderi* (Uhler).
3. *Melanoplus viridipes* (Walsh).
4. *Melanoplus obovatipennis* (Bl.).
5. *Melanoplus gracilis* (Brun.).
6. *Melanoplus morsei* Bl.
7. *Melanoplus fasciatus* (Walker).
8. *Melanoplus blatchleyi* Scudd.
9. *Melanoplus atlanis* (Riley).
10. *Melanoplus impudicus* Scudder.

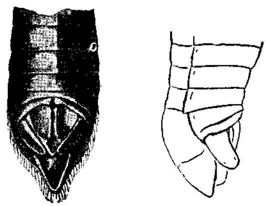
PLATE II.

Fig. 11. *Melanoplus femur-rubrum* (DeG.).
12. *Melanoplus extremus* (Walker).
13. *Melanoplus angustipennis* (Dodge).
14. *Melanoplus minor* (Scudder).
15. *Melanoplus luridus* (Dodge).
16. *Melanoplus differentialis* (Uhler).
17. *Melanoplus bivittatus* (Say).
18. *Melanoplus punctulatus* (Uhler).
19. *Phœtaliotes nebrascensis* (Thom.).
20. *Paroxya hoosieri* (Bl.).

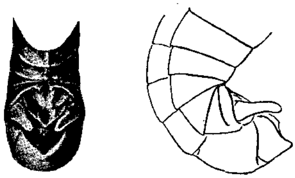
PLATE I.



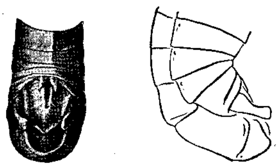
1



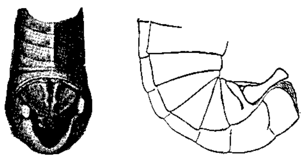
2



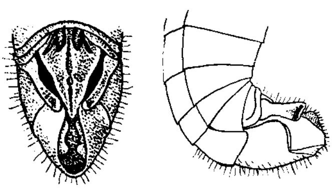
3



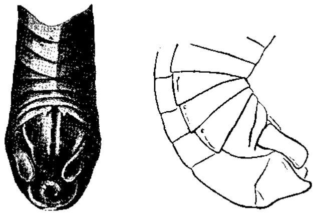
4



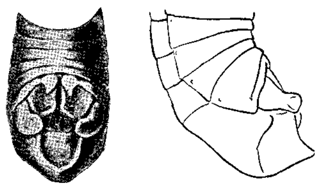
5



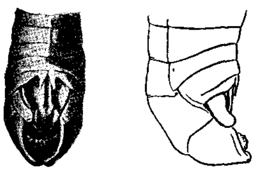
6



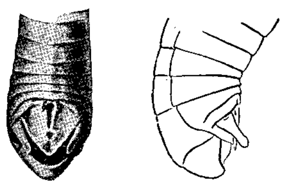
7



8



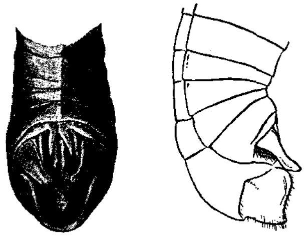
9



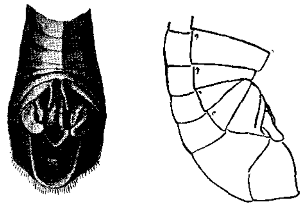
10

MALE ABDOMINAL APPENDAGES OF HESPEROTETTIX AND MELANOPLUS.

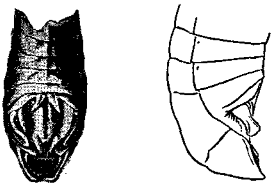
PLATE II.



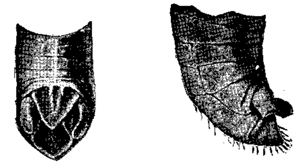
11



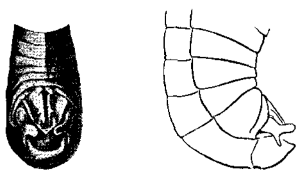
12



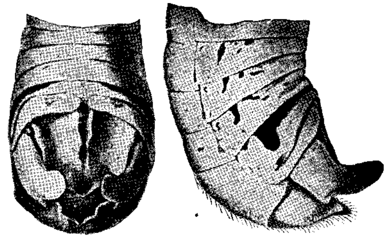
13



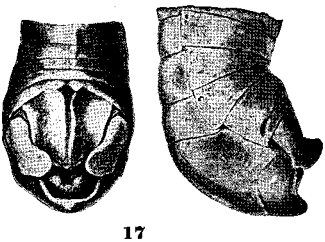
14



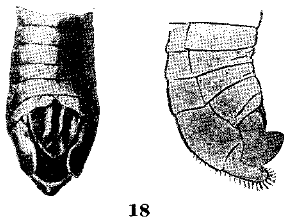
15



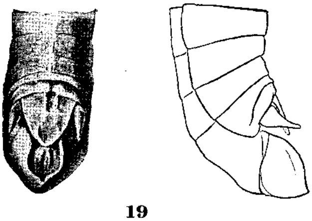
16



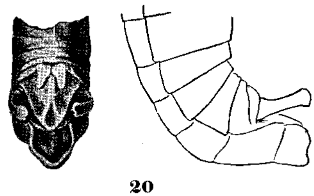
17



18



19



20

MALE ABDOMINAL APPENDAGES OF MELANOPLUS, PHŒTALIOTES AND PAROXYA.

and apparently enjoying the sunshine. It is able to withstand quite severe frosts and has been seen in copulation as late as November 15th. The general range of *scudderi* is over the United States east of the Great Plains.

61. **Melanoplus viridipes** (Walsh-Scudder). The Green-legged Locust.
Pezotettix viridipes Walsh, MS, 1865; Bl., 4, XXIII, 1891, 80; Id., 6, XXIV, 1892, 34.
Melanoplus viridipes Scudd., 179, XXXVI, 1897, 13, 33; Id., 181, 1897, 128, 255, Plate 17, Fig. 4; Id., 188, 1900, 65.
Pezotettix viridulus McN., 88, VI, 1891, 75; Bl., 6, XXIV, 1892, 34; Id., 11, XXVI, 1894, 245.

Size, medium. Vertex moderately swollen, but little elevated above the pronotum, the portion between the eyes, half as broad again (male) or twice as broad (female) as the basal joint of antennæ; the front half sloping downward and distinctly sulcate, especially in the male. Frontal costa narrowed slightly above the ocellus, shallowly sulcate in the male. Antennæ of male equaling or slightly exceeding the hind femora in length; those of female relatively shorter. Pronotum with the disk faintly expanding on posterior half, the median carina distinct on metazona, less so on prozona; the hind margin broadly rounded; prozona about half as long again as the densely punctate metazona. Tegmina equaling (female) or a little longer (male) than the pronotum, elliptical, the apex rounded, the inner edges slightly overlapping in the male, often a little separated in the female. Extremity of male abdomen much recurved; the cerci long and rather slender, erect and a little incurved, tapering gradually from base to apex. Furcula consisting of a pair of minute, widely separated, triangular lobes. Apex of sub-genital plate elevated and terminating in a conical tubercle. (See Fig. 3, Plate I.)

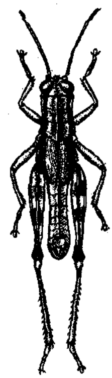


Fig. 65. *Melanoplus viridipes* (Walsh). Male. One and one-third times natural size. (Original).

Color, brownish fuscous above, yellowish brown below. Occiput of male darker. A broad, shining black band extends backward from the eye along the upper half of lateral lobe of pronotum, and is bordered below by an ivory white or yellowish band. Disk of pronotum and tegmina wood brown. Fore and middle femora greenish; hind femora yellowish brown, with two oblique dark bars on outer face, more distinct in male. Hind tibiæ pale green, the spines black.

Measurements: Length of body, male, 18 mm., female, 23 mm.; of antennæ, male, 9.5 mm., female, 8.5 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male and female, 6 mm.; of hind femora, male, 9.5 mm., female, 12 mm.

This handsome, short-winged form seems to be rather limited in distribution, having been noted only at two or three points in Illinois and in Posey, Monroe, Vigo, Marion and Lake counties, Indiana. With us, it is the first locust to reach maturity from eggs hatched in spring, a mature male having been taken in Vigo County on May 11th, and a number of both sexes in Posey County on May 12th. By June 1st it is common locally, and by August 1st has mostly disappeared. It frequents rather low, flat woods and clearings, being found about the margins of burned or bare places.

On June 3, 1900, I happened upon a large colony of *viridipes* in the upland woods just west of the State Fair Grounds, in Marion County. They were in an open, rather bare tract near the center of the woods, which was surrounded by beech and black maple trees. I took with the fingers, 40 of them in 20 minutes, and could have secured as many more. The males, when first disturbed, would leap two or three feet, almost perpendicularly, for several times in rapid succession, then give one or two sidewise leaps, and if still pursued, endeavor to hide the head beneath a dead leaf. The females were more clumsy, and after giving one or two short leaps would squat close to the ground, when they were readily taken. One pair were mating and a number were yet in the nymph stage. On June 1, 1902, I found the species abundant in the same place. In Lake County it was taken in a similar woods just back of the hotel on the west side of Cedar Lake. McNeill says that in Illinois "it shows a decided preference for open grassy ravines." It probably occurs in suitable localities over the greater portion of Indiana.

62. Melanoplus obovatipennis (Blatchley). The Obovate-winged Locust.

Pezotettix obovatipennis Bl., 11, XXVI, 1894, 241.

Melanoplus obovatipennis Scudd., 179, XXXVI, 1897, 14, 34; Id., 181, 1897, 129, 264, Plate 17, Fig. 10; Id., 188, 1900, 61; Bl., 15, XXX, 1898, 62.

Pezotettix rotundipennis Bl., 4, XXIII, 1891, 80 (nec. Scudder).

Male below the medium in size; female much larger and more robust. Head prominent, the occiput and vertex elevated a little above the pronotum, the interspace between the eyes nearly twice (male) or more than twice (female) the breadth of basal joint of antennæ; the front half strongly sloping downward, narrowly and shallowly sulcate in the male, broadly depressed with distinct raised margins in the female. Frontal costa about the width of the interspace between the eyes; distinctly sulcate in the male; a little depressed about the ocellus in the female. Eyes, large, prominent. Antennæ as long (male) or three-fourths as long (female) as hind femora. Pronotum rather long, faintly (male) or distinctly (female) widening on the posterior half; median carina distinct and equal throughout; front and hind margins truncate in the female, the latter a little rounded in the male; prozona twice as long as the densely punctate metazona. Tegmina shorter than the pronotum, obovate or broadly ovate in outline, a little longer than their greatest breadth, their inner edges widely separated in the female, less widely but never touching in the male. Wings represented by a slender oblong scale. Male abdomen well recurved; the cerci rather slender, the middle third but little more than half the width of base, the apical third again somewhat widened and slightly excavated on the outer face, the apex truncate. Furcula, consisting of a pair of tapering, cylindrical, diverging lobes, about one-third the length of supra-anal plate. Subgenital plate almost as broad as long, the apex not elevated. (See Fig. 4, Plate I.)

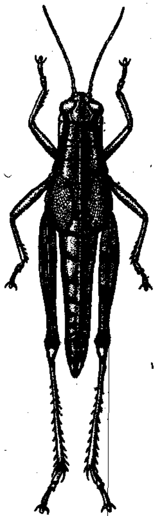


Fig. 66. *Melanoplus obovatipennis* Bl. Female. One and one-half times natural size. (Original.)

Color: Above, dull grayish brown or tan. A dark fuscous band starts from the middle of hind margin of each eye, and passes back, covering the upper half of lateral lobe of pronotum, then narrows and curves downward to coxa of middle leg. Below, this is bordered by an ivory white band which extends back from the cheek and covers the lower half of the lateral lobe, and then curves down between the front and middle coxa. Metapleurite ivory-white. Below, the general color is a dirty yellowish brown, with the lower face of the femora orange yellow. The hind femora with their knees black, and with two indistinct blackish bars on the upper and outer faces. Hind tibiæ olive green, annulate with whitish near the base, the spines black. Antennæ with the basal half reddish-brown, the apical half fuscous.

Measurements: Length of body, male, 16 mm., female, 24 mm.; of antennæ, male, 10 mm., female, 9.5 mm.; of pronotum, male, 4.5 mm., female, 6 mm.; of tegmina, male, 3 mm., female, 4 mm.; of hind femora, male, 10 mm., female, 12.5 mm.

This olive brown, short-winged locust probably occurs throughout the southern two-thirds of the State, but has been taken only in Crawford, Washington, Monroe, Franklin, Wells, Marion and Vigo counties. In central Indiana it reaches maturity about September 1st, and frequents, for the most part, high, dry, open woods, especially those in which beech and oak trees predominate. On the tops of the hills, in the coal district of Vigo County, where the soil is a clay, and the herbaceous vegetation somewhat limited, it is the prevailing, and often only, representative of the family. In late October, if the season is dry, it is often found in company with *Dicromorpha viridis* and *Truxalis brevicornis* among the reeds and tall rank grasses near the borders of marshes, and as late as November 22d, has been noted enjoying the afternoon sunshine from a perch on the bottom plank or rail of a fence. The females are always much more numerous than the males, the ratio being about eight to one. Their larger, robust form renders them more clumsy, and hence more readily caught by the hand, the males being active leapers, and requiring quick movement on the part of the collector to effect their capture. The range of the species is given by Scudder as "Indiana to Arkansas and Texas."

63. MELANOPLUS GRACILIS (Bruner). The Graceful Locust.

Pezotettix gracilis Brun., **20**, VIII, 1876, 124; Scudd., **165**, XII, 1880, 75; Bl., 4 XXIII, 1891, 81; Id., **11**, XXVI, 1894, 223.

Melanoplus gracilis Scudd., **179**, XXXVI, 1897, 16, 35; Id., **181**, 1897, 130, 327, Plate 22, Fig. 3; Id., **188**, 1900, 59; Lugg., **84**, 1898, 188.

Pezotettix minutipennis Thom., **209**, I, 1876, 66; Id., **211**, IX, 1880 90, 119.

Size below the medium. Vertex not swollen nor elevated above the pronotum; the interspace between the eyes very narrow, about equaling the width of first antennal joint (male) or nearly twice as broad (female); the front half strongly sloping downward and narrowly but distinctly sulcate (male) or broadly and shallowly sulcate (female). Frontal costa prominent, slightly wider than the interspace between the eyes; feebly or not at all sulcate. Antennæ about three-fourths the length of hind femora. Pronotum, sub-cylindrical, faintly expanding on posterior half; the disk with the sides sloping; the median carina low but distinct and equal throughout; front margin truncate, hind margin broadly rounded, with a median shallow notch; prozona twice the length of metazona. Tegmina about the length of the prozona, narrowly oblong, their inner edges widely separated. Hind femora very slender. Extremity of male abdomen moderately recurved; the cerci long, narrow, the middle third but half as broad as the base, the apical third a little expanded and flattened. Furcula consisting of a pair of minute rounded lobes. (See Fig. 5, Plate I.)

Color: Dull ash or wood brown above; greenish yellow beneath. Head greenish yellow except on occiput, where it is brownish. A dull blackish bar extends backward from eye along the upper half of lateral lobe of pronotum; the lower half of the lateral lobe greenish yellow. Hind femora bright green (becoming dark in drying) except the knees, which are black. Hind tibiæ green, the spines black.

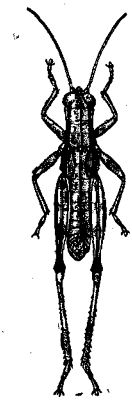


Fig. 67. *Melanoplus gracilis* (Bruner). Male. One and one-half times natural size. (Original.)

Measurements: Length of body, male, 16 mm., female, 20 mm.; of antennæ, male, 9 mm., female, 8 mm.; of pronotum, male, 4.5 mm., female, 5 mm.; of tegmina, male, 3 mm., female, 4 mm.; of hind femora, male, 9.5 mm., female, 11 mm.

This is, next to *M. scudderi,* our most common of the short-winged members of the genus. It probably occurs throughout the State, but has not been noted in the counties south of Monroe and Knox. It frequents rather low, wooded blue-grass pastures and is especially fond of resting and mating upon the foliage of the iron weeds (*Vernonia*) which grow abundantly in such places. It is also partial to the tall grasses growing in ravines and along the borders of sloughs and marshes. In central Indiana the males begin to reach maturity by June 15th, the females about a week later. By July 5th they are mating in numbers. They have also been noted mating as late as November 10th, and it may be possible that in favorable seasons, a second brood matures. Like most other wingless species, they are active leapers, the males, especially, being noted for their somersaults while endeavoring to escape capture. The range of *gracilis* is given by Scudder as "Indiana and Kentucky to Nebraska and Dakota."

64. Melanoplus morsei sp. nov.

Male below the medium in size; female larger and more robust. Head not prominent, the vertex but little swollen, and not at all (male) or a little (female) elevated above the pronotum; the interspace between the eyes very narrow, about as wide (male) or less than one and one-half times as wide (female) as the basal joint of antennæ; the front half gently sloping and distinctly angulate on the middle of each side, sulcate in the male, plane in the female. Frontal costa a little wider than basal joint of the antennæ, very feebly sulcate below the ocellus in male. Eyes of male very prominent. Antennæ as long (male) or two-thirds as long (female) as hind femora. Pronotum faintly expanding on posterior half in male, or distinctly throughout in the female; the median carina low but distinct except on posterior third of prozona, where it is sub-obsolete; the sides of disk distinctly sloping downward; the front margin truncate, the hind margin sub-truncate with a broad but shallow median notch or emargination; the prozona twice the length of the rather coarsely punctate metazona. Tegmina broadly ovate or sub-rounded, as broad as long, a little shorter than pronotum, their inner edges separated by a space equal to two-thirds their breadth. Extremity of male abdomen strongly recurved; the cerci rather broad, sub-falcate, the middle third more than half the width of base, the apical third expanded and curved upward or forward, excavated on the outer face, the apex obliquely rounded.

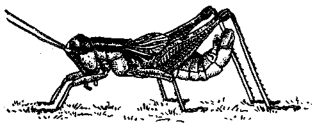


Fig. 68. *Melanoplus morsei* sp. nov. Male. One and one-half times natural size. (Original.)

Furcula consisting basally of a pair of broad, flat lobes, whose inner edges meet and overlie the median sulcus of supra-anal plate; about the middle they suddenly narrow and become slightly bifid, the outer fingers, slender, a little divergent, reaching nearly to middle of supra-anal plate, the inner ones forming a very short process or angulation. Sub-genital plate longer than broad; distinctly narrowing from below upward. (See Fig. 6, Plate I.)

Color grayish or purplish brown above, greenish yellow below. Face greenish yellow more or less sprinkled with fuscous. A broad shining black bar extends back from eye along the upper half of pronotal lobe; this bordered below with greenish yellow. Tegmina wood brown. Hind femora reddish brown, or with a fuscous tinge in female, the knees shining black. Hind tibia pale green, the spines black.

Measurements: Length of body, male, 18 mm., female, 24 mm.; of antennæ, male, 11 mm., female, 8 mm.; of pronotum, male, 4.5 mm., female, 5.5 mm.; of tegmina, male, 4 mm., female, 5 mm.; of hind femora, male, 11 mm., female, 12 mm.

In color and general appearance this locust bears a close resemblance to *M. obovatipennis* and it was not until I came to study them critically that I found them distinct. On comparing the two, *morsei* is easily distinguished by its less prominent head, larger eyes, narrower interspace between the eyes, more feebly sulcate frontal costa, longer antennæ of male, more coarsely punctate metazona, broader tegmina and especially by the form of the male cerci and furcula. So far it has been noted only along roadsides and in bare limestone glades on the crests of high wooded hills near Wyandotte, Crawford County. It probably occurs in similar situations throughout the southern third of the State. It reaches maturity some time in June, the first specimens having been taken on the 24th. Nothing distinctive of its habits is known, as when in the field it was thought to be *obovatipennis;* which, however, is a much later maturing insect.

Since the above was in type I found (July 15, 1903) *morsei* to be rather common among the underbrush of high wooded slopes on the State University farm, three miles southeast of Mitchell, Lawrence County. Here the soil was very sparsely vegetated, sedges and wild asters being the prevailing herbs. The ground was covered with the dead leaves of last season, with whose colors the hues of the locusts so blended that they were invisible while motionless. The males leap briskly when approached, but only for a short distance. The heavier bodied females are more clumsy, and are easily caught with the hand.

I take pleasure in naming this locust in honor of Prof. A. P. Morse, of Wellesley, Massachusetts, a special student and collector of Orthoptera, who has kindly shown me many favors during the preparation of the present paper.

65. MELANOPLUS FASCIATUS (Barnston-Walker).

Acridium fasciatum Barn., MS., 1870.

Caloptenus fasciatus Walk., 219, IV, 1870, 680; Thom., 206, V, 1873, 224.

Melanoplus fasciatus Scudd., 179, XXXVI, 1897, 14, 23, 34; Id., 181, 1897, 129, 134, 267, Plate 18, Figs. 2-4; Id., 188, 1900, 57; Lugg., 84, 1898, 210, Fig. 136½; Morse, 100, VIII, 1898, 257; 260, 281, Plate 7, Fig. 39.

Pezotettix borealis Scudd., 141 VII, 1862, 464; Thom., 206, V, 1873.

Melanoplus borealis Beut., 3, VI, 1894, 308.

Melanoplus rectus Scudd., 163, XIX, 1878, 284; Id., 161, VI, 1878, 43; Id., 164, 1879, 60; Fern., 53, 1888, 31.

Melanoplus curtus Scudd., 164, 1879, 59.

Size, medium. Head not prominent, the vertex distinctly elevated above the pronotum, the interspace between the eyes as broad (male) or nearly twice as broad (female) as the basal joint of antennæ; the front half strongly sloping downward, shallowly sulcate, the lateral margins distinct. Frontal costa as broad as the interspace between the eyes, feebly or not at all sulcate. Eyes relatively small, not prominent. Antennæ about as long (male) or two-thirds as long (female) as hind femora. Pronotum feebly expanding on its posterior half; the disk rounded on prozona, flat on metazona; the front margin truncate, the hind margin broadly rounded or obtuse angled; the median carina distinct only on metazona, faintly visible on portions of the prozona; the latter about one-fourth longer thán the metazona. Tegmina covering half (female) or three-fourths or more (male) of the abdomen,* sub-lanceolate, their inner edges overlapping. Extremity of male abdomen well upturned; the cerci straight, about four times as long as broad, the middle third but slightly narrowed, the apical third concave or sulcate, the tip rounded. Furcula consisting of a pair of minute, widely separated tubercular teeth. Sub-genital plate longer than broad, the apical margin somewhat elevated. (See Fig. 7, Plate I.)

Color: Dull grayish brown above, clay yellow below; the male the darker. Occiput fuscous. The usual black band behind the eye, extending along the upper half of lateral lobe of prozona. Tegmina, dull reddish brown, with often a few small fuscous spots on the discoidal area. Hind femora dull brownish yellow, with two broad oblique blackish bars on the upper and outer faces; the lower face dull red; the knees black. Hind tibiæ either red or pale green, with a lighter ring near the base; the spines black.

Measurements: Length of body, male, 17 mm., female, 21 mm.; of antennæ, male, 9.5 mm., female, 8 mm.; of pronotum, male, 4.5 mm., female, 5 mm.; of tegmina, male, 7.5 mm., female, 8 mm.; of hind femora, male, 10 mm., female, 15 mm.

This much described locust is a species of northern range, which has been taken in Indiana only in Marshall and Lake counties. In the former it has been noted only in a low sandy oak woods, bordering Lost Lake, and just west of the station of Arlington at Lake Maxinkuckee. Here among low huckleberry and other bushes it is common from July 15th on, the females, however, far outnumbering the males. Both sexes leap vigorously when disturbed, but often squat close to the ground after being flushed once or twice. In Lake County a few specimens have been taken in the sand dune region near Millers.

---

* A form (*M. f. volaticus*) occurs in which the tegmina are broad, sub-equal, and far surpass the hind femora. It has been taken in Michigan, but is not, as yet, known in Indiana.

66. MELANOPLUS BLATCHLEYI Scudder.

Melanoplus blatchleyi Scudd., 179, XXXVI, 1897, 15, 34; Id., 181, 1897, 129, 322, Plate 21, Fig. 10; Id., 188, 1900, 55; Bl., 15, XXX, 1898, 62; Lugg., 84, 1898, 186, Figs. 112–114.

Pezotettix occidentalis Brun., 20, VIII, 1876, 124; Bl., 11, XXVI, 1894, 243.

Pezotettix viola Bl., 4, XXIII, 1891, 81.

Size, above the medium. Vertex scarcely elevated above the pronotum, the interspace between the eyes nearly (male) or fully (female) twice as broad as the first joint of antennæ; the front half moderately sloping, broadly sulcate in the male, faintly in the female. Frontal costa short, not reaching clypeus, sulcate at and below the ocellus. Antennæ scarcely shorter than (male) or two-thirds as long as (female) the hind femora. Pronotum feebly expanding on the metazona; the disk flat or nearly so; the median carina distinct

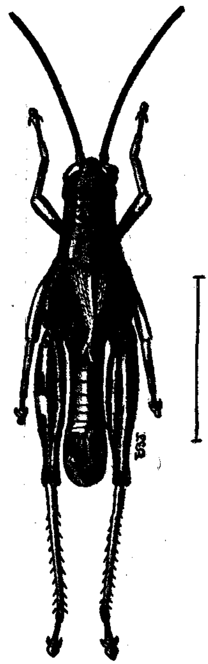


Fig. 69. *Melanoplus blatchleyi* Scudder. Male. Twice natural size. (After Lugger.)

only on the metazona; the front margin truncate, the hind margin broadly obtuse angled; the prozona about one-third longer than the closely punctate metazona. Tegmina about one-fourth longer than the pronotum, sub-lanceolate, their inner edges slightly overlapping. Fore and middle femora much swollen in the male. Extremity of male abdomen strongly recurved; the cerci coarse and heavy, the middle third, two-thirds as broad as base, the apical third slightly enlarged, curved abruptly inward, compressed, the tip broadly rounded. Furcula consisting of a pair of short, rather broad and flat triangular teeth whose bases almost touch. Sub-genital plate broader than long, the apex a little elevated. (See Fig. 8, Plate I.)

Color: Dark grayish brown above, yellowish below. Face dull brown, the occiput darker. A rather narrow black bar runs back from each eye along the upper third of lateral lobes of prozona, often indistinct or wanting, especially in the female. Disk and lower half of lateral lobes of pronotum and tegmina grayish brown, often more or less flecked with fuscous. Hind femora reddish or yellowish brown, with two crossbars of black on upper and outer faces, these sometimes indistinct in female; the lower face pale or vermilion red, the knees black. Hind tibiæ red, with a pale ring on basal third, the spines black.

Measurements: Length of body, male, 21 mm., female, 24 mm.; of antennæ, male, 12 mm., female, 9.5 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 8 mm., female, 9 mm.; of hind femora, male, 13 mm., female, 14 mm.

This clumsy bodied insect is among the least common of our Indiana Melanopli, having been taken only in Crawford, Knox, Monroe, Vigo, Putnam and Marion counties. Seldom more than a dozen or two are seen each season. It frequents, for the most part, upland woods and thickets, though it is sometimes found along the borders of marshes and swamps, but never close to the water. It is more arboreal than many of our locusts, having been taken in autumn on prickly ash and buttonbush shrubs, several feet above the ground, and also from the boles of hackberry and oak trees, where it was probably sunning. Lugger states that in Minnesota "it is very common, preferring the edges of forests or places overgrown with bushes and vines. The grapevine, especially, is preferred by these locusts, and they soon destroy its foliage by eating big holes in the leaves."

In central Indiana *blatchleyi* begins to reach maturity by June 14th, and ragged, forlorn looking specimens have been seen as late as November 3d. Its general range is west of the Mississippi, Marion County, Indiana, being the most easterly point from which it has been recorded.

67. MELANOPLUS ATLANIS (Riley). The Lesser-Locust.

Caloptenus atlanis Riley, 116, VII, 1875, 169; Id., 117, VIII, 1876, 113, 153; Id., 121, VI, 1881, 89, 90; Id., 122, II, 1884, 194; Id., 127, XXV, 1891, 26, Figs. 4a-c; Pack., 216, III, 1883, 273, Plates XX, XXI.

Caloptenus atlantis Thom., 209, I, 1876, 68; Id., 211, IX, 1880, 92, 96, 124.

Melanoplus atlantis Scudd., 163, XIX, 1878, 286; Id., 161, VI, 1878, 45.

Melanoplus atlanis Scudd., 215, II, 1880, 24, Plate XVII, Fig. 6; Id., 179, XXXVI, 1897, 20, 32; Id., 181, 1897, 132, 178, Plate 12, Fig. 7; Id., 188, 1900, 54; Fern., 53, 1883, 31, 33; Bl., 4, XXIII, 1891, 98; Brun., 26, XXVII, 1892, 12; Id., 28, XXVIII, 1893, 29, Figs. 14a-c; Beut., 3, VI, 1894, 306; Morse, 100, VIII, 1898, 256, 259, 279, Plate 7, Fig. 36; Lugg., 84, 1898, 190, Figs., 116-118.

Size, medium. Vertex somewhat elevated above the pronotum, the interspace between the eyes nearly (male) or fully (female) twice as broad as the basal joint of antennæ; the front half strongly sloping, distinctly sulcate in the male, shallowly in the female. Frontal costa short, not reaching clypeus; feebly or not at all sulcate below the ocellus, the upper third a little narrowed. Antennæ three-fourths

Fig. 70. ***Melanoplus atlanis*** Riley. Male. Natural size.

(male) or two-thirds (female) as long as hind femora. Pronotum rather short, distinctly expanding on the metazona, the disk flat or nearly so, the hind margin obtuse angled, the median carina distinct only on the metazona; the latter densely punctate and equaling the prozona in length. Tegmina fully developed, surpassing the hind femora. Extremity of male abdomen but little recurved; cerci about twice as long as broad, the apical half slightly upturned and somewhat inbent; the apex well rounded. Furcula consisting of a pair of moderately diverging slender, tapering spines, about one-third the length of the supra-anal plate. Sub-genital plate narrowing regularly from below upward, the apex somewhat thickened and elevated, and with a distinct median notch. (See Fig. 9, Plate I.)

Color, either dark grayish or reddish brown. Head olive brown mottled with darker. The usual black band behind eye is confined to the prozona and in the reddish brown specimens and the females is often indistinct or broken into smaller spots. Tegmina grayish brown, flecked distinctly with fuscous along the discoidal area. Hind femora reddish yellow, with two oblique dark bars across the upper and outer faces; the lower face usually pinkish, the knees blackish. side of abdomen yellow.

Measurements: Length of body, male, 20 mm., female, 24 mm.; of antennæ, male, 9 mm., female, 8 mm.; of pronotum, male, 5 mm., female, 5.5 mm.; of tegmina, male and female, 20 mm.; of hind femora, male, 12 mm., female, 13 mm.

This is a very common locust throughout the State, having been taken in every county in which collections have been made. It begins to reach maturity the latter part of May—May 27th and 30th, Vigo County; May 31st, Marion County—and from then until late November may be noted almost anywhere in open blue-grass pastures and woods, borders of roadsides and cultivated fields, meadows and lawns. Numerous examples have been found pairing as late as November 22d, and it may be that there are two broods each season. In late spring and early summer they are often seen resting on ironweeds and thistles in company with *M. gracilis, M. luridus* and other species. The cast off skin of their final moult is often noted on such weeds, showing that the nymph climbs thereon to change its garment of youth for one of maturity.

Atlanis is very often found associated with the more common *M. femur-rubrum* and is considered that species by most persons who deign to notice such a thing as a locust. The male, however, may be readily distinguished from that of *femur-rubrum* by the notched apex of sub-genital plate, the shorter and less tapering cerci, and by the greater relative length of the tegmina, which extend one-fourth or more their length beyond the tip of abdomen. The dark spots on tegmina are also larger and more distinct in *atlanis*. The female of *atlanis* may be known by the yellow color of the under side of abdomen which in *femur-rubrum* is reddish brown; and also by the more distinctly banded hind femora. The earlier specimens of *atlanis* are, in general, lighter colored and have relatively longer tegmina than those of late autumn, which are very dark gray in hue. The species ranges over most of the United States and Canada.

68. MELANOPLUS IMPUDICUS Scudder.

Melanoplus impudicus Scudd., **179**, XXXVI, 1897, 22, 32; Id., **181**, 1897, 134, 204, Plate 14, Fig. 1; Id., **188**, 1900, 60.

Size, medium. Vertex slightly swollen, distinctly elevated above the pronotum; the interspace between the eyes as broad (male) or one and a half times as broad (female) as the first joint of antennæ; the front half strongly sloping, feebly sulcate in both sexes. Frontal costa short, not reaching clypeus, narrow, feebly or not at all sulcate. Antennæ short, two-thirds as long as hind femora. Pronotum expanding but little (male) or more distinctly (female) on metazona, the disk feebly convex; median carina visible throughout, distinct on metazona; hind margin obtuse angled; the prozona but little, if any longer than the finely punctate metazona. Tegmina* reaching the tip of hind femora in both sexes, moderately broad and tapering. Extremity of male abdomen but little recurved; the cerci narrow, compressed, straight, the middle third about half as broad as the extreme base, the apical third but little expanded, the tip rounded. Furcula consisting of a pair of short, triangular spines which lie upon the bases of the ridges of the supra-anal plate. Sub-genital plate scarcely longer than broad, sub-conical, terminating in a blunt tubercle. (See Fig. 10, Plate I.)

Color: Reddish brown above, yellowish below. Face yellowish brown, dotted with fuscous; occiput and disk of pronotum darker. Antennæ reddish, the apical fourth fuscous. An indistinct black band extends from eye back across the upper half of the lateral lobe of prozona; this often nearly obsolete in the female. Tegmina grayish or reddish brown, with a number of dark spots along the discoidal area. Hind femora reddish brown, with two more or less distinct oblique black bars on upper and outer faces; the lower face orange red; the knees dusky. Hind tibiæ bright red, the spines black.

Measurements: Length of body, male, 18 mm., female, 22 mm.; of antennæ, male and female, 8 mm.; of pronotum, male, 5 mm., female, 5.5 mm.; of tegmina, male and female, 15 mm.; of hind femora, male, 11 mm., female, 12.5.

This is a southern species, heretofore recorded only from Georgia, Mississippi and Arkansas. On July 10, 1902, I found it plentiful on a sandy wooded slope in Gibson County, Indiana, about 10 miles southeast of Mt. Carmel, Illinois, and at a point where the terrace on the Indiana side of the Wabash River meets the sandy uplands. Here, among the scant grass and weeds the insect had found a suitable abiding place. The males take to wing readily when disturbed, but the females seem to depend only on their short hind legs to take them out of sight of their pursuer. Specimens were sent Professor Morse, who kindly verified my determination by comparing them with Scudder's types. It is probable that the species will be found over most of the sand-covered area of the lower Wabash River.

69. MELANOPLUS FEMUR-RUBRUM (De Geer). Common Red-legged Locust.

Acridium femur-rubrum DeG., 57, III, 1773, 498, Plate XLII, Fig. 5; Harr., 70, 1833, 583; Id., 71, 1841, 141; Id., 72, 1862, 174.

Caloptenus femur-rubrum Burm., 40, II, 1838, 638; Scudd., 141, VII, 1862, 464; Id., 147, 1872, 250, 253; Glov., 60. 1870, 76, Fig.

*Scudder, in his original description, gives them as "surpassing a little (male) or considerably (female) the hind femora," but this is not true of Indiana specimens.

32; Id., 62, 1872, Plate V, Fig. 11, Plate VIII, Fig. 2; Thom., 206, V, 1873, 163; Id., 211, IX, 1880, 91, 95, 124, Figs. 22, 23; Riley, 116, VII, 1875, 126, Figs. 26, 29; Id., 117, VIII, 1876, 114–118, 153; Id., 119, 1877, 14–17, 27, Figs. 1, 4; Id., 127, XXV, 1891, 27, Fig. 5.

Pezotettix (*Melanoplus*) *femur-rubrum* Stal, 200, I, 1873, 79.

Melanoplus femur-rubrum Scudd., 148, I, 1874, 375; Id., 163, XIX 1878, 285, 287; Id., 161, VI, 1878, 44, 46; Id., 181, 1897, 134, 278. Plate XIX, Figs. 1–4; Id., 188, 1900, 58; Comst., 41, 1888, 108, 110, Figs. 83, 98; Id., 42, 1895, 110, Fig. 120; Fern., 53, 1888, 31, 33; Bl., 4, XXIII, 1891, 98; Id., 16, 1899, 239, Fig. 65; Brun., 30, 1893, 458, Fig. 98; Id., 28, XXVIII, 1893, 30-32, Fig. 15; Id., 31, 1894, 163, 205, Fig. 68; Id., 35, 1899, 133, Fig. 77; Beut., 3, VI, 1894, 306, Plate VIII, Fig. 7; Lugg., 84, 1898, 195, Figs. 121, 122; Morse, 100, VIII, 257, 281, Plate 7, Fig. 40.

Size, medium. Vertex but little elevated above the pronotum, the interspace between the eyes a fourth wider than (male) or fully twice as wide (female) as the first antennal joint; the front half strongly sloping, distinctly sulcate in the male, feebly in the female. Frontal

Fig. 71. ***Melanoplus femur-rubrum*** (DeGeer). Male. Natural size.

costa as broad as the interspace between the eyes, deeply sulcate below the ocellus in the male. Antennæ about three-fourths (male) or two-thirds (female) as long as hind femora. Pronotum feebly expanding on posterior half, the disk flat or nearly so; the hind margin obtuse angled, more so in the female; the median carina visible throughout, more distinct on the metazona; the prozona about equal to the latter in length. Tegmina slightly surpassing the tip of hind femora, distinctly though very gradually tapering. Extremity of male abdomen well recurved; the cerci sub-falcate, tapering rapidly from base to middle, the apical third but little expanded, the apex very obliquely truncate and somewhat incurved. Furcula consisting of a pair of tapering cylindrical spines, about half as long as the supra-anal plate, their apical two-thirds well separated and lying just outside the ridges forming its median sulcus. Sub-genital plate with its apex less than half the breadth of the base, not elevated, truncate, and distinctly rounded. (See Fig. 11, Plate II.)

Color: Reddish brown, or brownish fuscous. Head olive to brownish yellow, the occiput darker with usually a pair of widening fuscous stripes on its sides. Disk of pronotum generally darker than the lower half of lateral lobes; the upper half of these lobes with a broad black bar on the prozona, often sub-obsolete in the female. Tegmina brownish fuscous, sometimes without spots, but more often with fuscous dots of varying size along the basal half of discoidal area. Hind femora reddish brown, the upper half of outer face usually more or less clouded with fuscous which often forms two oblique crossbars on the upper face; lower and inner faces dull yellow or orange. Hind tibiæ deep red, rarely pale yellowish green, the spines black.

Measurements: Length of body, male, 23 mm., female, 25 mm.; of antennæ, male, 10 mm., female, 8.5 mm.; of pronotum, male, 4.5 mm., female, 5 mm.; of tegmina, male, 20 mm., female, 21 mm.; of hind femora, male, 12.5 mm., female, 14.5 mm.

This is the most common and the most injurious of our Indiana locusts. It occurs everywhere in blue-grass pastures and meadows, along roadsides and borders of cultivated fields. In central Indiana it begins to reach maturity about June 5th, and has been seen in numbers and mating as late as November 22d. Those which occur in low damp places are usually darker than those in dry upland localities. The second crop of clover is, in a dry season, often almost wholly destroyed by these insects. When disturbed they either hop vigorously to one side, or fly swiftly and noiselessly straight ahead for 30 or more feet and then suddenly drop to the ground. The species ranges over most all of North America.

70. Melanoplus extremus (Walker).

Caloptenus extremus Walk., **219**, IV, 1870, 681; Thom., **206**, V, 1873, 225.

Melanoplus extremus Scudd., **179**, XXXVI, 1897, 24, 34; Id., **181**, 1897, 135, 287, Plate 18, Fig. 10; Id., **188**, 1900, 57; Bl., **15**, XXX, 1898, 57; Morse, **100**, VIII, 1898, 257, 259, 292, Plate 7, Fig. 41.

Pezotettix junius Dodge, **45**, VIII, 1876, 9.

Melanoplus junius Scudd., **163**, XIX, 1878, 286; Id., **161**, VI, 1878, 45.

Caloptenus junius Scudd., **165**, XII, 1880, 75.

Size, small to medium. Vertex slightly elevated above the pronotum; the interspace between the eyes nearly (male) or more than (female) twice as wide as the basal joint of antennæ; the front half steeply sloping, distinctly (male) or broadly and shallowly (female) sulcate. Frontal costa not reaching clypeus, faintly widening from above downward; feebly sulcate at and below the ocellus. Antennæ four-fifths (male) or two-thirds (female) as long as the hind femora. Pronotum widening on the metazona, especially in the female; the median carina visible throughout, more distinct on metazona; the hind margin strongly obtuse angled, the angle rounded in the female; the prozona one-third (male) or one-sixth (female) longer than the closely punctate metazona. Tegmina (in Indiana specimens) reaching nearly to tip of abdomen in the male, covering one-half to three-fourths of abdomen in female, rather broad at base, but rapidly tapering to a sub-acuminate apex. Extremity of male abdomen but little recurved; the cerci short and broad, slightly falcate, the basal third feebly tapering, the apical third but little, if any, wider than the middle; the apex obliquely rounded. Furcula consisting of a pair of parallel, tapering, cylindrical spines, about half as long as supra-anal plate, and resting upon the ridges bordering its median sulcus. Sub-genital plate half as broad at apex as at base, the apical margin well rounded, and not elevated. (See Fig. 12, Plate II.)

Color: Dark greenish yellow, tinged with fuscous. Head, greenish yellow, darker above. The usual black bar behind eye extends along the upper half of lateral lobe of prozona; below which the lobe is greenish yellow. Disk of pronotum and tegmina dull olive brown, the latter sometimes with a few small fuscous spots along the discoidal area. Hind femora dull yellow, tinged with reddish brown, usually without traces of dark crossbars; the lower face generally pale orange; knees feebly infuscated. Hind tibiæ pale red, or dull yellow, the spines black.

Measurements: Length of body, male, 18 mm., female, 22 mm.; of antennæ, male, 9 mm., female, 7 mm.; of pronotum, male, 4 mm., female, 5 mm.; of tegmina, male, 10 mm., female, 9.5 mm.; of hind femora, male, 10 mm., female, 11.5 mm.

This species first came to my notice in the State on August 6, 1897, when it was found near DeLong, Fulton County, in an open peat bog which was surrounded on all sides by a heavy growth of tamarack, *Larix americana* Michx. But about a dozen specimens were secured, all of which were of the short winged form *M. e. junius*. When disturbed they gave several short, quick leaps, and then burrowed as far as they could into the dense mass of sphagnum moss which everywhere covered the bog. It has since been taken several times in the same place; also in a marsh near the south end of Lake Maxinkuckee; and probably occurs about the most of the peat bogs and marshes of the northern third of the State. Mr. C. H. Bollman evidently found it near Bloomington, Monroe County, since Scudder mentions a specimen so labeled as occurring in the U. S. National Museum.

Extremus is an insect of northern range, Walker's type being recorded from Arctic America. According to Scudder "it probably occurs throughout the larger part of Canada and the northernmost United States. It has also been recorded from several points in Alaska."

71. MELANOPLUS ANGUSTIPENNIS (Dodge). The Narrow-winged Locust.

Caloptenus angustipennis Dodge, 46, IX, 1877, 111.

Melanoplus angustipennis Brun., 22, I, 1885, 138; Id., 28, XXVIII, 1893, 24, Fig. 12; Id., 34, 1896, 121, Fig. 23; Id., 36, 1899, 270, Fig. 58; Scudd., 179, XXXVI, 1897, 26, 34; Id., 181, 1897, 136, 305, Plate 20, Fig. 6; Id., 188, 1900, 53; Bl. 15, XXX, 1898, 58; Lugg., 84, 1898, 198, Fig. 123.

Melanoplus coccineipes Scudd., 179, XXXVI, 1897, 26, 34; Id., 181, 1897, 136, 303, Plate 20, Figs, 3-5; Id., 188, 1900, 56.

Size, medium. Vertex feebly swollen, slightly elevated above the pronotum; the interspace between the eyes one and a half times (male) or twice (female) as broad as the basal joint of antennæ; the front half strongly sloping, distinctly and broadly (male) or feebly (female) sulcate throughout. Frontal costa rather wide and equal throughout, faintly sulcate at and below the ocellus. Antennæ about five-sixths (male) or two-thirds (female) as long as the hind femora. Pronotum with the disk feebly enlarging on posterior half, the median carina distinct only on the metazona; the hind margin broadly obtuse angled; prozona distinctly (male) or scarcely (female) longer than the closely punctate metazona. Tegmina reaching or slightly surpassing the tips of hind femora, slender, tapering. Extremity of male abdomen scarcely recurved, the cerci rather short, spatulate, incurved, the middle third narrowest, the apex broadly rounded and hollowed on the outer face. Furcula consisting of a pair of diverging, tapering, cylindrical spines, about a third as long as the plate on which they rest. Sub-genital plate longer than broad, the apex a third narrower than base, and with a slight notch or emargination in the middle. (See Fig. 13, Plate II.)

Color: Dark grayish brown or fuscous; often with a reddish brown tinge. The occiput and disk of pronotum fuscous; the lower halves of lateral lobes lighter. The usual dark bar behind the eye covers the upper half of the sides of prozona. Tegmina brownish fuscous, either without spots or with small, indistinct fuscous ones along the middle area. Hind femora dull yellowish brown, obscurely and obliquely banded with fuscous; the lower face dull yellow; the knees blackish. Hind tibiæ either pale greenish blue or bright red, the spines black.

Measurements: Length of body, male, 20 mm., female, 22 mm.; of antennæ, male, 9.5 mm., female, 8 mm.; of pronotum, male and female, 5 mm.; of tegmina, male, 17 mm., female, 16 mm.; of hind femora, male and female, 12 mm.

This is one of the most common locusts about the south shore of Lake Michigan occurring in company with *M. atlanis* (Riley), *Spharagemon wyomingianum* (Thos.), and others over a large part of the sandy area within five miles of the lake. It seems to prefer such barren localities to those more promising in plant food, since Bruner mentions its partiality for "old breakings and well-fed pastures of many years' use." It probably begins to reach maturity some time in June, as numerous specimens have been found mating in late July.

The hind tibiæ of at least a third of the specimens noted were red instead of blue. Scudder* has based his separation of his nominal species *coccineipes* on the color of the tibiæ and degree of maculation of the tegmina, two extremely variable characters. The cerci and furcula of the red-legged male are the same in form as of the blue-legged one, and I have therefore combined the two species. In this view I am supported by Prof. A. P. Morse, who has kindly compared specimens from northern Indiana with Scudder's types.

Angustipennis is a western species, and has not been noted east of Kansas and Iowa, except in the sand dune region of northwestern Indiana. According to Bruner, it ranges from North Dakota to Texas, and west to Yellowstone, Montana. He also states that it is increasing rapidly in numbers, and is likely in places to become a serious pest. The vegetation of the area which it at present inhabits in Indiana is not sufficient in quantity and value to enable it to do much damage. Several successive favorable seasons might, however, enable it to so increase in numbers as to cause it to migrate into the richer agricultural regions to the south and east.

72. **Melanoplus minor** (Scudder).

Caloptenus minor Scudd., 152, XVII, 1875, 478; Id., 153, IV, 1875, 77; Id., 164, 1879, 22.

Melanoplus minor Scudd., 164, 1879, 84; Id., 179, XXXVI, 1897, 29, 35; Id., 181, 1897, 137, 337, Plate 22, Fig. 9; Id., 188, 1900, 61; Bl., 4, XXIII, 1891, 81; McN., 88, VI, 1891, 74; Beut., 3, VI, 1894, 307; Lugg., 84, 1898, 201, Fig. 127; Morse, 100, VIII, 1898, 256, 259, 293, Plate 7, Fig. 42.

Size, medium. Vertex but little elevated above the pronotum; the interspace between the eyes nearly twice (male) or three times

* "Revision of the Melanopli," p. 136.

(female) as wide as the first joint of antennæ; the front half but little sloping downward, distinctly and widely sulcate in the male, depressed but scarcely sulcate in the female, the lateral margins sharp. Frontal costa faintly narrowed between the antennæ, feebly sulcate at and below the ocellus. Antennæ about two-thirds the length of hind femora in both sexes. Pronotum short, distinctly widening on the metazona; the disk broadly convex; the hind margin obtuse angled; the median carina low, but visible throughout, a little less distinct on the prozona; the latter a fourth longer than the finely punctate metazona. Tegmina reaching the tips of hind femora in the female, slightly surpassing them in the male; of nearly equal width throughout. Extremity of male abdomen but little recurved; the cerci with the basal portion stout, four-sided, the apical portion nearly as long, but narrower, bent upward and inward; an inferior angle or process at point of bend; the apex broadly rounded. Furcula consisting of a pair of well separated parallel cylindrical spines, about a fourth the length of the supra-anal plate and overlying the ridges of its median sulcus. Sub-genital plate very short, the apex rounded, the lateral margins incurved near the base. (See Fig. 14, Plate II.)

Color: Above, dark brownish or fuscous, often with a reddish brown tinge, below yellowish. Occiput and disk of prozona darker than the metazona. A shining black bar behind eye extends back along the upper third of lateral lobes of prozona; this bordered below with brownish yellow. Tegmina brownish fuscous, more or less distinctly spotted with darker along the median area. Hind femora brownish yellow, indistinctly and obliquely barred with fuscous on the upper and outer faces; the lower face reddish orange; the knees black above. Hind tibiæ usually pale blue, pinkish at tip, but sometimes red or dull yellow; the spines black.

Measurements: Length of body, male, 18 mm., female, 24 mm.; of antennæ, male, 8 mm., female, 9 mm.; of pronotum, male, 4.5 mm., female, 5 mm.; of tegmina, male, 15 mm., female, 16 mm.; of hind femora, male, 11.5 mm., female, 13.5.

This seems to be one of the rarest of our Melanopli, but a half dozen or so specimens having been taken in the State during my collecting, and they only in Vigo, Monroe and Marion counties. It frequents blue-grass pastures, roadsides, and borders of cultivated fields in upland or sandy regions, and when disturbed, flies noiselessly for a short distance. A mature male was taken in Marion County on June 1, 1902. The species resembles *M. femur-rubrum* and *atlanis* in general appearance and is very likely to be confounded with them. It is probably, therefore, more numerous than my observations would denote, and is to be looked for throughout the State, its general range covering "the northern half of the United States and bordering parts of Canada."

73. MELANOPLUS LURIDUS (Dodge).

Caloptenus luridus Dodge, **45**, VIII, 1876, 11; Riley, **122**, II, 1884, 195.

Melanoplus luridus Brun., **216**, III, 1883, 60; Id., **22**, I, 1885, 138; Scudd., **179**, XXXVI, 1897, 29, 35; Id., **181**, 1897, 137, 344, Plate XXIII, Fig. 7; Id. **188**, 1900, 61; Lugg., **84**, 1898, 203, Figs. 128, 129.

Melanoplus collinus Scudd., **163**, XIX, 1878, 285; Id., **161**, VI, 1878, 44; Id., **179**, XXXVI, 1897, 28, 35; Id., **181**, 1897, 138, 346, Plate XXIII, Fig. 6; Id., **188**, 1900, 56; Fern., **53**, 1888, 31; Bl., **4**, XXIII, 1891, 99; Id., **11**, XXVI, 1894, 244; McN., **88**, VI, 1891, 74; Beut., **3**, VI, 1894, 306; Morse, **100**, VIII, 1898, 256, 259, 294, Plate 7, Fig. 43.

Size, medium. Vertex somewhat swollen, distinctly elevated above the pronotum; the interspace between the eyes slightly wider than (male) or fully half as wide again (female) as the first antennal joint; the front half moderately sloping, shallowly and broadly sulcate in the male, plane in the female. Frontal costa of nearly equal width throughout, faintly sulcate at and below the ocellus in the male. Antennæ about three-fourths (male) or two-thirds (female) as long as the hind femora. Pronotum feebly and regularly widening on posterior half; the disk flat or nearly so; the median carina distinct only on the metazona; the hind margin feebly obtuse angulate, the angle rounded; the prozona one-third (male) or but slightly (female) longer than the distinctly punctate metazona. Tegmina reaching tips of hind femora in the male, often a little shorter in the female, moderately broad, distinctly tapering. Extremity of male abdomen but little recurved; the basal half of cerci gently tapering, about twice as long as the greatest breadth; the apical half distinctly forked, the lower branch a little shorter and much narrower than the upper. Furcula consisting of a pair of well separated minute triangular denticulations. Sub-genital plate as broad as long, the apex broadly rounded. (See Fig. 15, Plate II.)

Color: Dark grayish brown varied with fuscous. Face dull bluish gray, with mottlings of brownish purple. Occiput and disk of prozona fuscous. A broad blackish bar extends from eye back along the upper half of lateral lobe of prozona; this often sub-obsolete, especially in the female. Tegmina brownish fuscous, often grayish in the female, with usually a row of fuscous spots along the discoidal area; though sometimes immaculate. Hind femora brownish yellow, indistinctly and obliquely barred with fuscous on the upper face, the lower face dull orange or yellowish; the knees black. Hind tibiæ bright coral red, the spines black.

Measurements: Length of body, male, 19 mm., female, 23 mm.; of antennæ, male, 9 mm., female, 8 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 14 mm., female, 16 mm.; of hind femora, male, 12 mm., female, 14 mm.

This is the species which, in my former papers I have called *M. collinus* Scudd. In his "Revision of the Melanopli," Scudder has said that *collinus* "is very closely allied to *M. luridus*, but differs in its lack of any projecting part of the furcula, the less divergent forks of the cerci, less elevated apical margin of the sub-genital plate and greater maculation of the tegmina." In all Indiana specimens the furcula are visible, and I therefore sent representatives to Prof. A. P. Morse to compare with Scudder's types of both species. This he kindly did and answered as follows: "From an examination of the material in Mr. Scudder's collection and in mine, I believe *M. collinus* Scudd. and *M. luridus* Dodge to be one species. My reasons for so thinking are these: First. The furcula of the male is equally as well developed in *collinus* as in *luridus*. It is as pronounced in one of the type specimens of *collinus* from Vermont as in typical *luridus*, and it occurs very frequently in other New England examples of *collinus*. Second. The other differences stated (Rev. Mel., p. 348) as distinguishing these species, viz., divergence of forks of cerci and degree of maculation of tegmina, are quite as inconstant and valueless as the degree of development of the furcula. Third. The geographical range of each species naturally and adequately supplements that of the other." I have, therefore, combined the two species under Dodge's name, which has priority.

M. luridus probably occurs in all parts of Indiana, though it has been taken only in Crawford, Monroe, Vigo, Putnam, Marion, Wells, Marshall, Laporte and Porter counties. It frequents open, blue-grass pastures and the borders of gravelly and sandy terraces and prairies; and like *M. gracilis* and *M. bivittatus*, delights to carry on its courtship among the leaves and branches of the iron weeds. They begin to reach maturity about July 20th, and may be taken until late November. While of about the same length, the females of *luridus* are much more robust than those of either *M. femur-rubrum* or *M. atlanis*, and the tegmina just reach the tip of or are a little shorter than the abdomen, instead of exceeding it as in those species.

74. MELANOPLUS DIFFERENTIALIS (Uhler). The Lubberly Locust.

Coloptenus differentialis Uhl., MS., 1863; Thom., 206, V, 1873, 166; Id., 211, 1880, 91, 96, 127, Fig. 24; Glov., 62, 1872, Plate VIII, Fig. 12; Palte IX, Fig. 4; Plate XI, Fig. 6; Riley, 119, 1877, 89, 194, 198, Fig. 34; Id,, 214, I, 1878, 220, 223, 225, 298, Figs. 32, 110, Plate IV, Fig. 1; Id., 122, II, 1884, 194, Fig. 271; Id., 127, XXV, 1891, 30, Fig. 8.

Acridium differentiale Thom., 202, V, 1865, 450.

Melanoplus differentialis Brun., 22, I, 1885, 139; Id., 23, 1888, 88, Fig. 4; Id., 26, XXVII, 1892, 32; Id., 28, XXVIII, 1893, 15, Fig. 5; Id., 30, 1893, 461, Fig. 103; Id., 31, 1894, 163, 204, Fig. 67; Id., 35, 1899, 133, Fig. 76; Id., 36, 1899, 247, 270, Fig. 53; Comst., 41, 1888, 108, Fig. 100; Bl., 4, XXIII, 1891, 99; Id., 15, XXX, 1898, 62; Id., 16, 1899, 238, Fig. 64; Scudd., 179, XXXVI, 1897, 30, 35; Id., 181, 1897, 138, 349, Plate XXIII, Figs. 3, 4; Id., 188, 1900, 57; Lugg., 84, 1898, 204, Figs. 130–132.

Size, large. Vertex gently arched, but little elevated above the pronotum; the interval between the eyes three times or more as broad as the first antennal joint; the front half gently sloping, broadly but not deeply impressed. Frontal costa broad, but narrower than the interspace between the eyes, broadly and shallowly sulcate at and below the ocellus. Antennæ more than twice as long (male)

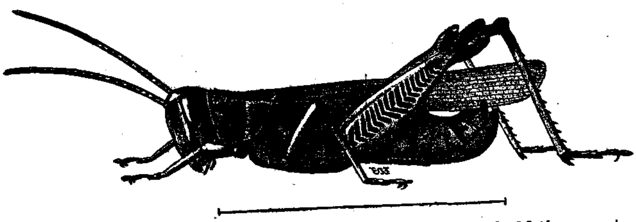


Fig. 72. *Melanoplus differentialis* (Uhler). Male. One and one-half times natural size. (After Lugger.)

or fully half as long again (female) as the pronotum. Disk of pronotum expanding feebly on the metazona, flat or nearly so; the front margin slightly convex, the hind margin obtusely and roundly angulate; the median carina distinct and sharp on the metazona, less distinct but visible on the front half of prozona; the metazona a little shorter than the prozona and finely rugulose. Tegmina exceeding the tips of hind femora in both sexes, the narrowest apical portion about half as wide as the broadest basal portion. Hind femora stout and rather short, slightly exceeding the abdomen in the male. Extremity of male abdomen but little recurved, the cerci boot-shaped, the basal half oblong; the apical half expanding and feebly forked, the strongly upcurved upper prong being as long and more than half as wide as the basal half; the lower prong (heel of the boot) being only a rounded, downward projecting lobe. Furcula absent. Sub-genital plate short and broad, the apical margin thickened. (See Fig. 16, Plate II.)

Color: A nearly uniform dark brownish green, or olive brown above, yellow beneath. The transverse sulci of pronotum and pleural incisions black, as are also one or two small patches on the upper half of lateral lobes of pronotum. Tegmina olive brown, immaculate. Hind femora, either dull or bright yellow, the outer face with narrow black marks arranged herring-bone fashion, the upper, inner face with three oblique black bars. Hind tibiæ yellow, with a narrow black basal ring, the spines black.

Measurements: Length of body, male, 30 mm., female, 44 mm.; of antennæ, male, 17 mm., female, 15 mm.; of pronotum, male, 7 mm., female, 10 mm.; of tegmina, male, 29 mm., female, 32 mm.; of hind femora, male, 18.5 mm., female, 22 mm.

This is the largest and at the same time one of the most common and destructive of our Melanopli. It occurs throughout the State, having been taken in every county in which collections have been made. In central Indiana it begins to reach maturity about July 25th, and may be found in favorable seasons until December 1st. In late autumn the females are always worn and bedraggled, while many of the males are bright colored and evidently freshly moulted. The species becomes darker with age and those which mature in autumn are darker than those of midsummer.

In Indiana, the lubberly locust delights in low, damp waste places, such as the margins of lakes and ponds, the borders of streams, fence rows and the margins of low-land cultivated fields. It is especially fond of the greater rag weed, *Ambrosia trifida* L., of the river bottoms, and is often seen by scores feeding upon its leaves, or mating among its foliage. The various species of smartweed, *Polygonum,* which grow in shallow water, are also much frequented by it in early autumn. On October 2, 1894, vast numbers were seen along the edge of a field of low-land corn, the leaves of the marginal rows of which they had almost wholly destroyed. When a stalk was approached they did not desert it but dodged quickly around to the opposite side, much as does a squirrel around the trunk of a tree when pursued. If, however, one took alarm and jumped, all the others in the immediate vicinity did likewise.

On one occasion a specimen of *differentialis* was found feeding upon a dead example of *Dicromorpha viridis,* half or more of the abdomen of the latter having been devoured. The Logger-head shrike, *Lanius ludovicianus* L., catches many of these and other locusts and often impales them on the barbs of wire fences. On one October day I gathered fully a pint of such impaled insects from a fence row half a mile long, and found that they represented sixteen species; eight of grasshoppers, two of katydids, and six of beetles, all injurious, so that this bird, although savage and bloodthirsty, is of great benefit to the farmer and fruit grower.

M. differentialis, according to Scudder, "inhabits the Mississippi Valley from as far north as latitude 43° to the Gulf, and the region to the west as far as the Pacific, from a somewhat lower latitude to central Mexico. I do not think it occurs above 6,000 feet. It certainly is occasionally one of the most destructive pests in the west, particularly in Kansas, Missouri and Illinois, and it has been noted as injuring grass, alfalfa, Indian corn, beets, orchard trees, mulberry, poplar and catalpa trees, and even grape vines; also dahlias, hollyhocks and other garden flowers have been specified as its food, not to mention the rag-weed, *Ambrosia trifida.*" Riley states that "in the vicinity of St. Louis, Missouri, the first specimens of this locust were observed to become winged July 19th. Eggs were laid September 9th. As a deviation from the usual egg-laying habits of the genus * * * the eggs are sometimes very numerously placed under bark of logs that have been felled on low lands. The eggs of this species, unlike those of *spretus, atlanis* and *femur-rubrum,* are not quadrilineарly but irregularly arranged. * * * The head ends of the eggs in the pod point mostly outward. One hundred and seventy-five eggs have been counted in a single mass." Bruner gives the following summary of its destructiveness and habits: "This insect has very frequently multiplied in such numbers in limited areas over its range as to do considerable injury to cultivated crops growing upon low, moist ground; and has even been known very frequently to spread over higher and drier lands adjoining these, its customary haunts. It is one of the few species of locusts that has thus far shown a tendency toward civilization. This it has done readily, since its habits are in unison with the cultivation of the soil. It is only since the settlement of the country where it originally occurred that it has multiplied so as to become sufficiently numerous as to become a serious pest. * * *

"The eggs are laid in cultivated grounds that are more or less compact, preferably old roads, deserted fields, the edges of weed patches and well grazed pastures adjoining weedy ravines. Egg laying begins about the middle of August and continues into October, varying, of course, according to latitude and climatic conditions. Usually, but not always, only a single cluster of eggs is deposited by each female. Frequently there are two, and in extreme cases perhaps even three, of these clusters deposited by a single female."

75. MELANOPLUS BIVITTATUS (Say). The Yellow-striped Locust.

Gryllus bivittatus Say, 138, IV, 1825, 308; Id., 139, II, 1859, 237.

Caloptenus bivittatus Uhl., in Say, 139, II, 1859, 238; Pack., 104, 1869, 570; Glov., 62, 1872, Plate I, Fig. 16; Thom., 206, V, 1873, 166; Id., 211, IX, 1880, 91, 96, 126; Riley, 119, 1877, 89, 194, Fig. 38; Id., 214, I, 1878, 220, 226, 327, 459, Fig. 111; Id., 122, II, 1884, 194, Fig. 272; Id., 127, XXV, 1891, 31, Fig. 9.

Melanoplus bivittatus Scudd., 148, I, 1874, 376; Id., 179, XXXVI, 1897, 31, 35; Id., 181, 1897, 138, 363, Plate XXIV, Fig. 5; Id., 188, 1900, 54; Bl., 4, XXIII, 1891, 99; Id., 11, XXVI, 1894, 244; Id., 16, 1899, 244, Fig. 70; Brun., 28, XXVIII, 1893, 19, Fig. 8; Id., 30, 1893, 461, Figs. 104-105; Id., 31, 1894, 163, 205, Fig. 71; Id. 35, 1899, 133, Fig. 80; Id., 36, 1899, 247, 270, Fig. 50; Beut., 3, VI, 1894, 308, Plate VIII, Fig. 8; Lugg., 84, 1898, 206, Figs. 133-135.

Caloptenus femoratus Burm., 40, II, 1838, 638.

Melanoplus femoratus Scudd., 163, XIX, 1878, 284, 288; Id., 161, VI, 1878, 43, 47; Id., 179, 1897, XXXVI, 31, 35; Id., 181, 1897, 138, 360, Plate XXIV, Fig. 4; Id., 188, 1900, 58; Comst., 41, 1888, 108, 110, Fig. 99; Fern., 53, 1888, 31, Fig. 13; Morse, 100, VIII, 1898, 257, 258, 294, Plate 7, Fig. 45.

Acridium flavovittatum Harr., 71, 1841, 140; Id., 72, 1862, 173; Emm., 49, V, 1854, 147; Rathv., 109, 1862, 384.

Size, large. Vertex gently swollen, but little elevated above the pronotum; the interspace between the eyes about three times the width of first antennal joint; the front half feebly sloping, broadly and shallowly sulcate. Frontal costa broad, sub-equal, feebly sulcate at and below the ocellus. Antennæ about as long (male) or two-thirds as long (female) as the hind femora. Pronotum enlarging feebly on posterior half, more distinctly in female, the disk nearly flat, the hind margin broadly rounded; the median carina low but visible throughout; the prozona fully a half (male) or about one-third (female) longer than the closely and delicately punctate metazona. Tegmina reaching or a little surpassing the hind femora, sometimes a little shorter in the female, tapering regularly and gradually from base to tip. Hind femora rather long and moderately stout. Extremity of male abdomen but little upcurved; the cerci very stout, large and broad, the basal half narrowing gently, and beyond the middle expanding into two lobes; an upper, ovate, compressed one, nearly as long as the basal half, directed upward and backward; and a lower, short triangular one, broader than long, directed downward. Furcula consisting of a pair of short, much swollen, triangular, widely separated lobes. Sub-genital plate narrow, the apex a little elevated and ending in an obtuse tubercle. (See Fig. 17, Plate II.)

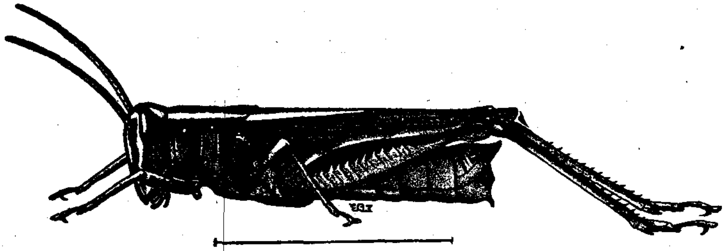


Fig. 73. ***Melanoplus bivittatus*** (Say). Female. One and one-quarter times natural size. (After Lugger.)

Color: Dull olive brown above, yellowish beneath. Face either yellow or olive green. Occiput and disk of pronotum reddish or olive brown. A narrow yellowish stripe extends back from the upper angle of each eye along the lateral carinæ of pronotum nearly to the tips of the tegmina; this usually bordered below with blackish on head and lateral lobes of pronotum. Tegmina with often a few fuscous dots along the discoidal area, but sometimes immaculate. Hind femora dull yellow, more or less infuscated along the upper half of outer face; the lower face yellow; the knees partly infuscated. Hind tibiæ usually bright coral red, with black spines; sometimes purplish or greenish yellow.

Measurements: Length of body, male, 28 mm., female, 37 mm.; of antennæ, male, 16 mm., female, 14 mm.; of pronotum, male, 7 mm.; female, 9 mm.; of tegmina, male, 22 mm., female, 24 mm.; of hind femora, male, 16 mm., female, 21 mm.

This is also a very common locust throughout the State. It begins to reach maturity about June 15th, perhaps earlier in the southern counties, and has mostly disappeared by mid-September. It frequents clover fields, open blue-grass pastures, prairies and roadsides, and is to be found in both moist and dry localities. When flushed, it usually leaps vigorously; seldom flying; and then noiselessly and for a short distance. It delights to rest on the branches and foliage of the iron weeds and other Compositæ, and is often found after death, clinging to them and to tall grasses, where it has fallen a prey to the locust fungus. More than any other of our Melanopli it seems to be subject to the attacks of the red locust mite, *Trombidium locustarum* Riley. In August I once noted, in Putnam County, a large male with a dozen or more of the mites in different stages, attached to the membrane of the inner wings. A female near by, with both tegmina and wings absent, had more than 20 of the mites clinging to the thin membrane beneath the metathorax. Old and worn examples of this locust usually have the wings badly damaged.

I have combined the red-legged form *femoratus* with Say's older yellow-legged *bivittatus*, as I have taken the two forms in copulation, and have seen numerous specimens in which the tibiæ were brown at base, greenish or glaucous in the middle and red on the apical third. Specimens from New England labeled *femoratus* by A. P. Morse, differ in nowise from those from Indiana, called *bivittatus* by Prof. Lawrence Bruner.

The yellow striped locust ranges from Hudson Bay to North Carolina, and from the Atlantic to the Pacific. It sometimes occurs in such numbers as to be highly injurious. Bruner, in one of his accounts of this species says it is a "lover of rank and succulent vegetation, such as is found upon bottom lands, along the edges of cultivated fields, at the margins of woodlands and on the shaded mountain slopes." When "it develops in large numbers, then these haunts are forsaken, to a greater or less extent, and it spreads over cultivated fields, eating the choicest of everything."

76. MELANOPLUS PUNCTULATUS (Uhler). The Grizzly Locust.

Caloptenus punctulatus Uhl., MS., 1862; Scudd , **141**, VII, 1862, 465; Thom., **206**, V, 1873, 163.

Melanoplus aunctulatus Scudd., **148**, I, 1874, 376; Id., **163**, XIX, 1878, 285; Id., **161**, VI, 1878, 44; Id., **179**, XXXVI, 1897, 32, 35; Id., **181**, 1897, 139, 374, Plate XXV, Fig. 4; Id., **188**, 1900, 63; Fern., **53**, 1888, 31; Beut., **3**, VI, 1894, 252, 307; Bl., **15**, XXX, 1898, 62; Id., **16**, 1899, 187; Lugg., **84**, 1898, 208, Fig. 136; Morse, **100**, VIII, 1898, 257, 258, 295, Plate 7, Fig. 45.

Caloptenus griseus Thom., **205**, V, 1872, 454; Id., **206**, 1873, 165; Glov. **62**, 1872, Plate XII, Fig. 14.

Melanoplus griseus Bl., **6**, XXIV, 1892; 30; Id., **11**, XXVI, 1894, 245.

Caloptenus helluo Scudd., **152**, XVII, 1875, 476; Id., **153**, IV, 1875, 75; Id., **164**, 1879, 20.

Melanoplus helluo Scudd., **163**, XIX, 1878, 285; Id. **161**, VI, 1878, 44.

Size, medium. Head prominent; the vertex swollen and distinctly elevated above the pronotum; the fastigium or front half rapidly sloping and sulcate throughout, the margins much raised between the eyes which are separated by a space twice as wide as the basal joint of antennæ. Frontal costa prominent above, of equal width throughout, sulcate below the ocellus. Eyes large and, in the male, very prominent. Antennæ about as long as (male) or a fourth shorter than (female) the hind femora. Pronotum with its front border slightly flaring to receive the head; the posterior half widening but little; the median carina usually visible throughout but more distinct on the metazona; the hind margin broadly obtuse angled; the prozona about a third (male) or scarcely (female) longer than the finely rugulose metazona. Tegmina slightly surpassing the hind femora in both sexes; very gradually tapering to a well rounded apex. Extremity of male abdomen moderately recurved; the cerci large, broad; the basal half oblong; the apical half expanded to double the width of the basal, the upward expansion being twice or more as large as the downward. Furcula wholly wanting. Subgenital plate of moderate width, the apex rather abruptly elevated and thickened. (See Fig. 18, Plate II.)

Color: Dark gray, much mottled with blackish. Head and face greenish gray mottled with fuscous; the occiput and disk of prozona darker. The usual black bar behind eye on upper half of lateral lobes is broken and somewhat indistinct. The disk and sides of metazona and the tegmina are thickly sprinkled with numerous rounded or quadrate fuscous spots, which give to the insect a grizzly appearance, quite distinct from any other of our Melanopli. Hind femora alternately and plainly barred with blackish and dull yellow on the upper and outer faces; the lower face and basal third of inner face coral red. Hind tibiæ either dull red or gray, or a mixture of both; the spines black. Abdomen clay yellow beneath.

Measurements: Length of body, male, 24 mm., female, 27 mm.; of antennæ, male, 14 mm., female, 12 mm.; of pronotum, male, 5.5 mm., female, 6 mm.; of tegmina, male, 20 mm., female, 22 mm.; of hind femora, male, 13 mm., female, 15 mm.

This prettily mottled locust has been taken in Crawford, Monroe, Vigo, Putnam, Montgomery, Marion, Marshall and Fulton counties, but is nowhere common, seldom more than half a dozen being seen each season. It is preëminently an autumn insect; the first mature specimen having been taken on August 20th, while most of those seen were in October and November after heavy frosts. In central Indiana it frequents for the most part low wooded tracts along streams, where it may often be noted resting on the trunks of trees, two or three feet above the ground. In the northern part of the State it has been found only in the depths of the tamarack swamps of Fulton and Marshall counties. While other Acrididæ are common up to the very border of the tamarack growth, this and two species of grouse locusts were the only ones found within this border. Several pairs of *punctulatus* were taken in coitu on September 24th. It is not an active insect; usually after one or two short leaps, squatting close to the earth, and seemingly depending upon the close similarity of its hues to the grayish lichens about it to avoid detection. The general range of *punctulatus* is given by Scudder as Maine to Virginia and westward to Texas and Nebraska. In most places it frequents the vicinity of pine or coniferous trees, and Walker has recently given an interesting account of its habits as follows: "I found them most numerous on dead stumps and logs, in a wood of second growth white pine, at De Grassi Point, Ontario. They were sometimes seen on the trunks and branches of living trees, but most often on the stumps and fallen trunks of the old forest, and on the pine rails of a snake fence enclosing the wood. They were found only on the borders and more open parts of the woods, where they were to be seen upon almost every stump. I have seen ten females on a single stump. It is in these dead stumps and logs that the females deposit their eggs, in which operation I have observed them repeatedly. The female chooses a crack in the wood or an old beetle boring of suitable size and lowers her abdomen down this, sometimes nearly as much as an inch. Sometimes when the hole is of a large size, only the head and legs of the insect can be seen above it. Unlike *Chlœaltis conspersa*, the female of *M. punctulatus* apparently never bores herself, unless merely to make her way through any loose rubbish that might be obstructing the hole. She generally chooses sound or only partly decayed wood.

"I managed to obtain several fragments and one complete packet of eggs. The latter was fixed by the cement substance at its lower end to the wall of the beetle-boring three-eighths of an inch in diameter. It was attached at a distance of about three-quarters of an inch down the hole, and except at the lower end, which was imbedded in a depression in the wall, the packet was quite free. It was covered with a rather thick coating of a porous or vesicular cement substance, which also filled all the spaces between the closely packed eggs. The latter were twenty-three in number, and their arrangement was in general in a longitudinal direction, the anterior ends pointing toward the free end of the packet, but was otherwise irregular. The eggs are 4 to 4.8 mm. long, elongate-elliptical in form, finely and densely punctate, reddish brown."*

* Can. Ent., XXXIII, 1901, 22.

XXXIX. Phœtaliotes Scudder (1897).

Body elongate, rather slender, a little compressed. Head large, prominent, nearly half as long again as the prozona. Vertex prominent; the narrowest portion one and one-half times as wide as the frontal costa, the front half sloping downward, with a broad, median furrow or depression. Frontal costa with the lower half much wider than the upper; the region just below the ocellus concave. Antennæ about three-fourths the length of hind femora. Pronotum enlarged a little in front to receive the head; the disk with the sides a little sloping, the hind margin broadly obtuse angled; the median carina rather sharp, of equal height throughout, cut by all three of the transverse sulci. Lateral lobes of pronotum with the lower margin obtuse angled near the middle. Tegmina either abbreviate or fully developed. When the former, a little longer than the pronotum, broadly lanceolate, the inner margins touching about the middle. When developed, surpassing the hind femora in both sexes. Hind femora slender, surpassing the tip of abdomen in male, a little shorter in female. Abdomen compressed, carinate above, its apical fourth thickened and curved upward in the male. Cerci depressed, styliform. Furcula minute, triangular. (See Fig. 19, Plate II.)

One species is known from the United States; the short-winged form of which occurs in northern Indiana.

77. **Phœtaliotes nebrascensis** (Thomas).

Pezotettix nebrascensis Thom., **205**, V, 1872, 455; Id., **206**, V, 1873, 151; Glov., **62**, 1872, Plate XIII, Fig. 2.

Phœtaliotes nebrascensis Scudd., **177**, XXXII, 1897, 205; Id., **181**, XX, 1897, 377, Plate I, Fig. 9, Plate 25, Figs. 6, 7; Id., **188**, 1900, 65.

Pezotettix autumnalis Dodge, **45**, VIII, 1876, 10; McN., **88**, VI, 1891, 76.

Caloptenus volucris Dodge, **46**, IX, 1877, 112.

Color: Olive green, more or less marked with fuscous. Face olive green, darker above. A broad blackish band back of eye extends along side of pronotum to posterior transverse sulcus. Disk of pronotum and tegmina wood brown. Abdomen of male with the sides greenish, the posterior third of each segment fuscous; in the female the fuscous predominates. Hind femora greenish tinged with reddish brown; the lower face reddish yellow; the knees black. Hind tibiæ dull green, the spines black. The structural characters are given above under the generic heading.

Measurements: Length of body, male, 22 mm., female, 26 mm.; of antennæ, male, 9.5 mm., female, 7 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 6 mm., female, 7 mm.; of hind femora, male, 13 mm., female, 14 mm.

Only the short-winged form of this dull colored locust has been taken in Indiana, and those only in Lake and Porter counties on October 11 and 12, 1898. Just east of Hammond, they were found in a long, low, marshy tract among the leaves of blue flag. The next day they were more abundant about some marshes northwest of Dune Park. The males were strong and active leapers, oftentimes giving several great jumps to a tuft of bunch grass or weeds and gliding down it to the ground, where they squatted close until picked up with the fingers. The females were more sluggish and several were taken from between the stems of grass where they were standing on their heads, after endeavoring to escape by diving downward. This is the most eastern point from which the species has been recorded, its range, as given by Scudder, being from the Rocky Mountains to the Mississippi River, though McNeill has taken it in Rock Island and Henry counties, Illinois.

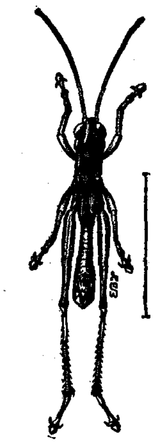


Fig. 74. *Phœtaliotes nebrascensis* (Thos.). Male. (After Lugger.)

XL. PAROXYA Scudder (1877).

Size, medium. Body straight, sub-cylindrical. Head of average size, the eyes very large and prominent. Vertex narrowed between the eyes, but less so than in *Hesperotettix,* the narrowest portion, in the male, being about as broad as the frontal costa, broader in the female; the widened portion in front with a broad lengthwise furrow. Frontal costa prominent above the ocellus, flattened below, scarcely sulcate in the male, more strongly in the female. Antennæ of male usually more than half as long again as head and pronotum together. Disk of pronotum twice as long as average breadth, its edges nearly parallel, the surface flat or nearly so; the prozona half as long again as the metazona, the surface of the latter finely and densely punctate; the hind margin obtusely and bluntly angulate; the median carina low, of equal height throughout, cut only by the last transverse sulcus. Lateral lobes of pronotum vertical, longer than deep, the lower margin with its front half strongly directed upward. Tegmina and wings variable in length, but in our species always much longer than the pronotum. Hind femora of average stoutness, equaling or more usually surpassing the tip of abdomen. Sub-genital plate of male short, the apex more or less truncate; the cerci long, spoon-shaped, the apex incurved.

Four species are known from the United States, two of which have been described from Indiana.

KEY TO INDIANA SPECIES OF PAROXYA.

a. Length of body of male, 20 or more mm. Antennæ of male longer than hind femora. Tegmina reaching middle of abdomen in both sexes ....78 *hoosieri*, p. 336

aa. Length of body of male not over 17.5 mm. Antennæ of male but three-fourths the length of hind femora. Tegmina nearly as long as abdomen in female, slightly surpassing abdomen in male....... 79 *scudderi*, p. 338

78. PAROXYA HOOSIERI (Blatchley). The Hoosier Locust.

Pezotettix hoosieri Bl., 6, XXIV, 1892, 31.

Paroxya hoosieri Scudd., 177, XXXII, 1897, 205; Id., 181, XX, 1897, 381, 382, Plate 25, Fig. 9; Id., 188, 1900, 66; Bl., 15, XXX, 1898, 63.

Paroxya, atlantica, Bl., 11, XXVI, 1894, 244.

Antennæ of male very long, exceeding the length of posterior femora. Foveolæ present, almost twice as long as wide, more distinct in the female. Pronotum broadening slightly on posterior half (more noticeable in the female); median carina distinct and equal throughout, the transverse sulci scarcely noticeable in the female, distinct but shallow in the male; the lateral carinæ present but rounded obtusely off; the disk and sides of posterior lobe densely and rather coarsely punctate. Tegmina oblong, two and a half times as long as broad, reaching to middle of abdomen and slightly overlapping on the median dorsal line, the wings but little shorter. Sub-genital plate of male broader than high, the lateral edges higher and flaring slightly outward. Cerci long and slender, gently incurved, narrowed at the middle, with the apical third flattened and slightly hollowed on the exterior face. Furcula consisting of a pair of oblong, parallel, flattened plates, whose inner edges touch; their apical third somewhat tapering and blunt. (See Fig. 20, Plate II.)

Fig. 75. *Paroxya hoosieri* (Bl.). Male. One and one-third times natural size. (Original.)

Color of living specimens: Male, antennæ, light reddish brown, infuscated at tip, and with the apical sixth of each segment yellowish. Face, green; clypeus and mouth parts yellow. Vertex, disk of pronotum and tegmina, plain olive, immaculate. Lateral lobes of pronotum greenish-yellow below; above with a broad, shining black line reaching from the eye to their posterior edge. The under side of abdomen pale yellow, and the metapleura with an oblique yellow line. Femora, green; knees, black; hind tibiæ, greenish, yellowish brown at base, with black spines.

Female: Duller; the disk of pronotum and tegmina sometimes with minute fuscous spots; a black stripe on the sides of abdomen, above which are numerous small black blotches.

Measurements: Length of body, male, 22 mm., female, 31 mm.; of antennæ, male, 15 mm., female, 11 mm.; of pronotum, male, 5 mm., female, 6 mm.; of tegmina, male, 10 mm., female, 13 mm.; of hind femora, male, 14 mm., female, 17.5 mm.

This species was first noted in Indiana about the margins of the "Goose Pond," Vigo County, on October 11, 1901. It at once attracted attention on account of the length of the male antennæ, and the black stripes on the sides of the abdomen of the female. The pond was then almost dry, and the dense growth of sedges and rushes which had filled its shallow margins, were, in some places, burned away. Over the burned spots had sprung up a dense green vegetation, and here this *Paroxya* flourished in company with *Truxalis brevicornis* and *Dicromorpha viridis*, while a few feet away *Leptysma marginicollis* found a suitable home among the rushes and sedges still standing. Both sexes of *P. hoosieri* were very active, leaping vigorously when approached, and difficult to capture except by throwing the net over them as they rested on the ground. The females were exceedingly difficult to kill in the cyanide bottle, "coming to" after having been kept in it for several hours, although the males were killed in a few minutes. On October 27th, the spot was again visited, and, although several heavy frosts had occurred, yet the species was still fairly common. At this time, however, they were all found in the small patches of grass which grew among the fallen leaves a few yards from the edges of the pond proper.

Since then the species has been found to be rather common in the western and northern portions of the State, having been taken in Gibson, Fulton, Starke, Lake, Kosciusko, Steuben, Whitley and Wells counties, and also by Mr. Lynds Jones near Oberlin, Ohio. In all these localities it occurs about the borders of marshes, especially those bordering the lakes and tamarack bogs of the north. In Gibson County it was found mature on July 10th.

On one occasion I found a female of this species and also one of *Chlœaltis conspersa* Harr., a few inches apart on the stump of a downy poplar, *Populus heterophylla* L., each with the abdomen buried to the full length in the soft wood, but no eggs could be discovered. Nothing has been recorded concerning the habits of oviposition of the members of the genus *Paroxya,* and it would be surprising if they, like the *Chlœaltis* mentioned, should seek wood rather than earth as the receptive matrix for the eggs.

I at one time considered *hoosieri* a short winged form of *P. atlantica,* but, on account of distinctive characters pertaining to the abdominal appendages of the male, Scudder regards it as a valid species.

79. Paroxya scudderi Blatchley. Scudder's Paroxya.
Paroxya scudderi Bl., 15, XXX, 1898, 59; Scudd., 188, 1900, 66.

The smallest known member of the genus, the body of the male averaging but 17 mm. in length. Antennæ relatively short, being but 9 mm. in length in both sexes. Tegmina reaching slightly be-

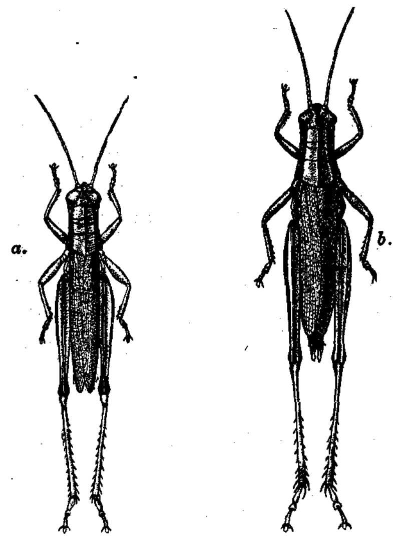


Fig. 76. *Paroxya scudderi* Bl. *a*, Male. *b*, Female. One and one-third times natural size. (Original.)

yond tip of abdomen in male, a little shorter than abdomen in female. Supra-anal plate of male very short, triangular, with a short, basal, triangular sulcus, in which rest the furcula. These consist of a pair of flattish, oblong, sub-equal plates with their inner edges touching except at the apices, where they slightly diverge. Cerci strongly incurved, narrowed at the middle, the basal half stouter than in *P. hoosieri*, the apical third flattened and rounded at the end.

Color: Metazona, tegmina, and upper and outer faces of all the femora of male a uniform light wood brown; occiput and prozona darker. A broad black stripe extends from the eye along the upper half of the lateral lobes of pronotum as far as the posterior transverse sulcus, where it ends abruptly, the posterior lateral lobe being uniform in color with the disk. Below this black stripe is one of ivory white, brightest on the head. Metapleura also ivory white. Face grayish olive, flecked or tinged with yellowish. Basal two-thirds of antennæ the color of the tegmina; apical third darker. Palpi and prosternal spine yellow. Sternites of thorax olive brown; those of abdomen yellow as also the lower faces of all the femora. Hind tibiæ dull, pale green (basal third sometimes light brown), with a black spot at knee; the spines eleven in number in the outer series, with their apical thirds black.

Female darker; the tegmina sometimes obscurely and sparingly flecked with fuscous; the yellow of under side dull or wanting.

Measurements: Length of body, male, 17 mm., female, 24 mm.; of antennæ, male and female, 9 mm.; of pronotum, male, 5 mm., female, 5.5 mm.; of tegmina, male, 13 mm., female, 14.5 mm.; hind femora, male, 11.5 mm., female, 13.5 mm.

This graceful-bodied species was first found in small numbers on July 27, 1897, about the grassy margins of a pond in the sand dune region north of Millers, Lake County, and within one-half a mile of the shore of Lake Michigan. On the following day a single pair were taken from a similar locality near Tolleston, in the same county, and about four miles from the lake, but still within the sand covered area. It was usually found clinging to the stems of the tall rushes and grasses common in such locations, and when disturbed the males used the wings in a noiseless flight, while the females depended upon their leaping powers to escape. When closely followed, they would attempt to hide by burrowing in the fallen grass.

No others were secured until July 24, 1902, when a single male was taken from low ground along a railway southeast of Hammond. On August 20th it was found in numbers in the tall grasses along a lobe of Bass Lake, Starke County.

P. scudderi is more closely allied to *P. atlantica* than to either of the other two known species of the genus, but its smaller size, shorter antennæ of male, longer cerci, and the different shape of the male furcula at once distinguish it. It will probably be found to occur about low moist places in many of the counties of the northern third of the State.

Family LOCUSTIDÆ.

As already noted the sub-order, *Saltatoria* or Jumpers, includes three families of Orthoptera, one of them being the *Locustidæ*. This family comprises those insects commonly called katydids, green or long-horned grasshoppers and stone or camel crickets.

The distinguishing characters of the members of the family *Locustidæ*, as given in the key, p. 210, are the long, slender, tapering, many-jointed antennæ; the almost universal absence of ocelli or simple eyes; the four-jointed* tarsi or feet; and the sword-shaped or falcate ovipositor of the females, which is made of four flattened plates. The head in many of the species is wedge-shaped and the mouth parts are well developed, the mandibles, especially, being long and sharp pointed. This enables the insect to dig into plant tissue or to eat the seeds of grasses, as many of them do. The males have, in many instances, abdominal appendages corresponding to the parts of the ovipositor, which are used as clasping organs. The tegmina or wing covers, when present, slope obliquely downwards, instead of being bent abruptly, as in the *Gryllidæ* or true crickets; and in most cases, the wings are longer than the tegmina.

The stridulating or musical organ of the males is quite similar in structure to that of the male cricket, being found at the base of the overlapping dorsal area of the tegmina and usually consisting of a transparent membrane, of a more or less rounded form, which is crossed by a prominent curved vein, which, on the under side, bears a single row of minute file-like teeth. In stridulating, the wing covers are moved apart and then shuffled together again, when these teeth are rubbed over a vein on the upper surface of the other wing cover, producing the familiar, so-called "katydid" sound. Each of the different species makes a distinct call or note of its own, and many of them have two calls, one which they use by night and the other by day. Any one who will pay close attention to these different calls can soon learn to distinguish each species by its note as readily as the ornithologist can recognize different species of birds in the same manner. The ear of these insects, when present, is also similar in structure and position to that of the cricket's, being an oblong or oval cavity covered with a transparent or whitish membrane and situated on the front leg, near the basal end of the tibiæ.

* The members of the genus Daihinia, no one of which occurs in Indiana, have the fore and hind tarsi three jointed.

The young of *Locustidæ*, like those of the other families of the *Orthoptera*, when hatched from the egg resemble the adults in form but are wholly wingless. As they increase in size they moult or shed the skin five times, the wings each time becoming more apparent, until after the fifth moult, when they appear fully developed, and the insect is mature or full grown, never increasing in size thereafter. Throughout their entire lives they are active, greedy feeders, mostly herbivorous in habit; and where present in numbers necessarily do much harm to growing vegetation.

In the number of species in any given locality, the *Locustidæ* far outrank the *Gryllidæ*, being excelled in this respect among the other Orthopteran families only by the *Acrididæ* or Locusts. According to Scudder, 194 species of the family are known from the United States. Of these, 40 have been taken in Indiana and are described in the present paper, specimens of all being in my private collection. This is seven more than are known in any other State from which lists have been published except Nebraska, where Bruner records the presence of 58 species. McNeill has listed 27 from Illinois; Smith 33 from New Jersey; Osborne 24 from Iowa, and Scudder 23 from all New England.

Six sub-families of *Locustidæ* occur in the United States and all are represented in the Indiana fauna. They may be separated by the following table:

A SYNOPSIS OF THE SUB-FAMILIES OF LOCUSTIDÆ KNOWN TO OCCUR IN INDIANA.

a. Tegmina and wings present.

- *b.* Prosternal spines absent; vertex rounded or deflexed without spine, tubercle or cone; tegmina always shorter than wings; hind tibiæ with an apical spine on each side................ PHANEROPTERINÆ, p. 342
- *bb.* Prosternal spines present; vertex either terminating in a sharp flat spine or produced upward and forward in a rounded tubercle or prominent cone; hind tibiæ with an apical spine on outer side only or on neither.
  - *c.* Wing covers leaf-like, broadly expanded in the middle, concave within, longer than the wings; vertex terminating in a sharp, flat spine; pronotum crossed by two distinct transverse sulci........PSEUDOPHYLLINÆ, p. 358
  - *cc.* Wing covers narrow, expanded but little, if any, in the middle, often shorter than the wings; vertex terminating in a rounded tubercle or prominent cone; pronotum without, or with only one, transverse sulcus..... CONOCEPHALINÆ, p. 362

aa. Tegmina and wings absent, or the former rudimentary.

d. Pronotum extending back to the abdomen; prosternal spines present; fore tibiæ with a hearing organ near the base; tegmina rudimentary .... DECTICINÆ, p. 392

dd. Pronotum short, not covering the whole top of thorax; prosternal spines absent; fore tibiæ without a hearing organ near the base; wholly wingless.

e. Eyes ovate, vertical, situated on the side of the basal joint of antennæ; ovipositor ensiform, curved strongly upward .... GRYLLACRINÆ, p. 395

ee. Eyes sub-rotund, situated partly above the basal joint of the antennæ; ovipositor nearly straight................. STENOPELMATINÆ, p. 396

Sub-family PHANEROPTERINÆ.

The species of this sub-family are among the largest of our Locustidæ, and, with those of the Pseudophyllinæ, are commonly known as "Katydids." The apex of the head is obtuse or rounded, without cone or spine, and the prosternum is unarmed. The wing covers are shorter than the wings, usually expanded in the middle, and of a bright uniform green color. The wings are folded like a fan and are long and strong, the insects being flyers rather than leapers. The hind limbs, being seldom used except to give themselves an upward impetus at the beginning of flight, while long and slender, are proportionally much smaller in diameter than in the sub-family *Conocephalinæ,* whose members leap rather than fly.

The "katydids" are the most arboreal of all of the *Locustidæ,* the great majority of them passing their entire lives on shrubs and trees, where they feed upon the leaves and tender twigs, and, when present in numbers, often do excessive injury. The color and form of their wings serve admirably to protect them against their worst foes, the birds; and as they live a solitary life, i. e., do not flock together in numbers as do the green grasshoppers, they are but seldom noticed by man. Their love calls, or songs, however, make the welkin ring at night from mid-August until after heavy frost, and though but one or two of the eight species found in the State make a note in any way resembling the syllables "Katy did, she did," yet all are accredited with this sound by the casual observer, and hence the common name usually given to the members of this sub-family. Their call is seldom made by day for the obvious reason that it might attract the attention of the birds and so lead to the destruction of the songster. As twilight approaches, however, the male of each species begins his peculiar note, which is kept up with little or no intermission until the approach of day warns him that his feathered enemies will soon be on the alert, and that silence will be, for a time, the best policy to pursue.

From the other Locustidæ, the katydids differ widely in their habits of oviposition. The eggs are not deposited in the earth or in twigs, but are usually glued fast in double rows to the outer surface of slender twigs, or are inserted in the edges of leaves. The eggs of the most common species appear like small flattened hemp seeds, and usually overlap one another in the row in which they are placed. On account of this method of oviposition, the ovipositors of the katydids are broader, more curved, and more obtuse at the end than in the other sub-families whose members oviposit in the earth, in rotten wood or in stems of grass. This sub-family is represented in Indiana, so far as known, by three genera, which may be separated by the following table:

KEY TO GENERA OF INDIANA PHANEROPTERINÆ.

a. Wing covers of nearly equal breadth throughout; fastigium of vertex no broader than the first antennal joint; supra-anal plate of male with a long decurved spine which is notched at the end......
XLI. SCUDDERIA, p. 343

aa. Wing covers widest in the middle; fastigium of vertex much broader than the first antennal joint; supra-anal plate of male not as above.

b. Hind femora but little, if any, shorter than wing covers; ovipositor well developed, curved gradually upward............
XLII. AMBLYCORYPHA, p. 350

bb. Hind femora much shorter than wing covers; ovipositor very short, turned abruptly upward............................
XLIII. MICROCENTRUM, p. 353

XLI. SCUDDERIA Stal (1873).

This genus includes katydids of medium size, with wing covers long, narrow, of nearly equal width throughout, and rounded at the ends. The fastigium of vertex is acuminate, scarcely deflexed and very narrow, while the vertex itself is compressed, and hollowed out on either side for the better accommodation of the eyes, which are nearly hemispherical. The fore and middle femora are unarmed beneath, while the hind femora are long and slender, almost equaling the length of the wing covers in some of the species. The ovipositor is short, broad, curved sharply upward, and has the apical third finely crenate on both margins. The males are readily distinguished from those of the other genera by having both anal plates projected into long curved processes; the one from the supra-anal plate curving downward and notched or forked at the end, that from the sub-anal curving upward, and likewise notched. The form of these processes, together with that of the notches, serve as valuable characters in distinguishing the species. Eight species have been described from the United States, four of which are known to occur in Indiana.

KEY TO INDIANA SPECIES OF SCUDDERIA.

a. Length of posterior femora 28 or more mm.

b. Notch of supra-anal spine of male square with a minute median tooth, the notch as wide as the middle of the upturned sub-anal spine, and embracing the latter when in natural position; the lateral processes slender and compressed.......... 80 *texensis*, p. 344

bb. Notch of supra-anal spine of male acute, without median tooth, and much narrower than the middle of the upcurved sub-anal spine; the lateral processes (at side of notch) broadly rounded with the lower margin thinner, touching only and not embracing the upturned sub-anal spine...................... 81 *curvicauda*, p. 345

aa. Length of posterior femora less than 25 mm.

c. Notch of supra-anal spine of male very similar to that of *curvicauda;* tegmina much broader than depth of body....... 82 *pistillata*, p. 347

cc. Notch of supra-anal spine of male deep and rounded, forming a curious fork-like appendage, the lateral processes of which are much swollen; tegmina no broader than depth of body.... 83 *furcata*, p. 348

80. SCUDDERIA TEXENSIS Saussure-Pictet. The Texas Katydid.

Scudderia texensis Sauss-Pict., **136**, 1897, 328, Plate 15, Figs. 18-19; Scudd., **182**, 1898, 273, 277, Fig. 1; Id., **188**, 1900, 69.

Scudderia curvicauda Bl., **7**, 1893, 99; Beut., **3**, VI, 1894, 275, Plate VII, Figs. 5, 6; Lugger, **84**, 1898, 216, Fig. 138.*

Tegmina, wings and legs bright grass green; body and face somewhat paler, approaching a whitish in dried specimens. Pronotum much longer than broad, narrower in front than behind, and with a yellowish line along the lateral carinæ. Posterior femora very slender, armed beneath on inner carina with three or four minute spines.

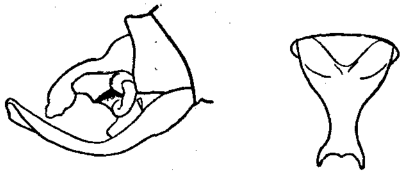
Measurements: Length of body, male, 22 mm., female, 25 mm.; of pronotum, male, 6.5 mm.; of tegmina, male, 37.5 mm.; of wings

*The synonymy of the species of *Scudderia* has, in the past, been so badly mixed, that it is difficult to say just what species was referred to by any writer. Mr. Scudder, in his monograph entitled, "The Orthopteran Group Scudderiæ" (Proceedings Americau Academy Arts and Science, XXXIII, 1898,) finally brought order out of chaos, and fixed the present standing of each species.

beyond tegmina, 6 mm.; of hind femora, male, 30 mm., female, 32 mm.; of ovipositor, 7 mm. Width of tegmina, 6.5 mm.

Texensis is, in Indiana, one of the most common of the katydids. It has been taken in Crawford, Vigo, Putnam, Henry, Wells, Fulton, Marshall, Porter, Starke and Lake counties. According to Scudder, it ranges over the United States east of the Great Plains. In southern Indiana it probably reaches maturity about July 15th. The earliest date on which I have taken it was July 22d, in Putnam County.

The eggs of *texensis* are laid in the edges of leaves between the upper and lower epidermis, and at first are so thin that they are not



a b

Fig. 77. *a*. Extremity of male abdomen of *Scudderia texensis* Sauss.—Pict. *b*. Dorsal view of anal segment of same. (After Scudder.)

noticeable except when the leaf is held between one's self and the light. They are loosely inserted in these pockets made by the ovipositor of the mother, and as they swell in coming in contact with the ruptured tissues of the plant, they are held tightly in place. The winter of this, as well as of the other species of the genus, is passed in the egg stage, the young appearing about the last of April.

This insect is probably less arboreal than any other species of katydid, as it is often found clinging to the tall, coarse grasses and sedges which grow near the borders of lakes, ponds and in damp ravines, and to the coarse weeds along the margins of prairies and meadows. When approached, it flies rapidly in a zigzag, noiseless manner for a long distance to another clump of grass or weeds, or to the lower branches of an oak, a tree in which it delights to dwell.

81. SCUDDERIA CURVICAUDA (De Geer). The Curve-tailed Katydid.

Scudderia curvicauda De G., **57**, III, 1773, 446, Plate 38, Fig. 3; Brunn., **38**, 1878, 240; Sauss.-Pict., **136**, 1897, 331, Plate 15, Fig. 20; Scudd., **182**, 1898, 274–278, Fig. 3; Id., **188**, 1900, 68.

Phaneroptera angustifolia Harr., **71**, 1841, 129.

Scudderia angustifolia Scudd., **168**, 1892, 67 (note of set to music).

Scudderia furculata Bl., 7, 1893, 100; Beut., 3, VI, 1894, 275; Lugger, **84**, 1898, 217, Figs. 139–140.

This species closely resembles *S. texensis* in size and general appearance, and the females of the two are difficult to distinguish; the males, however, are readily separated by the different form of the notch of the supra-anal spine. The general color of the two species is the same, but the yellow carinal lines of the pronotum are less distinct or wholly wanting in *curvicauda*.

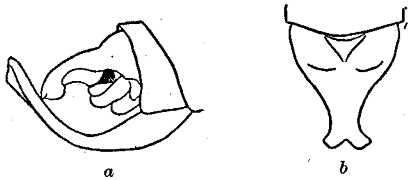


Fig. 78. (*a*) Extremity of male abdomen of *Scudderia curvicauda* (De Geer). (*b*) Dorsal view of anal segment of same. (After Scudder.)

The wing covers vary in width, but are usually broader than in *texensis*; and longer and much less broad, proportionally, than in the next species, *S. pistillata*. The females of *curvicauda* are more robust, and have the serrations on the margins of ovipositor less prominent than those of *texensis*.

Measurements: Male—Length of body, 23 mm.; of tegmina, 35-37 mm.; of posterior femora, 28-30 mm.; of pronotum, 6 mm. Width of tegmina, 7-8 mm. Female—Length of body, 25 mm.; of tegmina, 38 mm.; of posterior femora, 32 mm.; of ovipositor, 7 mm. Width of tegmina, 8.5 mm.

Curvicauda probably occurs in all portions of the State, but is less common than *texensis*. It has been taken in Lake, Starke, Fulton, Marshall, Kosciusko, Putnam, Vigo and Posey counties and is especially common about the marshy meadows bordering some of the lakes and tamarack swamps of northern Indiana. The earliest date on which a mature specimen was taken was July 10th, in Knox County. The general range of *curvicauda* is the same as that of *texensis*. The habits of flight, as far as noted, are also essentially the same as in that species.

In New Jersey, according to J. B. Smith, both *curvicauda* and *texensis* are very common on cranberry bogs, and destroy many of the berries. They eat into the fruit to get at the seed, which they devour, and leave the berry to dry up. A flock of turkeys which will destroy the young of these katydids and drive off those that are winged is probably the most effective remedy.

Mr. S. H. Scudder, who has studied carefully the songs of many species of Orthoptera and has even set a number of them, including that of *curvicauda*, to music, has given a pleasing account of its song, from which I take the following extract: "It is more noisy by night than by day; and the songs differ considerably at these two times. The day song is given only during sunshine, the other by night and in cloudy weather. I first noticed this while watching one of the little creatures close beside me; as a cloud passed over the sun he suddenly changed his note to one with which I was already familiar, but without knowing to what insect it belonged. At the same time all the individuals around me, whose similar day song I had heard, began to respond with the night cry; the cloud passed away, and the original note was resumed on all sides. Judging that they preferred the night song to that of the day, from their increased stridulation during the former period, I imitated the night song during the sunshine, and obtained an immediate response in the same language. The experiment proved that the insects could hear as well as sing. * * * The note by day is *bzrwi* and lasts for one-third of a second. The night song consists of a repetition, ordinarily eight times, of a note which sounds like *tchw*. It is repeated at the rate of five times in three-quarters of a second, making each note half the length of the day note."

82. SCUDDERIA PISTILLATA Brunner.

Scudderia pistillata Brunn., **38**, 1878, 240; Beut., 3, VI, 1894, 276; Sauss. Pict., **136**, 1897, 328, 332; Lugg., **84**, 1898, 220, Figs. 144, 145; Scudd., **182**, 1898, 273, 277; Id., **188**, 1900, 69.

This species is closely allied to *S. curvicauda* but is shorter bodied, broader winged and shorter legged. The notch of supra-anal spine of male is very similar to that of the male *curvicauda*, but the lateral processes are sub-triangular and distinctly tapering instead of well rounded and of sub-equal breadth as in the latter species. The sub-

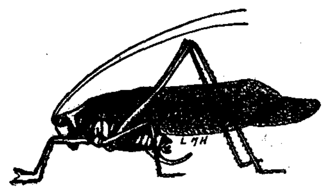


Fig. 79. *Scudderia pistillata* Brunn. Male. (After Lugger).

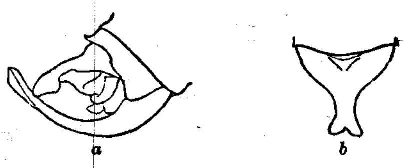


Fig. 80. (*a*) Extremity of male abdomen of *Scudderia pistillata* Brunn. (*b*) Dorsal view of anal segment of same. (After Scudder).

anal spine is also shorter than in *curvicauda*. The short, broad tegmina and the short hind femora of *pistillata* are the characters which most readily distinguish the two.

Measurements: Male—Length of body, 19 mm.; of tegmina, 32 mm.; of hind femora, 21 mm.; of pronotum, 5.5 mm.; width of tegmina, 10 mm. Female—Length of body, 19 mm.; of tegmina, 27 mm.; of hind femora, 20 mm.; of pronotum, 5.5 mm.; of ovipositor, 6.5 mm.; width of tegmina, 9 mm.

Pistillata is a species of northern range, its general distribution being "Northern United States and Canada east of the Great Plains." It is a scarce insect in Indiana, having, up to the present, been taken in small numbers only about the peat bogs and borders of lakes in Fulton and Kosciusko counties. Mr. Scudder, in his revision of the group, was mistaken in referring the species described in my former paper under the name of *furculata* to *pistillata;* as the measurements in my paper will prove. They belonged to *curvicauda* as at present limited, and are so placed in this paper.

83. SCUDDERIA FURCATA Brunner. The Fork-tailed Katydid.

Scudderia furcata Brunn., 38, 1878, 239, Fig. 72; Bl., 7, 1893, 101; Beut., 3, VI, 1894, 275; Sauss.-Pict., 136, 1897, 328, 331, Plate 15, Figs. 16, 17; Scudd., 182, 1898, 275-284, Fig. 8; Id., 188, 1900, 68.

Scudderia angustifolia Bl., 7, 1893, 102.

Phaneroptera curvicauda Riley, 115, 1874, 164, Figs., 50, 51. (Text in part.)

This is the smallest, and at the same time, our most common species of the genus. The general color is a dark leaf green, the head and pronotum paler; the latter without trace of yellow on its carinæ. The anterior margin of the pronotum is but slightly narrower than the posterior, whereas in the three preceding species the difference in width is plainly perceptible. The notch of the supra-anal spine of the male is deep and rounded, forming a curious fork-like appendage, the lateral processes of which are much swollen.

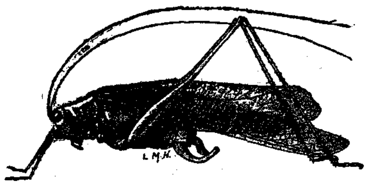


Fig. 81. *Scudderia furcata* Brunn. Male. (After Lugger.)

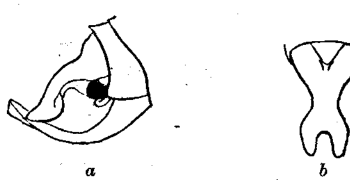


Fig. 82. (*a*) Extremity of male abdomen of *Scudderia furcata* Brunn. (*b*) Dorsal view of anal segment of same. (After Scudder.)

Measurements: Male—Length of body, 14-16 mm.; of tegmina, 26-31 mm.; of posterior femora, 19-22 mm.; of pronotum, 5 mm.

Width of tegmina, 6 mm. Female—Length of body, 18 to 20 mm.; of tegmina, 26-30 mm.; of posterior femora, 22 mm.; of ovipositor, 5 mm.

Furcata occurs in all portions of the State, having been taken in every county where collections have been made. Its general range includes the United States and southern Canada east of the Great Plains. In central and southern Indiana the first mature specimens appear about July 15th, but they do not become plentiful before the first of August, and I have seen the nymphs in Vigo County as late as September 18th. It is most frequently seen on the low bushes and trees about the margin of thickets and along fence rows, but in the prairie country north it frequents coarse grasses and weeds in company with the preceding species. Its flight is noiseless and seemingly without direction, and is not so prolonged as that of *S. texensis.* I have seen the adult of this species captured and borne away by the sand wasp.

Dr. C. V. Riley (*loc. cit.*), gives the following account of the egg laying habits of *furcata;* "The female stations herself firmly by the middle and hind legs on twigs or leaves contiguous to the one selected to receive the eggs. This leaf is then grasped by the front feet and held in a vertical position, while the edge is slightly gnawed or pared off by the jaws to facilitate the entrance of the point of the ovipositor. When this is done the abdomen is curved under and brought forward, and the ovipositor is seized on its convex edge by the mandibles and maxillæ, which, with the aid of the palpi, guide the point to that portion of the leaf prepared to receive it. After gentle, but repeated efforts, the point of the instrument is finally inserted between the tissues of the leaf, and gradually pushed in to more than half its length. As soon as the cavity is formed, the egg is extruded, and passed slowly between the semi-transparent blades of the ovipositor. As the egg leaves the ovipositor the latter is gradually withdrawn, while the egg remains in the leaf, retained in place, probably, by a viscid fluid that is exuded with it. As many as five of the eggs are sometimes deposited in one row in the same leaf, but more often they are single.

Of the call note of *furcata* Riley also states: "The shrill of the male is by no means so loud as that of the oblong-winged katydid, *Amblycorypha oblongifolia* DeGeer, in which its sound is always drowned in the woods. It consists of a softer *zeep, zeep,* sometimes uttered singly, but generally thrice in succession. The call is occasionally responded to by a faint chirp from the females, produced by stretching out their wings as if for flight, and is as often heard in the day as at night."

XLII. AMBLYCORYPHA Stal (1874).

Head with the vertex flat and without spines; its fastigium deflexed, much broader than the first antennal joint; eyes elliptical or oblong oval. Wing covers broad and rounded at the tip. Stridulating organ of the male, brownish, opaque, traversed by a strong green cross-vein. Supra-anal plate of male short, truncate; sub-anal plate short and broad at base, narrower at apex, with a broad triangular notch, the tips at side of which end in a short, blunt, spine-like process. Ovipositor, broad, of medium length, curved gradually upward from the middle; obtuse or rounded at the end, and with the apical half sharply and strongly serrate on both edges. Six species are listed by Scudder from the United States. Of these, three are known to occur in Indiana.

KEY TO INDIANA SPECIES OF AMBLYCORYPHA.

a. Size, large; tegmina, 34 to 37 mm. in length; those of the male exceeding the tip of posterior femora...........84 *oblongifolia*, p. 350

aa. Tegmina not more than 30 mm. in length; those of the male sometimes reaching but not exceeding the tip of the posterior femora.

b. Size, medium; greatest breadth of tegmina contained less than three times in their length; ovipositor strongly curved........ 85 *rotundifolia*, p. 352

bb. Size, small; greatest breadth of wing covers contained from three and one-fourth to three and one-half times in their length; ovipositor but moderately curved.....86 *uhleri*, p. 353

84. AMBLYCORYPHA OBLONGIFOLIA (DeGeer). The Oblong Leaf-winged Katydid.

Locusta oblongifolia DeG., 57, III, 1773, 445, Plate 38, Fig. 2.

Phylloptera oblongifolia Harris, 72, 1862, 159 (Text only); Scudd., 141, VII, 1862, 444.

Amblycorypha oblongifolia Brunner, 38, 1878, 266; Bl., 7, 1893, 104; Beut., 3, VI, 1894, 278; Lugger, 84, 1898, 222, Fig. 147; Scudd., 188, 1900, 70.

This is the largest of the three species occurring in the State, measuring about 45 mm. to the end of the wing covers, which are 3.3 times as long as wide. The wings exceed the wing covers by 5 to 6.5 mm. Anterior margin of pronotum much narrower than the posterior, the lateral carinæ sharply defined; the hind margin of deflexed lateral lobes broadly rounded. The inner, lower carina of posterior femora armed with six to 12 rather strong teeth. General color a bright pea-green, the shrilling organ of the male brownish, with a heavy green cross-vein. The abdomen yellowish or brownish green. Specimens sometimes occur which are wholly pink or rose color.

Measurements: Male—Length of body, 21 mm.; of tegmina, 38 mm.; of posterior femora, 30 mm.; of pronotum, 6.5 mm. Female—Length of body, 23 mm.; of tegmina, 36 mm.; of posterior femora, 31 mm.; of ovipositor, 11.5 mm. Width of tegmina of male, 11.5.

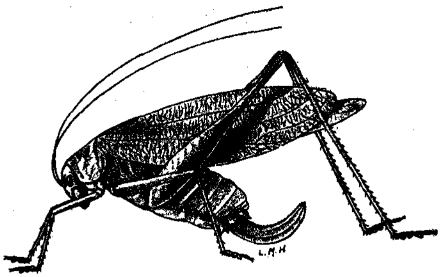


Fig. 83. *Amblycorypha oblongifolia* (DeG.) Female. (After Lugger).

The oblong-winged katydid is a common species throughout the State, its general range including the northern United States and Canada, east of the Great Plains. In southern Indiana it becomes mature about July 20th, and in the northern counties probably a fortnight later. A number of pink specimens have been taken from low meadows near Bass Lake, Starke County, by Mr. Frank Hay. Two of these are in my private collection. They were taken in a large marshy meadow in the lowlands bordering Yellow River. The causes which produce this curious "sport," by which a grass green is changed to a delicate pink, are, as yet, unknown. Scudder has said that "One thinks at once of autumn leaves and their change from green to red and notices that these pink katydids all occur in the autumn." In Indiana the pink specimens have been taken in early August, long before frost and before any noticeable change in the surrounding vegetation.

Oblongifolia frequents the shrubbery and flowers of the golden-rod and other Compositæ along fence rows and the edges of thickets and woods, especially in damp localities; and when flushed, flies with a kind of whirring noise, alighting on fence or the lower branch of tree. I have often located the male by its note, which to me is a creaking squawk—like the noise made by drawing a fine-toothed comb over a taut string. It is usually but once repeated, though sometimes three times. On several occasions it has been made after the insect was in my fingers. McNeill says that it is a "quick, shuffling noise which resembles 'katy' or 'katydid' very slightly."

85. **AMBLYCORYPHA ROTUNDIFOLIA (Scudder). The Round-winged Katydid.**

Phylloptera rotundifolia Scudder, 141, VII, 1862, 445.

Amblycorypha rotundifolia Brunner, 38, 1878, 268; Bl., 7, 1893, 105; Beut., 3, VI, 1894, 277, Plate VI, Fig. 2; Lugger 84, 1898, 222, Fig. 146; Scudd., 188, 1900, 70.

Phylloptera oblongifolia Harris, 72, 1862, Fig. 75 (Not text); Riley, 115, 1874, 169, Fig. 55 (Text in part).

The length of *A. rotundifolia* is about 32 mm. to the end of tegmina, which are proportionally much broader than those of *oblongifolia*. The posterior femora reach the tip of tegmina in the male, a little longer in the female; armed on the lower, inner carina with four or five minute teeth. Anterior margin of pronotum, especially

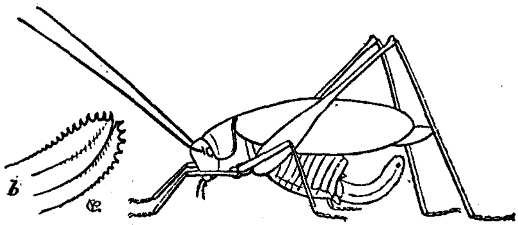


Fig. 84. *Amblycorypha rotundifolia* (Scudd.) Female. *b* Enlarged end of ovipositor. (After Riley.)

in the female, but little narrower than posterior; the hind margin of deflexed lateral lobes oblique and less broadly rounded than in *oblongifolia*. The ovipositor is more curved and more strongly serrate than in either the preceding or the following species. The color is essentially the same as that of *oblongifolia*. Pink specimens have been recorded from Pennsylvania, but they appear much more rarely than in the preceding species.

Measurements: Male—Length of body, 19 mm.; of tegmina, 27 mm.; of posterior femora, 25 mm.; of pronotum, 5 mm.; width of tegmina, 10 mm. Female—Length of body, 20 mm.; of tegmina, 27 mm.; of pronotum, 6 mm.; of ovipositor, 10 mm.; width of tegmina, 10 mm.

The round-winged katydid is also a common insect throughout Indiana, though more abundant in the southern half of the State. It is more of a terrestrial species than *oblongifolia*, being often seen on the ground, or on the clumps of tall grass and weeds, which grow in damp ravines. Its flight is comparatively noiseless and less prolonged than that of the preceding species. In southern Indiana the males become mature about the fifth of July; the females a week later. Of its note, Mr. Scudder says: "This insect stridulates both by day and by night, and without variation. The song consists of from two to four notes—sounding like *chic-a-chee*—repeated rapidly so as to be almost confounded, and when three requiring just one-third of a second; the song is repeated at will, generally once in about five seconds, for an indefinite length of time."

86. AMBLYCORYPHA UHLERI **Brunner.** **Uhler's Katydid.**
Amblycorypha uhleri **Brunn., 38, 1878, 267; Bl., 7, 1893, 106; Lugg., 84, 1898, 223; Scudd., 188, 1900, 70.**

Uhler's katydid is our smallest species of the genus, measuring but about 27 mm. to end of tegmina. The posterior femora are armed as in *rotundifolia*, and slightly exceed the tegmina in both sexes. Pronotum narrower in front, the anterior half of lateral carinæ rounded, the posterior rather sharp; the hind margin of lateral lobes as in *rotundifolia*. The male has longer wings and narrower tegmina than the female. Ovipositor less curved than in either of the other species, the apical half with comparatively strong serrations on both margins. General color a light grass green.

Measurements: Male—Length of body, 14 mm.; of tegmina, 23 mm.; of hind femora, 20 mm.; of wings beyond tegmina, 5 mm. Female—Length of body, 17.5 mm.; of tegmina, 22 mm.; of hind femora, 23 mm.; of wings beyond tegmina, 3 mm.; of ovipositor, 8.5 mm.

This species is much less common than either of the preceding, having been taken only in Vigo County, where it frequents the tall sedges and willows bordering the large ponds in the Wabash River bottoms; and in Crawford County near Wyandotte Cave, where a number were secured, on grass and herbs. The young feed upon the leaves of the black and scarlet oaks, *Quercus velutina* Lam. and *Q. coccinea* Wang, and the perfect insect is often found on or beneath these trees. It has been recorded before from New Jersey, Maryland and the District of Columbia, and ranges southwest to Texas.

XLIII. MICROCENTRUM Scudder (1862).

Size, large. Wing covers moderately expanded in the middle, much longer than the posterior femora, and with the outer border sloping off quite sharply, thus causing the tip to be more pointed than in *Amblycorypha*. Vertex much as in that genus, slightly furrowed. Eyes broadly oval, very prominent. Hind legs slender and very short, *the femora but little more than half as long as the tegmina*. Anal plates of male not prolonged; the supra-anal bluntly rounded; the sub-anal forked at the tip as in *Amblycorypha*. Ovipositor very short, bent abruptly upward, bluntly pointed, and with the apical third finely serrate above.

Two species occur in the United States, but one of which has, as yet, been taken in Indiana. Since the other, *M. retinerve* Burm., may in time be found in the southern half of the State, the following key will enable the student to separate the two:

KEY TO THE SPECIES OF MICROCENTRUM.

a. General color bright green; front border of pronotum sinuate, with a slight rounded median projection; hind femora one-half the length of tegmina .... 87 *laurifolium*, p. 354

aa. General color yellowish green; front border of pronotum truncate, without median tooth; hind femora more than one-half the length of tegmina .... *retinerve*

87. MICROCENTRUM LAURIFOLIUM (L.) The Larger Angular-winged Katydid. The Oblique-winged Katydid.

Gryllus laurifolius L., **81**, II, 1767, 695, 17.

Phylloptera laurifolia Burm., **40**, II, 1838, 693; Serv., **196**, 1839, 404.

Microcentrum laurifolium Brunn., **38**, 1878, 334, 339; Bl., **7**, 1893, 107; Id., **15**, 1899, 215, Figs. 47, 49; Beut., **3**, VI, 1894, 278, Plate VI, Fig. 3; Lugg., **84**, 1898, 224, Figs. 148, 149, 150; Scudd., **188**, 1900, 70.

Microcentrum affiliatum Scudd., **141**, VII, 1862, 447, Fig. 5.

Microcentrus retinervis Riley, **115**, 1874, 155, Figs. 43-47.

This is the largest species of "katydid" found in the State, both sexes measuring two inches and more to the tip of the wings. The general color is light, grass green, the body yellowish green, lighter beneath. The vertex is quite broad, with its center hollowed out so as to form a shallow pit, which is more prominent in the male. The pronotum is about as broad as long, its anterior margin a little sinuate and usually possessing a slight median tooth, though this is

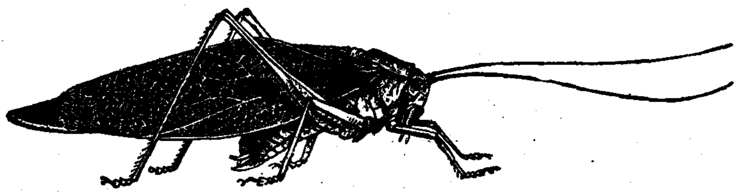


Fig. 85. ***Microcentum laurifolium*** **(L.) Male. (After Riley).**

sometimes obsolete, or is replaced with a shallow notch. The overlapping dorsal surface of the wing covers form a sharp and prominent angle with the lateral portions, whence the common name.

Measurements: Male—Length of body, 25 mm.; of tegmina, 42 mm.; of posterior femora, 22.5 mm.; of pronotum, 6 mm.; width of tegmina, 13 mm. Female—Length of body, 30 mm.; of tegmina, 46 mm.; of posterior femora, 24 mm.; of ovipositor, 5 mm.; width of tegmina, 14 mm.

In the country it is this insect which is most commonly called "the katydid," and the note of *Cyrtophyllus perspicillatus* L. is usually attributed to it, but its true note may be represented "by the syllable '*tic*,' repeated from eight to twenty times at the rate of about four to the second." However, *M. laurifolium* is probably less common in Indiana than the broad-winged katydid, with which it is confused. I have taken it in but three counties, viz., Putnam, Vigo and Marion. It is evidently attracted by light, being occasionally found in the gutters beneath electric lights. It, perhaps, occurs throughout the State, as its general range is given as the "United States east of the Rocky Mountains," but it is nowhere in Indiana so common as to be injurious.

The eggs of *M. laurifolium* are usually glued in double rows on the sides of slender twigs, which have been previously roughened with the jaws and otherwise prepared for a place of deposit. The two rows are contiguous and the eggs of one alternate with those of the other. Those of the same row overlap about one-fourth their length. They are of a grayish brown color, long oval in shape, very flat, and measure 5.5x3 mm. They are usually deposited in September, hatch the following May, and the young, in central Indiana, reach maturity during the first half of August. These eggs have, tember, hatch the following May, and the by persons who found them on their fruit trees, and thought they were the San Jose scale or some other injurious scale insect.

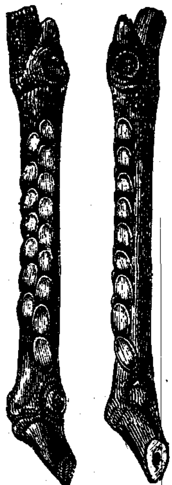


Fig. 86. Eggs of the Angular-winged Katydid. (After Riley).

Prof. C. V. Riley has written (*loc. cit.*) a pleasing description of the egg laying habits and call note of the angular-winged katydid, from which I quote at length as follows:

"The females commence to oviposit early in September, and continue to lay at intervals until the first severe frost. The eggs are occasionally deposited during the day, but the operation usually takes place at night. Selecting a twig of about the size of a common goose quill, this provident mother prepares it for the reception of the eggs by biting and roughening the bark with her jaws for a distance of two or three inches. This bite is not gradual like that made when feeding, but is sudden and vigorous, the insect chewing and pressing the twig each side so as to form an edge. This operation is accompanied by a sudden nervous shake of the body from side to side, and lasts sometimes but two or three minutes, sometimes more than ten. When the operation is accomplished to her satisfaction, she clutches with her front feet the stem to be used, and anchors the middle and hindmost feet for the most part upon contiguous leaves or branches, and often quite wide apart. Then, if she has her head in an upward direction (for it seems to be immaterial to her whether the eggs are placed from below up or *vice versa*), she begins at the lower end of the roughened portion of the twig, and, after fretting it anew with her jaws and measuring and feeling it over again and again with her palpi, as if to assure herself that all is as it should be, she slowly—with much apparent effort, and not without letting it partly fall several times—curls the abdomen under until the lower edge of the curved ovipositor is brought between the jaws and palpi, by which it is grasped and guided to the right position. It is then worked slightly up and down for from four to six minutes—all the time guided by the jaws—while a shiny viscid fluid is given out apparently from the ovipositor. Finally, after a few seconds rest or suspension of this work, the egg gradually rises, and, as it passes between the ovipositor, turns so that the one end appears almost simultaneously, from between the convex edge, with the other from the lower tip, of the blades. The egg adheres to the roughened bark in an oblique position. It is at first almost black and highly varnished, but it acquires its normal gray color within eight or ten hours. After the egg is placed, the abdomen is straightened out and the insect rests for a few moments, soon, however, to resume her efforts and repeat the like performance, in every particular, except that the second egg is placed on the opposite side of the twig and a little above the first one. The third egg is pushed in between the top of the first one and the twig, the fourth between the top of the second, and so on, one on each side, alternately. Thus these eggs are not laid, as we might naturally imply, one over the other, but rather, one under the other; i. e., each succeeding pair having their ends thrust in between the tops of the preceding pair, the teeth at the end of the ovipositor helping to crowd the end into place.

"The length of time required from the commencement of the fretting of the twig to the proper placing of the egg varies all the way from five to 20 minutes. Sometimes, as for instance where a bud comes in the way, the preparation of the twig will require a comparatively long time, and after the ovipositor is brought up and a futile attempt made to place the egg, it will be let down again and the work of preparing the twig more vigorously prosecuted a second time.

"The number of eggs laid at one time varies from two to 30, the first batches containing more than those deposited later in the season. Each female produces from 150 to 200, or perhaps more, and I have known them to lay on the edge of a leaf, or of a piano-cover, or along a piece of cord.

"These eggs, as already remarked, are rather flat when laid, but become more swollen, so that they have a narrower look as they approach the hatching period in spring. During the early part of May, the embryo larva—which lies straight in its egg, completely filling it, with the legs bent up as in a pupa, and the long antennæ curling around them—attains its full development, and after hours of tedious contracting and expanding movements, manages to burst the egg open at its top or exposed end, along the narrow edge, and generally about half way down. Through this opening young Katy slowly emerges, undergoing a moult during the process, and leaving its first skin, in a crumpled white mass, attached to the empty bivalvular egg shell. Including hind legs and antennæ it measures at this time, rather more than an inch in length, the body alone being one-eighth of an inch long; and in contemplating it, one can not but wonder how the long, stiff legs and great length of antennæ, together with the plump body, could so recently have been compressed into the comparatively small shell to which we see it clinging.

"In from ten to twenty minutes after hatching, these little beings essay their first leaps, and soon begin to eat with avidity. They feed with almost equal relish upon a great variety of foliage, but I have found that when reared upon very succulent leaves, such as lettuce, cabbage, purslain and the like, they are less hardy, and do not attain so great an age as when nourished upon more ligneous food, as the leaves of oak, apple or cherry.

"The first notes of this katydid are heard about the middle of July, and the species is in full song by the first of August. The wing covers are partially opened by a sudden jerk, and the notes produced by the gradual closing of the same. The song consists of a series of from 25 to 30 raspings, as of a stiff quill drawn across a coarse file. There are about five of these raspings or trills per second, all alike, and with equal intervals, except the last two or three, which, with the closing of the wing covers, run into each other. The whole strongly recalls the slow turning of a child's wooden rattle, ending with a sudden jerk of the same; and this prolonged rattling, which is peculiar to the male, is invariably and instantly answered by a single sharp 'chirp' or 'tschick' from one or more females, who produce the sound by a sudden upward jerk of the wings.

"Both sexes are for the most part silent during the day, but during the period of their greatest activity their stridulations are never for an hour remitted, from the time the great setting sun hides behind the purple curtains of the west till he begins to shed his scarlet rays in the east—the species being so numerous that the sound as it comes from the woods is one continuous rattling, not unlike the croaking of frogs, but set to a higher key."

Sub-family PSEUDOPHYLLINÆ.

This sub-family is represented in Indiana by only one genus—characterized as follows:

XLIV. Cyrtophyllus Burmeister (1838).

Tegmina broad and leaf-like, longer than the wings, obtuse and rounded at the ends, and concave or hollowed within. The vertex extends forward between the eyes in the form of a small triangular spine which is grooved above and crowded by the basal joints of the antennæ. Eyes small, globose. Prosternum armed with two short spines. Pronotum crossed by two transverse sulci; its surface rugose; its posterior third highest. Anterior pair of legs long and rather stout and well adapted for climbing. The "shrilling" organ of the male is brown in color, with the central portion as transparent as glass, and is set in a strong half-oval frame. Sub-anal plate of male produced into a long paddle-shaped appendage which is grooved on the upper side. Ovipositor of female broad, with the apical half up-curved and denticulate below; apex rather sharply pointed. One species which occurs throughout the eastern United States is common in Indiana.

88. Cyrtophyllus perspicillatus (L.) The True Katydid. The Broad-winged Katydid.

Gryllus perspicillatus L., 80, 1763, 15.

Cyrtophyllus perspicillatus Burm., 40, II, 1838, 697; Brunn., 39[a], 1895, 239; Scudd., 188, 1900, 71.

Platyphyllum concavum Harris, 72, 1862, 158, Fig. 74; Riley, 115, 1874, 167, Figs. 52-54.

Cyrtophyllus concavus Scudder, 141, VII, 1862, 444; Bl., 7, 1893, 109; Id., 16, 1899, 214, Fig. 48; Beut., 3, VI, 1894, 279, Plate VI, Fig. 1; Lugger 84, 1898, 226, Figs. 151-152.

The broad-winged katydid is readily known by the characters of the genus given above. The wing covers and wings of living specimens are dark green; the body, pronotum and head lighter, with a tendency to turn yellowish when dried. The main veins of the wing

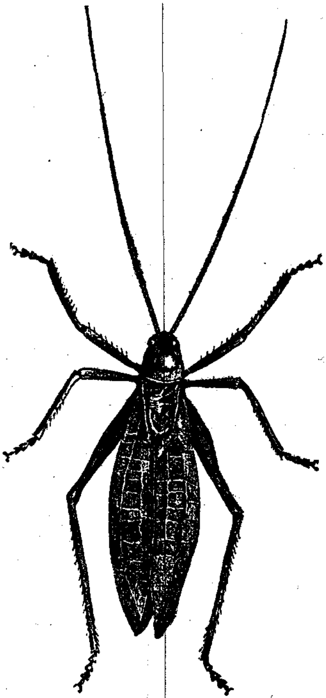


Fig. 87. *Cyrtophyllus perspicillatus* (L.) Male. (After Harris).

cover are very prominent with many reticulating branches, giving that organ much the appearance of a leaf. Posterior femora short, slender, and armed on apical half of lower outer carina with about six small spines. The ovipositor is almost as long as the abdomen, cimeter-shaped, sharp pointed, and with but slight serrations on the lower edge of apical third. The anal cerci of the male are broadly forked, and when in natural position the lower branch curves beneath the projecting sub-anal plate.

Measurements: Male—Length of body, 30 mm.; of tegmina, 37 mm.; of posterior femora, 21 mm.; of sub-anal spine, 11 mm. Width of tegmina, 18 mm. Female—Length of body, 29 mm.; of tegmina, 36 mm.; of posterior femora, 22 mm.; of ovipositor, 14 mm. Width of tegmina, 16 mm.

The broad-winged katydid is found in considerable numbers throughout the State, but is much more commonly heard than seen, as it dwells in small colonies in the densest foliage which it can find, such as the tops of shade trees and the entwining vines of the grape arbor. It is more domestic in its habits than any other species of the "katydid" group, frequenting, for the most part, the shrubbery of yards and orchards and the trees along fence rows, being seldom, if ever, heard in extensive wooded tracts. Its note is the loudest made by any member of the family, the male having the musical organ larger and better developed than in any other. The call is almost always begun soon after dusk with a single note uttered at intervals of about five seconds for a half dozen or more times. This preliminary note gives the listener the impression that the musician is tuning his instrument, preparatory to the well-known double call which is soon begun and kept up almost continuously from dark till dawn. Occasionally, in warm cloudy weather, this call is made by day, and if the musician is located he will sometimes be found resting on the topmost leaf of a shrub; swinging to and fro as the breezes blow, and sounding his cymbals in seeming unison with the movement. This katydid probably reaches maturity in southern Indiana by mid-July. The song has been heard in Putnam County as early as July 22d, and a single female was captured in Laporte County as late as October 15th.

In a Putnam County farmyard I listened for hours, one August night, to the serenade of a band of katydids. They seemingly tried to outdo themselves for my benefit. But to them I was a nonentity —an unknown being. No thought of me or of my attentive ear lurked in or passed through their brains, as they clashed their cymbals in every shrub and tree around the old farm house. One idea alone possessed the minds of the male musicians. That idea was love—passion—"that greatest thing in the universe." Long and loud the cymbals sounded, each shuffle, each note, doubtless accompanied by the wish that the next would call from the skies, from the branches above or about them—from anywhere, it mattered not—one of their form and kind. One to whom they could "whisper sweet nothings"—one whom they could caress tenderly with long antennæ —one whom, in time, they could clasp lovingly with their slender limbs and forget cymbals, calls, skies, food, earth, everything in that long embrace which to them is the acme, the one, the highest object of their mature existence.

The serenade continued thus, almost unbroken, from dusk till dawn. A serenade it was in truth — a song of love — of passion, poured out to the listening ears of the other sex. At times a single player dropped out of the chorus. His work, his love-calls had not been in vain. From some leafy retreat, where she had been hidden by day, a lady katydid slowly emerged, and, entranced by the song—by, to her ears, the tender wooing notes—drew nearer and nearer unto the charmed circle whence the cymbals clanged and shuffled. Their notes became less vigorous. More softly they fell upon her ear, until finally, as she coyly advanced they ceased and the caress of the antennæ took their place. The other musicians noted the absence of one of their chorus, and sounded their drums the louder, but for most of them their labor was in vain. Many of them doubtless go through life unblessed by the presence of the gentler sex, clanging their nightly calls from mid-July to the coming of the hoarfrost, and to its biting nips finally succumbing, possessed by the thought—if a katydid can think—that this earth is a desolate and cruel abiding place for such as they. So have the most of bachelors—human and otherwise—doubtless thought, as in the past they yielded up the ghost.

Of the call of this species Mr. Scudder has written: "The note, which sounds like *xr*, has a shocking lack of melody; the poets who have sung its praises must have heard it at the distance that lends enchantment. In close proximity the sound is excessively rasping and grating, louder and hoarser than I have heard from any other of the Locustarians in America or in Europe, and the Locustarians are the noisest of all Orthoptera. Since these creatures are abundant wherever they occur, the noise produced by them, on an evening specially favorable to their song, is most discordant. Usually the notes are two in number, rapidly repeated at short intervals. Perhaps nine out of ten will ordinarily give this number; but occasionally a stubborn insect persists in sounding the triple note—('Katy-she-did'); and as katydids appear desirous of defiantly answering their neighbors in the same measure, the proximity of a treble-voiced songster demoralizes a whole neighborhood, and a curious medley results; notes from some individuals may then be heard all the while, scarcely a moment's time intervening between their stridulations, some nearer, others at a greater distance; so that the air is filled by these noisy troubadours with an indescribably confused and grating clatter."

According to Riley the eggs are thrust, by means of the sharp ovipositor, into crevices and soft substances, and probably, in a state of nature, into the crevices of loose bark, or into the soft stems of woody plants. They are of a dark slate color, about 6.5x2 mm. in size, very flat, pointed at each end, and with the edges beveled off or emarginate.

Sub-family CONOCEPHALINÆ.

Vertex projecting forward and upward in the form of a tubercle or cone, sometimes blunt, sometimes much prolonged. Prosternum toothed or with two slender spines. Fore tibiæ without apical spines. Front coxæ (in our genera) with a spine on the outside. Wing covers seldom expanded in the middle, often shorter than the abdomen, and in color either green or brown. Shrilling organ of male well developed, the cross-vein prominent, the color light brown, with the central portion transparent (except in the genus *Conocephalus*). Hearing organs present near the base of fore tibiæ. Hind legs usually stout and much thickened at the base, as the insects seldom fly, but are active leapers, and very difficult to capture.

The eggs are deposited between the stems and root leaves of grass, in the pith of twigs, or sometimes in the turnip-shaped galls so common on certain species of willow. The ovipositor, being thus used as a piercer, has in time developed into a slender and sharp-pointed instrument which is but little curved and is frequently of excessive length, in some species being over twice as long as the remainder of the body.

To this sub-family belong those slender-bodied green grasshoppers, with long, tapering antennæ which are so common in summer and early autumn in damp meadows and prairies and along the margins of streams, ditches and ponds. They are mostly terrestrial in their habits, but one or two of the larger ones ever being found in trees.

The color of their bodies corresponds closely with that of the stems and leaves of the sedges and grasses among which they dwell, and so protects them from the sight of the few birds which frequent a like locality. Their songs, produced in the same manner as those of their larger cousins, the katydids, are as frequent by day as by night, but are usually soft and low in comparison with those of the former. Their day song differs from that of the night, and, says Scudder, "It is curious to observe these little creatures suddenly changing from the day to the night song at the mere passing of a cloud and returning to the old note when the sky is clear. By imitating the two songs in the daytime the grasshoppers can be made to represent either at will; at night they have but one note."*

This sub-family is represented in Indiana by three genera which may be separated by the following key:

KEY TO GENERA OF INDIANA CONOCEPHALINÆ.

a. Fore and middle femora spined beneath; vertex produced forward into a long sharp cone; stridulating organ of male green and opaque ....XLV. CONOCEPHALUS, p. 363

aa. Fore and middle femora unarmed beneath; vertex terminating in a rounded tubercle which is hollowed out on the sides; stridulating organ of male light brown and partly transparent.

b. Prosternal spines very short; ovipositor slender, straight or nearly so; insect small.............XLVI. XIPHIDIUM, p. 371

bb. Prosternal spines longer and more slender; ovipositor stout, usually upcurved; insect of medium size....................
XLVII. ORCHELIMUM, p. 381

XLV. CONOCEPHALUS Thunbergh (1815).

THE CONE-HEADED GRASSHOPPERS.

The members of this genus are readily known by having the vertex prolonged forward and upward into a cone which much exceeds in length the first segment of the antennæ, and bears a pointed tooth beneath. Face very oblique. Eyes sub-rotund, rather prominent. Spines of prosternum long and slender. Wing covers long, narrow, rounded at the end, much exceeding the abdomen and slightly exceeding the wings in all our species. The stridulating organ of the male is opaque and of a coarse texture in the left wing cover, but transparent at the center of the right. Hind femora of moderate length, rather slender, the insects often using the wings as locomoters. Ovipositor rather narrow, nearly straight, oftentimes of excessive length; the eggs of those species in which the oviposition has been noted, being deposited between the stem and the root leaves of plants. Anal plates of male not produced; the cerci much swollen, recurved and toothed.

Although these insects are said to be rather common by those writers who have prepared lists of Orthoptera from other states, yet in Indiana they are the least abundant of all the winged *Locustidæ*, ten years' collecting having yielded less than twenty specimens. They appear to be more common in the northern than in the southern half of the State.

* American Naturalist, II, 1868, 116.

Of the habits of the species found in Illinois, McNeill has written: "All the species of *Conocephalus* seem to possess more intelligence than is usual among the Orthoptera, and they are about the most difficult of the order to approach. In escaping they usually slip or fall into the grass instead of jumping or flying; but they seem to fully understand that they are very well protected by their color and form. If approached very cautiously they often remain quite still upon the stem of grass upon which you have surprised them with the usually well founded expectation that you will not be able to distinguish them from the green herbage around. If they think it worth while to make some active movement to escape they will frequently slip around on the other side of the stem and walk down the stem to the ground or off upon another plant. Unlike most Orthoptera they do not use their front legs in holding to the mouth the thing upon which they feed. Instead of biting they seem to wrench or tear away pieces from the stems or leaves."*

The genus is a large one, 101 species being included by Redtenbacher in his monograph. Only sixteen, however, are listed by Scudder as occurring in the United States, and but five have, up to the present, been taken in Indiana. These may be distinguished by the following table:

KEY TO INDIANA SPECIES OF CONOCEPHALUS.

a. Cone of vertex slender, extending 3 mm. or more in front of eyes, and with either the margin or lower face black.

b. Each margin of cone with a black line extending from the apex half way or more to base; inner, lower carina of posterior femora with four or five minute spines................ 89 *ensiger*, p. 365

bb. Lower face of cone wholly black from apex to inferior basal tooth; posterior femora armed on both the lower carinæ with a number of plainly visible spines.

c. Length of body of female less than 36 mm.; of cone of vertex not over 4.5 mm...........90 *nebrascensis*, p. 366

cc. Length of body of female more than 45 mm.; of cone of vertex more than 7 mm...............91 *bruneri*, p. 367

aa. Cone of vertex rather stout, extending less than 3 mm. in front of eyes, devoid of black markings.

d. Lateral carinæ of pronotum with a yellow line; wing covers with irregularly distributed black dots; ovipositor exceeding 25 mm. in length.........................92 *robustus*, p. 368

dd. Lateral carinæ of pronotum without trace of yellow; wing covers a bright grass green, immaculate; ovipositor less than 20 mm. in length...........................93 *palustris*, p. 369

*Psyche, VI, 23.

89. CONOCEPHALUS ENSIGER Harris. The Sword-bearer.

Conocephalus ensiger Harris, 72 1862, 163, Fig. 79; Riley, 122, II, 1884, 187, Fig. 263; Comstock, 41, I, 1888, 115; Redtenb., 110, 1891, 67, 89; Scudd., 168, XXIII, 1892, 72 (note of to music); Id., 188, 1900, 72; Bl., 7, 1893, 114; Beut., 3, VI, 1894, 281, Plate VI, Fig. 8; Lugger, 84, 1898, 230, Figs. 153, 154.

A slender bodied species, the general color of which is grass green (rarely brown), the body and face paler; the posterior tibiæ and tip of ovipositor infuscated. Lateral carinæ of pronotum sometimes with a faint yellow line, more plainly visible in the dried specimens. Tegmina very long and slender.

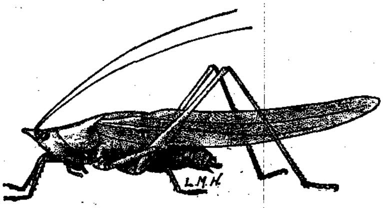


Fig. 88. *Conocephalus ensiger* Harris. Male. (After Lugger.)

Measurements: Male—Length of body, 26 mm.; tegmina, 42 mm.; of posterior femora, 21 mm. Female—Length of body, 28-30 mm.; of tegmina, 47 mm.; of posterior femora, 23 mm.; of cone of vertex, 3.25 mm.; of pronotum, 7.5 mm.; of ovipositor, 28-31 mm.

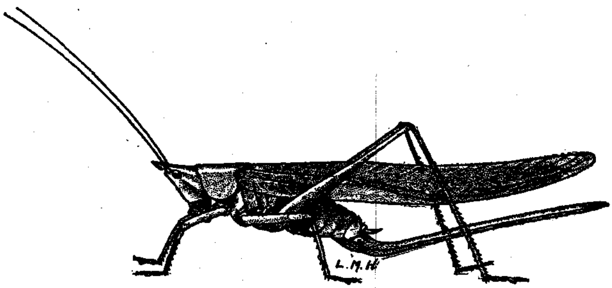


Fig. 89. *Conocephalus ensiger* Harris. Female. (After Lugger.)

Ensiger is probably the most widely distributed species of Conocephalus occurring in the eastern United States, having been recorded from Maine to the Rocky Mountains. It is the most common one occurring in northern Indiana, where it frequents the tall grasses along ditches and the borders of damp prairies. In the central and southern counties it is scarce, being replaced by the next species.

The female of *ensiger* has been recorded as depositing her eggs between the stem and the root leaves of *Andropogon*, a genus of tall, coarse grasses which grow in dry, sandy localities. The young, hatched in May, reach maturity in central Indiana about July 20th. Mr. Scudder, who has set the note of the male to music, says of the song: "This insect has but a single song and stridulates only by night, or during cloudy weather. It begins its song as soon as the sky is obscured or the sun is near the horizon. It commences with a note like *brw*, then pauses an instant and immediately emits a rapid succession of sounds like *chwi* at the rate of about five per second, and continues them for an unlimited time. Another writer likens its note to the syllable *'ik-ik-ik,'* as if sharpening a saw, enlivening the low bushes, and particularly the cornpatch, as it seems to especially delight in perching near the top of a cornstalk and there giving forth its rather impulsive song."

90. CONOCEPHALUS NEBRASCENSIS Bruner. The Nebraska Cone-head.
Conocephalus nebrascensis Bruner, 25, XXIII, 1891, 72; Scudder, 168, XXIII, 1892, 72; Id., 188, 1900, 72; Bl., 7, 1893, 115; Lugg., 84, 1898, 231.

This is a heavier bodied and shorter winged species than the preceding. The cone of the vertex projects upward more strongly and has the apical half more tapering than in *ensiger;* the basal tooth is also more prominent. The anal cerci of male are stout, with strong internal hooks. Ovipositor long and slender, lanceolate, a little curved upward and extending about one-fourth of an inch beyond the closed tegmina.

General color either bright grass green or a yellowish brown or tan with narrow, yellowish lines along the lateral carinæ of the pronotum. Posterior tibiæ together with all the feet more or less infuscated.

Measurements: Male—Length of body, 28 mm.; of tegmina, 37 mm.; of pronotum, 8 mm.; of cone of vertex, 3.5 mm.; of posterior femora, 21 mm. Females—Length of body, 33 mm.; of tegmina, 42 mm.; of posterior femora, 23 mm.; of ovipositor, 29 mm.

The above measurements are very nearly the same as those given by Mr. Bruner in the original description of the species, and are the average of a half dozen specimens in my collection. I have one female, however, which is so much larger that at first I was inclined to think it a different species, but the color and structure, except the measurements, agree in every particular with those given above of *nebrascensis*. The following are the measurements of the specimen in question: Length of body, 36 mm.; of cone, 4.5 mm.; of tegmina, 49 mm.; of posterior femora, 30 mm.; of ovipositor, 39 mm.

In central Indiana this is the most common of the three species of Conocephalus there occurring. A number of specimens have been taken in Putnam County by Mr. W. A. Riley, and in Vigo, Fulton and Starke counties by myself. When approached it often attempts to escape by burrowing beneath the fallen grass. It frequents the same localities as *C. ensiger* and is very liable to be mistaken for that species by the casual observer, but may at once be distinguished by the characters given in the key.

91. CONOCEPHALUS BRUNERI sp. nov. **Bruner's Cone-head.**

A large but comparatively slender bodied species, having the cone of vertex excessively long, flat rather than convex above, and with its under side a shining black as far back as the basal tooth.

General color: A light pea green tinged with yellowish on the head, pronotum and fore femora. A narrow yellowish line along the lateral carinæ of pronotum, absent on the head but present on the

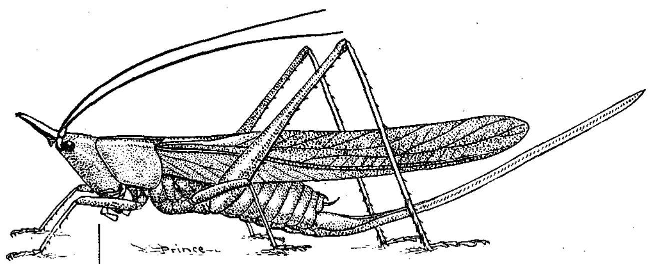


Fig. 90. *Conocephalus bruneri* **sp. nov. Female. Natural size. (Original.)**

lateral margins of cone of vertex. A very narrow and oblique yellowish line also extends a short distance back from each eye. Mandibles yellow. Feet and apical joints of palpi more or less infuscated.

Cone of vertex very prominent, extending 7.5 mm. in front of eyes, flattened above, with a slight median furrow in its basal half, gradually tapering from the base forward, its apical half curved slightly upward, the apex rounded and rather blunt; the lower basal tooth small and blunt. Pronotum the same length as the fore femora, of more than average breadth, the lateral carinæ evident but dull, the hind margin broadly rounded; the sides flaring noticeably outward, rather than at right angles to the dorsal field as in most species, their surface a little rugose. Tegmina reaching a little beyond the middle of ovipositor, their basal third rather broad, the apical two-thirds tapering very gradually to the rounded apex. Wings equaling the tegmina in length. Fore and middle femora short and stout, unarmed beneath, the former one-third the length of hind femora, the latter a little longer. Hind femora short but slender, armed on both margins of lower carinæ with about nine small but sharp teeth, those on inner carina a little longer and more distant, one from another, than those on outer. Hind tibiæ a little shorter than the femora. Ovipositor slender, of more than average length, of equal width to within 5 mm. of the apex, from whence it tapers gradually to a rather dull point.

Measurements: Female—Length of body, 44 mm.; of pronotum, 9.5 mm.; of tegmina, 50 mm.; of fore femora, 9.5 mm.; of hind femora, 30 mm.; of hind tibiæ, 29 mm.; of ovipositor, 45 mm.

This large and odd appearing Locustid is represented in my collection by a single female, taken in September, 1900, by Mr. Arthur Dransfield in the campus of the "Working Men's Institute," at New Harmony, Posey County, and kindly presented to me. It is quite distinct from any other species in this country, approaching most closely the Brazilian species *C. truncatirostris* described by Redtenbacher. The fastigium of the vertex is, however, even longer than in that species. Professor Lawrence Bruner, to whom the specimen was sent for examination, writes that he has a single female of the same insect taken from the Potomac bottoms, D. C., some years ago. The male is, as yet, unknown. The species is evidently southern in its range, and should be looked for throughout southern Indiana.

I take pleasure in naming this large Locustid in honor of Prof. Lawrence Bruner, of Lincoln, Nebraska, an authority on North American Orthoptera, who has shown me many courtesies during the preparation of this paper.

92. Conocephalus robustus Scudder. The Robust Cone-head.

Conocephalus robustus Scudd., **141**, VII, 1862, 449; Id., **168**, XXIII, 1892, 72 (song of); Id., **188**, 1900, 72; Riley, **122**, II, 1884, 187; Comstock, **41**, I, 1888, 115; Redtenb., **110**, 1891, 89, Plate III, Fig. 36; Bl., 7, 1893, 116; Beut., 3, VI, 1894, 280, Plate VI, Fig. 9; Lugg., **84**, 1898, 232.

General color bright green or pale brown; sometimes a mixture of both; the wing covers usually speckled with black. Cone of vertex much like that of *C. ensiger* but shorter, with the apex more obtuse; rarely with a black spot at apex, its sides often with a narrow yellowish line; the frontal basal tooth distinct but blunt. Posterior femora armed beneath on both carinæ with a number of rather weak spines. Wings of male equaling the tegmina in length, in the female a little shorter. Ovipositor shorter than in any of the preceding species.

Measurements: Male—Length of body, 30 mm.; of tegmina, 44 mm.; of hind femora, 23 mm.; of pronotum, 8 mm.; of cone, 2 mm. Female—Length of body, 31 mm.; of tegmina, 48 mm.; of hind femora, 26 mm.; of ovipositor, 26 mm.

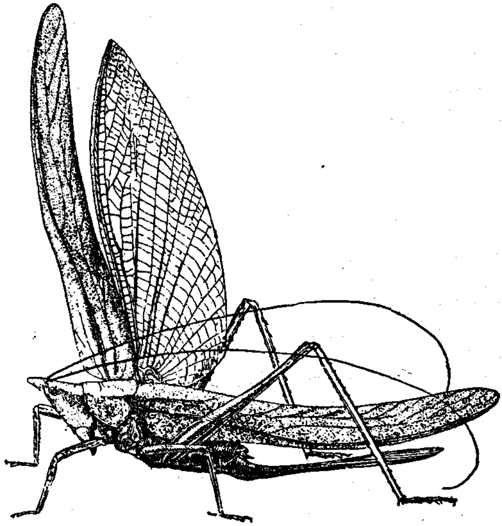


Fig. 91. *Conocephalus robustus* Scudd. Female. Natural size. (After Beutenmüller).

This species seems to be an inhabitant of sandy districts and occurs only along the Atlantic seacoast and the shores of the Great Lakes. In Indiana it has been noted only in Laporte County, where Prof. E. E. Slick found it quite frequently along the shore of Lake Michigan during September and October. Of the specimens sent to me—a half dozen males—he wrote: "They were caught off the trees, in the dusk of the evening, as they were singing. They sang ('whetted') continuously for ten minutes or longer while I watched them."

Mr. Scudder thus describes the note as heard in New England: "Robustus is exceedingly noisy and sings equally, and I believe similarly, by day and night. The song resembles that of the harvest fly, *Cicada canicularis*. It often lasts for many minutes, and seems, at a distance, to be quite uniform. On a nearer approach one can hear it swelling and decreasing in volume * * * and it is accompanied by a buzzing sound, quite audible near at hand, which resembles the humming of a bee or the droning of a bag-pipe."

93. CONOCEPHALUS PALUSTRIS Blatchley. The Marsh Cone-head.
Conocephalus palustris Bl., 10, XXV, 1893, 89; Id., 7, 1893, 118; Scudd., 188, 1900, 72.

A small but comparatively heavy-bodied species, having the cone of the vertex devoid of black markings and without a basal tooth; ovipositor very short and more than usually broad; posterior femora armed beneath on both carinæ. Cone of vertex short and stout, the tip round, the deflexed front with a dull median carina. Pronotum short, broad, the posterior margin regularly rounded, the lateral

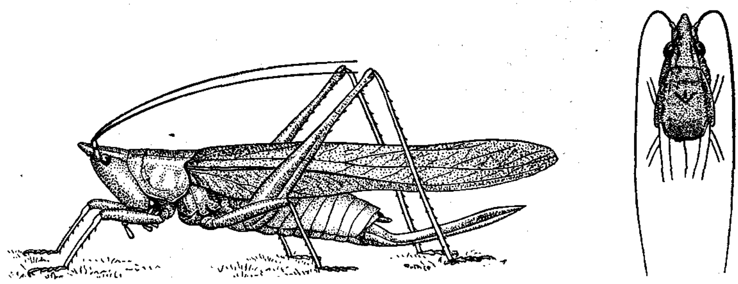


Fig. 92. *Conocephalus palustris* Bl.
(*a*) Female. One and one-third times natural size.
(*b*) Head of same from above. (Original).

carinæ well defined, the entire surface thickly and rather deeply punctate. Tegmina long and rather narrow, regularly rounded to the apex; of a more delicate texture than in either *C. ensiger* Harris or *C. robustus* Scudder. Fore and middle femora with two short spines on the apical third of the lower outer carina. Hind legs short, the tibiæ but little more than half as long as the closed tegmina; the femora with plainly visible spines on both of the inferior carinæ, eight on the outer and six on the inner. Ovipositor a little shorter than the hind tibiæ, broadest at a point about two-thirds the distance from the base, thence tapering regularly to a sharp apex.

General color a very bright grass green. Fastigium tipped with dull yellow, which extends half way down the sides. Labrum and apical segments of all the palpi a rose red tinged with violet. Tarsi somewhat infuscated. Antennæ and apical third of ovipositor reddish-brown.

Measurements: Female—Length of body, 27 mm.; cone of vertex, 2.75 mm.; of pronotum, 7 mm.; of tegmina, 37 mm.; of hind femora, 20 mm.; of hind tibiæ, 19.5 mm;. of ovipositor, 19 mm.

This handsome species of *Conocephalus* belongs to the same group as *C. robustus* and *C. crepitans* Scudder, but is smaller and of a more uniform and brighter green than either of those species, besides having shorter legs, ovipositor, etc. It is described from a single female taken October 24, 1891, from the fallen grasses on the margins of a large lowland pond in Vigo County. This pond, now extinct, was surrounded on all sides by heavy timber, and its margins yielded a number of interesting Orthoptera found nowhere else in the county. Among them were *Leptysma marginicollis* Serv., *Paroxya hoosieri* Bl., *Anaxipha exigua* Say, *Phylloscirtus pulchellus* Uhler, and *Xiphidium nigropleura* Bruner. The first four mentioned are insects of a southern range, and perhaps *C. palustris* will, in time, be found to be more common southward.

XLVI. Xiphidium Serville (1831).

This genus includes our smallest winged Locustidæ. The vertex projects forward and slightly upward in the form of a rounded tubercle which is hollowed out on the sides for the reception of the basal joint of the antennæ. Face rounded, somewhat oblique. Eyes rather large, sub-globose. Spines of prosternum very short and weak; often mere cone-shaped protuberances. Wing covers narrow, straight, rounded at the end, often varying much in length in the same species, but for the most part shorter than the abdomen. Wings usually a little shorter than the wing covers. Stridulating organ of male well developed, the veins prominent, light brown in color, and with the middle transparent. Hind femora of medium length, stout at base; mostly unarmed beneath. Ovipositor narrow, straight or but slightly curved, oftentimes of excessive length. Anal plates of male not prolonged; the cerci usually much swollen, and toothed at base on the inner margin. Eight species are known to occur in Indiana.

These insects are more variable in color and in the length of wings than those of any other genus of Orthoptera known to me. The variations, however, seem to be abrupt with no intervening forms. There are long-winged and short-winged forms of the same species but none with the wings of medium length; and when a brown form is tinged with green, or *vice versa*, the amount of the different color varies but little. Four of our eight species are thus dimorphic as regards the length of the wings, the short-winged individuals, as far as my observation goes, far outnumbering those with the wings fully developed; and at least three of the eight are variable with respect to color.

KEY TO INDIANA SPECIES OF XIPHIDIUM.

a. Ovipositor shorter than the body.

b. Ovipositor straight.

c. Body very slender; wings a little longer than the tegmina; the latter always fully developed and longer than abdomen .... 94 *fasciatum*, p. 372

cc. Body stouter; wings in the common form shorter than the tegmina; the latter usually abbreviated, not reaching tip of abdomen................95 *brevipenne*, p. 373

bb. Ovipositor a little curved; tegmina constant in length, covering about two-thirds of the abdomen in the male; shorter in the female ....96 *nemorale*, p. 374

aa. Ovipositor equal to or longer than the body.

d. Length of posterior femora almost equal to that of the ovipositor.

e. Body rather stout; the tegmina always covering more than half the abdomen.

f. Abdomen with dorsal surface light brown, the sides green, or yellowish green; ovipositor no longer than body ....97 *ensiferum*, p. 375

ff. Abdomen with the dorsal surface a fuscous brown, the sides shining black; ovipositor plainly longer than body ....98 *nigropleura*, p. 376

ee. Body very slender; the tegmina exceedingly short, padlike, covering only one-third of abdomen, the sides of latter dull reddish brown...............99 *saltans*, p. 377

dd. Posterior femora much shorter than the ovipositor, the latter of excessive length.

g. Under side of hind femora unarmed; the sides of the body green ....100 *strictum*, p. 378

gg. Under side of hind femora armed on the outer carina with several short black spines; the sides of the body dull reddish brown...............101 *attenuatum*, p. 379

94. **Xiphidium fasciatum** (DeGeer). **The Slender Meadow Grasshopper.**

Locusta fasciata DeG., 57, III, 1778, 458, Plate XL, Fig. 4.

Xiphidium fasciatum Burm., 40, II, 1839, 708; Pack., 104, 1883, 567; Riley, 122, II, 1884, 186; Comst., 41, I, 1888, 114; Redtenb., 110, 1891, 192, Plate IV, Fig. 82; Scudd., 168, XXIII, 1892, 75 (song of); Id., 183, XXX, 1898, 184; Id., 188, 1900, 74; Brun., 27, III, 1892, 265; Bl., 7, 1893, 119; Beut., 3, VI, 1894, 283, Plate VI, Fig. 7; Lugg., 84, 1898, 238, Figs. 157, 158.

Fasciatum is one of the most slender bodied Locustids belonging to our fauna. It is the only species of Indiana *Xiphidium* whose wings are never shorter than the body. Posterior femora reaching to or slightly beyond the tip of tegmina in the female, distinctly shorter in the male. Face, sides of pronotum and abdomen, and basal portion of ovipositor green; tegmina and apical third of ovipositor light reddish brown; upper side of abdomen, and stripe on occiput and disk of pronotum darker brown; legs green, brownish on the knees and tarsi.

Measurements: Male—Length of body, 13.5 mm.; of tegmina, 17.5 mm.; of hind femora, 11.5 mm.; of pronotum, 3.5 mm. Female

—Length of body, 14 mm.; of tegmina, 16 mm.; of hind femora, 13 mm.; of ovipositor, 8 mm.

This handsome meadow grasshopper is abundant throughout the State in timothy and clover meadows and especially so about small streams in low ground, blue-grass pastures. It is one of the first of the Locustidæ to reach maturity, specimens having been taken in Vigo County as early as July 5th, and it may be found until mid-October. The note of the male is very faint—a kind of *zr-r-r-r* long drawn out.

Fasciatum has, perhaps, the widest distribution of any of our American Locustidæ, its range, according to Redtenbacher, being from British America to Buenos Ayres, S. A.

The *Orchelimum gracile* of Harris, usually quoted as a synonym of *X. fasciatum*, has been shown by Bruner (*loc. cit.*) to be a distinct and valid species.

95. Xiphidium brevipenne Scudder. The Short-winged Meadow Grasshopper.

Xiphidium brevipennis Scudd., 141, VII, 1862, 451; Beut., 3, VI, 1894, 283, Plate VI, Fig. 6.

Xiphidium brevipenne Scudd., 148, 1874, 368; Id., 183, XXX, 1898, 184; Id., 188, 1900, 74; Riley, 122, II, 1884, 186; Comst., 41' I, 1888, 114; Redtenb., 110, 1891, 206, Plate IV, Fig. 91; Bl., 7, 1893, 121; Lugg., 84, 1898, 239.

A little shorter and thicker bodied species than *X. fasciatum*. Posterior femora rather short and stout, unarmed beneath, or rarely with one to four minute spines. Cerci of male swollen, the apex strongly compressed and obtuse, armed below the middle with a rather flat, sharp pointed tooth.

General color: Light reddish brown; the face and sides of pronotum usually green; stripe on occiput and disk of pronotum a very dark brown, margined on each side with a narrow yellow line; tegmina and wings a light reddish brown; ovipositor reddish brown throughout, darker toward the apex.

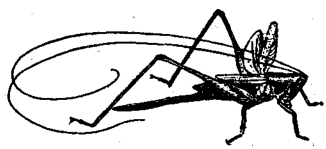


Fig. 93. *Xiphidium brevipenne* Scudd Female. Natural size. (After Beutenmüller.)

Measurements: Male—Length of body, 11 mm.; of tegmina, 7 mm.; of posterior femora, 10 mm.; of pronotum, 3 mm. Female—Length of body, 11-13 mm.; of tegmina, short winged form, 7 mm.; of posterior femora, 11 mm.; of pronotum, 3 mm.; of ovipositor, 10 mm.

This is also an abundant species throughout the State, frequenting the same localities as *fasciatum* and reaching maturity about a fortnight later. Long winged forms of *brevipenne* occasionally occur, but in Indiana they are very scarce, but one or two having come under my notice. Of the variations in the length of the wing covers of it and allied species, Professor Bruner has well said: "That in the genera *Xiphidium* and *Orchelimum* wing length is a character not to be relied upon as specific or even varietal difference;" yet Redtenbacher, in his "Monographie der Conocephaliden," has separated a number of his species by this character alone, and I can find no mention in his work of the fact that such a variation exists.

96. XIPHIDIUM NEMORALE Scudder.

Xiphidium nemorale Scudd., 151, XVII, 1875, 462; Id., 153, IV, 1875, 65; Id., 164, 1879, 15; Id., 168, XXIII, 1892, 75 (song of); Id., 183, XXX, 1898, 184; Id., 188, 1900, 75; Bl., 7, 1893, 122; Beut., 3, VI, 1894, 284; Lugg., 84, 1898, 240.

Xiphidium curtipenne Redtenb., 110, 1891, 208.

A rather robust species with the general color a dark, greenish brown; tegmina light reddish brown with the front or lower area fuscous. Dorsal stripe of occiput and pronotum a lighter grayish brown margined with a narrow yellowish line on each side. All the femora punctate with reddish dots, the tarsi and tip of hind femora dusky. Tegmina with the veins and cross-veins unusually prominent, giving them a coarse and scabrous look; the tympanum of male stout and elevated. Cerci conical, the apex obtuse, but little compressed. Ovipositor as long as the abdomen, the apical half with a gentle but evident upward curve.

Measurements: Male—Length of body, 14 mm.; of tegmina, 8 mm.; of hind femora, 12 mm.; of pronotum, 3.5 mm. Female—Length of body, 15 mm.; of tegmina, 5.5 mm.; of hind femora, 13 mm.; of ovipositor, 9 mm.

Nemorale is a common insect in central and southern Indiana, but has not as yet been taken north of Marion and Wells counties. It reaches maturity about August 1st, and from then until after heavy frosts may be found in numbers along the borders of dry, upland woods, fence rows, and roadsides, where it delights to rest on the low shrubs, blackberry bushes, or coarse weeds usually growing in such localities. On sunny afternoons of mid-autumn it is especially abundant on the lower parts of the rail and board fences, the male uttering his faint and monotonous love call—a sort of *ch-e-e-e-e—ch-e-e-e-e*, continuously repeated—the female but a short distance away, a motionless, patient, and apparently attentive listener. When in *coitu* the male does not mount the back of the female, but, with his body reversed, is dragged about by her, this being the common practice of all the species of *Xiphidium* and *Orchelimum.* The females at times evidently oviposit in decaying wood, as on several occasions I have found them on old fence posts and rails with their ovipositors inserted the full length in the wood.

Nemorale has been recorded from Nebraska, Iowa, Illinois and New York, and seems to be confined to the northern half of the middle United States.

97. XIPHIDIUM ENSIFERUM Scudder.

Xiphidium ensifer Scudd., **141**, VII, 1862, 451.

Xiphidium ensiferum Scudd., **166**, 1880, Appen., II, 23; Id., **183**, XXX, 1898, 183; Id., **188**, 1900, 74; Riley, **122**, II, 1884, 186; Comst., **41**, I, 1888, 114; Wheel., **223**, II, 1890, 222 (oviposition of); Redtenb., **110**, 1891, 209; Bl., **7**, 1893, 123; Lugg., **84**, 1898, 240.

Very similar in general appearance to *X. brevipenne* Scudder, and may be only a large variety of that species. Typical examples are larger, with a longer ovipositor, which is equal in length to the body and equals or slightly exceeds the length of hind femora. Tegmina of the common short-winged form covering about two-thirds of the abdomen in the female; usually reaching its tip in the male. Hind femora usually unarmed, though sometimes bearing one to four small teeth on their lower outer carina. Cerci of male rather stout, with the apical half curved slightly outward and depressed. Ovipositor slender, straight.

The general color is more of a green than in *brevipenne;* the face, sides of pronotum and abdomen, and usually the four anterior femora, being of that hue. The tegmina and wings are light reddish brown, as are also the tibiæ and ovipositor.

Measurements: Male—Length of body, 12.5 mm.; of tegmina, 10 mm.; of hind femora, 13 mm.; of pronotum, 3.5 mm. Female—Length of body, 12-14 mm.; of tegmina, short winged, 8.5 mm.; long winged, 14 mm.; of hind femora, 13.5 mm.; of ovipositor, 12-14 mm.

Although found in Indiana wherever collections have been made, this species appears to be less common than either *fasciatum* or *brevipenne.* It differs from them occasionally in the manner of oviposition, as, instead of always depositing its eggs in the stems of grasses, it sometimes seeks the turnip-shaped galls so common on certain species of *Salix* (willow), and oviposits between their scales. The gall is not formed by the Locustid, but by a Dipterous insect belonging to the family of *Cecidomyidæ.* Although I have never seen the eggs deposited I have on a number of occasions found them within the galls, but did not know to what insect they belonged until

Mr. Wheeler published (*loc. cit.*) his excellent account of the oviposition of this species. From that I quote as follows: "On September 8th I observed a female in the act of oviposition. She was perched with her head turned toward the apex of the gall. Slowly and sedately she thrust her sword-like ovipositor down between the leaves, and, after depositing an egg, as slowly withdrew the organ in order to recommence the same operation, after taking a few steps to one side of where she had been at work. She soon observed me and slipped away without completing her task. The number of eggs found in a gall varies considerably. Sometimes but two or three will be found, more frequently from 50 to 100. In one small gall I counted 170." The egg is cream-colored, very thin, elongate oval in outline, and measures 4x1 mm.* The young emerge about the middle of May and reach maturity about August 10th. Long winged forms of this species are occasionally met with.

Ensiferum was first described from Illinois, and, as yet, has not been recorded east of the Alleghany Mountains. One which was still in the nymph stage on October 21st, was found to have a white hairworm *(Gordius sp?)* eight and a half inches long in its abdomen. The development of the nymph had probably been retarded by the presence of the parasite.

98. **Xiphidium nigropleura Bruner. The Black-sided Grasshopper.**
Xiphidium nigropleurum Bruner, 25, XXIII, 1891, 58; Bl., 7, 1893, 125; Lugg., 84, 1898, 241.
Xiphidium nigropleura Scudd., 183, XXX, 1898, 184; Id., 188, 1900, 75.

A medium sized, rather robust species, easily distinguished from all others of the genus by its peculiar coloration. In Indiana dimorphic forms occur; one having the pronotum, tegmina and legs bright grass green, the other with these parts brownish yellow, the green wholly absent. Both forms have the stripe on the occiput and the sides of the abdomen shining black; the former narrowing in front to the width of the tubercle, and bordered on each side with yellowish white. In the green forms the usual brown stripe on the disk of pronotum is but faintly defined, in the other it is very evident.

The tegmina are usually abbreviated, reaching only four-fifths of the length of the abdomen, but an occasional specimen is to be found in which they are fully developed and then reach beyond the middle

*Mr. B. D. Walsh, in the Proc. Ent. Soc. Phil., III, 1864, 232, recorded the finding, on numerous occasions, of the eggs of an *Orchelimum* in the turnip-shaped galls of *Salix cordata*. Their shape and proportional dimensions, as given by him, differ much from those of *X. ensiferum*, as they were cylindrical, .16 to .17 of an inch long, and seven times as long as wide.

of the ovipositor in the female. Ovipositor straight, quite broad and heavy. Male cerci of medium length, rather stout, tapering gently toward the apex, and with a strong sub-basal tooth.

Measurements: Male—Length of body, 14 mm.; of tegmina, 9 mm.; of hind femora, 13.5; of pronotum, 3.5. Female—Length of body, 15 mm.; of tegmina, short-winged form, 8.5 mm.; of tegmina, long-winged form, 17 mm.; of hind femora, 14 mm.; of ovipositor, 16 mm.

In Indiana this handsome insect has been taken in Gibson, Vigo, Fulton, Marshall, Starke, Lake, Kosciusko, Wells and Steuben counties, and probably occurs in suitable localities throughout the State. It appears to be a semi-aquatic species, inhabiting only the margins of ditches, large ponds and lakes, where it abides in the tall, rank grasses and sedges growing in the shade. It reaches the perfect stage about July 1st in southern Indiana, and in Fulton County has been taken as late as October 24th. The males leap actively when approached. The females are more clumsy and usually dive headlong into a bunch of fallen grass. They can then be most readily captured by clasping the hand about a bunch of grass stems or branches of shrubs, on the under side of which the insects have taken refuge.

Nigropleura has been recorded only from Iowa, Nebraska and Ithaca, New York, specimens having been sent me from the latter locality by one of my correspondents, thus extending eastward its known habitat by more than 700 miles.

Of its habits in Nebraska, Bruner *(loc. cit.)*, has written as follows: "It is quite plentiful among the rank vegetation on low moist ground, and is especially common in wet places where the "cut grass" (*Leersia oryzoides* Swartz) grows. The supposition is that this grass offers a better place than usual for the deposition of its eggs, which are deposited between the leaves and stems of grass. Grapevines and other creeping plants which form matted clusters that afford shelter from the noonday sun and the bright light of day are favorite haunts of this and other species of our nocturnal grasshoppers and a few of the arboreal crickets."

99. Xiphidium saltans Scudder.

Xiphidium saltans **Scudd., 147, 1872, 249; Id., 183, XXX, 1898, 184; Id., 188, 1900, 75.**

Xiphidium modestum **Brun., 25, XXIII, 1891, 56; Bl., 7, 1893, 126.**

This is the smallest and most slender-bodied Locustid found in the State. It is a dull, reddish brown in color, except the stripe on the occiput and disk of pronotum, which is a dark, chocolate-brown, the two colors being separated by a rather wide yellowish line which in living specimens is very distinct.

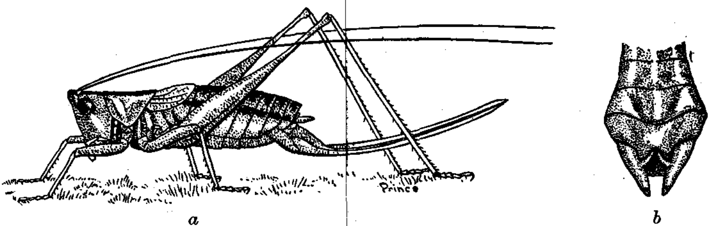


Fig. 94. *Xiphidium saltans* Scudder.
(*a*) Female. Two and one-half times natural size.
(*b*) Tip of male abdomen, showing form of cerci. (Original.)

The cone of the vertex is short and rather narrow. Tegmina, especially those of the female, very short and obtusely rounded. The shrilling organ of the male is narrower and farther removed from the base of the wing cover than in the male of *X. strictum*, its nearest ally. The tip of male abdomen is but slightly enlarged, cerci elongate, tapering, a little curved outward and armed with a rather long sub-basal tooth. Ovipositor equaling the body in length, very slender and tapering, with its apical half slightly upcurved.

Measurements: Male—Length of body, 10 mm.; of tegmina, 3 mm.; of hind femora, 9 mm.; of pronotum, 3 mm. Female—Length of body, 11 mm.; of tegmina, 2.5 mm.; of hind femora, 9.5 mm.; of ovipositor, 11 mm.

Saltans as yet has been noted only at one point in the State, namely, the border of a raw prairie near Heckland, Vigo County, where it was found in small numbers on October 21, 1893, and in September, 1894. It appears to be less active than any other *Xiphidium*, leaping a shorter distance when disturbed, and frequenting the surface of the ground rather than the stems of the tall prairie grasses among which it makes its home. It will probably be found, by close search, to inhabit most of the few remaining patches of raw prairie in the western part of the State. However, it has not been noted elsewhere than in Vigo County, east of the Mississippi River, although it is said by Bruner to be very plentiful in Nebraska, Iowa and Kansas.

100. Xiphidium strictum Scudder.

Xiphidium strictum, Scudd., **151**, XVII, 1875, 460; Id., **153**, IV, 1875, 63; Id., **164**, 1879, 13; Id., **183**, XXX, 1898, 183; Id., **188**, 1900, 75; Redtenb., **110**, 1891, 205; Bl., 7, 1893, 127; Lugg., **84**, 1898, 242.

In this species the body is rather slender and of more than average length; constant in color but dimorphic as respects the length of wings, the long-winged forms, however, being very scarce. Sides of head and body, together with all the femora, green. The usual reddish brown stripe on occiput and pronotum narrowly edged with whitish, especially on the fastigium of the vertex. Tegmina reddish brown; in the females exceedingly short and pad-like, or well developed and reaching almost to knees; when the former, a little longer than the wings, when the latter, 5 mm. shorter than the wings. In the short-winged males (the only ones I have seen) the tegmina are somewhat less than half the length of the abdomen. There is a reddish brown band on dorsal surface of abdomen, darker where it meets the green on sides. Ovipositor pale red, straight, one and a half times the length of the posterior femora. Cerci of male, long, the apical half acuminate, curved slightly inward near the tip.

Measurements: Male—Length of body, 14 mm.; of tegmina, 5.5 mm.; of pronotum, 3.5 mm.; of hind femora, 13.5 mm. Female—Length of body, 17 mm.; of tegmina, short-winged form, 3.5 mm.; long-winged form, 16 mm.; of hind femora, 15.5 mm.; of ovipositor, 23 mm.

Strictum is a common species in the western and northern parts of the State, where it frequents, for the most part, dry upland meadows, open pastures and prairies, and reaches maturity about August 1st. The mature females are usually much more abundant than the males and vary much in size. It is an active leaper and tumbler and like several of its allies, often strives to escape detection by burrowing beneath fallen weeds and grasses. The general range of *strictum* is to the west and southwest, it having been first described from Texas, and not heretofore recorded east of Illinois, except in my former paper on Indiana Locustidæ.

101. XIPHIDIUM ATTENUATUM Scudder. The Lance-tailed Grasshopper.

Xiphidium attenuatum Scudd., **146**, II, 1869, 305; Id., **183**, XXX, 1898, 183; Id., **188**, 1900, 74; Brun., **25**, XXIII, 1891, 57; Id., **27**, III, 1892, 265; Redtenb., **110**, 1891, 191; Bl., **7**, 1893, 128; Id., **16**, 1899, 219, Fig. 51. (Long winged form).

Xiphidium scudderi Bl., **5**[a], XXIV, 1892, 26; Scudd., **183**, XXX, 1898, 183; Id., **188**, 1900, 75. (Short-winged form).

General color a dull testaceous or reddish brown, in some specimens tinged with greenish. Antennæ with the basal third reddish, the remainder fuscous, longer than in any other member of the genus belonging to our fauna, measuring 73 mm. in one specimen at hand. Tegmina and wings either abbreviated or fully developed;

when the former covering about three-fourths of the abdomen in the female and reaching or slightly surpassing its tip in the male; when developed, fully twice the length of abdomen; the wings extending 4 mm. beyond the tegmina. Femora greenish brown, very rarely bright green, the tibiæ and tarsi darker. Abdomen tapering but slightly posteriorly, with the base of ovipositor but little enlarged. Posterior femora heavy on their basal two-fifths, slender beyond, armed on their lower outer carina with two to four minute blackish

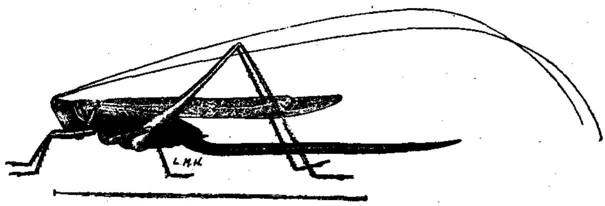


Fig. 95. *Xiphidium attenuatum* Scudd. Female. (After Lugger.)

spines. Cerci of male long, broad, with the apical third gently tapering, the basal tooth minute, slender. Ovipositor excessively long, slender, straight or but gently curved, the apex very acuminate.

Measurements: Male—Length of body, 12-15 mm.; of antennæ, 73 mm.; of pronotum, 2.6 mm.; of tegmina, short winged form, 8.5 mm.; of long winged form, 19 mm.; of hind femora, 14 mm. Female—Length of body, 13-16 mm.; of pronotum, 3 mm.; of tegmina, short winged form, 10 mm.; long winged form, 19 mm.; of hind femora, 14 mm.; of ovipositor, 26-30 mm.

The short winged form of this species has proven much more abundant locally in Indiana than the long winged form. In Vigo County it was, ten years ago, very plentiful about the borders of two large ponds in the Wabash River bottoms. In Knox County a few specimens were secured in 1901 from the margin of a similar pond bordering a large cypress swamp, while in Kosciusko County it was found to be quite common in some marshes near Tippecanoe and Turkey lakes. In all these places the insects dwell among the tall rank grasses and rushes growing in shallow water. The males are, as far as my experience goes, the most active leapers among the winged Locustidæ, jumping a half dozen or more times without pause when flushed, and in the net leaping so rapidly from side to side as to prevent capture with the fingers. The females are evidently handicapped in their leaping powers by the excessive length of the ovipositor, and so more often endeavor to escape by burrowing beneath the dense masses of fallen grass and reed stems which are always found in their accustomed haunts.

The long winged form was first taken in Indiana in August, 1902, when it was found in some extensive low ground meadows in Kosciusko County. Here the long and short winged forms were about equally abundant. The former flew readily when approached, but to no great distance. A few of the long winged ones were also taken near Bass Lake, Starke County. The specimens from these northern counties are more slender bodied than those from the south, where only the short winged form has been found. *Attenuatum* was first described from Illinois, though it is not mentioned in McNeill's "List of Orthoptera of Illinois." Outside of Indiana it has been recorded from Nebraska, Iowa and Minnesota.

I find that the length of the ovipositor among the different species of Xiphidium is not at all dependent upon the age of the insect. In both *attenuatum* and *scudderi* it is almost as long after the third, and fully as long after the fourth moult as it is in the adult; while a female of *strictum* has been taken, with no vestige of tegmina, in which the ovipositor measured 18 mm. The eggs of *attenuatum*, as the length of the ovipositor indicates, are laid between the stems and leaves of tall rank grasses among which the insects live.

XLVII. Orchelimum Serville (1831).

Locustidæ of medium size, but with a short and stout body. Vertex, face and eyes much as in *Xiphidium*. Spines of the prosternum well developed, cylindrical and slender. Antennæ slender and tapering, usually of excessive length. Wing covers narrow, the apical half often much less in width than the basal, exceeding the abdomen in all our species; almost always shorter than the wings. Stridulating organ of the male as in *Xiphidium*, but proportionally larger. Ovipositor stout, broad, with the apical half usually upcurved; when straight the apical third tapers rather abruptly on the under side to a fine point. Anal plates and cerci of males as in *Xiphidium*.

This genus is very close to *Xiphidium*, and is, by some writers, united with it. Redtenbacher places it as a sub-genus of *Xiphidium*, separating its members from those of *Xiphidium* proper by the same characters as did Serville. As scientists differ in opinion as to what characters are necessary to constitute a genus, and as, at best, it is but an artificial and arbitrary grouping of species for the sake of convenience, I follow Serville, Scudder and Bruner in separating the two, believing that the prime idea of convenience can thus be better subserved.

As noted in the Key to the Genera of *Conocephalinæ*, the larger, heavier body, longer prosternal spines, and shorter and broader falcate ovipositor are the chief distinguishing characters of *Orchelimum*. The wing covers are more uniform in length, and the color, while of slightly different shades of brown or green in the same species, according to season and habitat, does not run to the extremes of variation as in *Xiphidium*.

The generic name, *Orchelimum*, the literal meaning of which is "I dance in the meadows," is a most appropriate one, for low, moist meadows everywhere swarm with these insects from July to November; and though waltzes and quadrilles are probably not indulged in, yet the music and song, the wooing and love-making which are the natural accompaniments of those amusements, are ever present, and make the short season of mature life of the participants a seemingly happy one.

Eight species of the genus have been taken by the writer within the State. These may be separated by means of the following key:

KEY TO THE INDIANA SPECIES OF ORCHELIMUM.

a. Ovipositor with a very evident curve, its length less than 10 mm.
- *b.* Face without a median brown stripe.
  - *c.* Hind femora not armed with small spines on the under side.
    - *d.* Tegmina broadest at base; the apical third narrower; body robust.
      - *e.* Tegmina and wings sub-equal in length; not much exceeding the hind femora; size, medium. 102 *vulgare*, p. 383
      - *ee.* Tegmina distinctly shorter than wings; plainly exceeding the hind femora; size, large........ 103 *glaberrimum*, p. 385
    - *dd.* Tegmina of nearly equal width throughout; body slender; size, small...........104 *campestre*, p. 386
  - *cc.* Apical half of posterior femora armed beneath with several small spines; all the tibiæ and tarsi black or dark brown ....105 *nigripes*, p. 387
- *bb.* Face with a dark reddish brown stripe down the center......... 106 *indianense*, p. 388

aa. Ovipositor straight or nearly so; its length 10 or more mm.
- *f.* Posterior femora unarmed beneath.
  - *g.* Body slender; pronotum short, not more than 4 mm. in length; tegmina narrow, shorter than the wings......... 107 *delicatum*, p. 389
  - *gg.* Body stout; pronotum 5 or more mm. in length; tegmina and wings sub-equal in length.......108 *gladiator*, p. 390
- *ff.* Posterior femora armed on the outer lower carina with several small spines ....109 *volantum*, p. 390

102. ORCHELIMUM VULGARE Harris. The Common Meadow Grasshopper.

Orchelimum vulgare Harris, 72, 1862, 162, Fig. 77; Scudd., 142, II, 1868, 117 (note of set to music); Id., 168, XXIII, 1892, 73 (note of set to music); Pack., 104, 1883, 567; Riley, 122, II, 1884, 187; Comst., 41, I, 1888, 114; Bl. 7, 1893, 130; Id., 16, 1899, 220, Fig. 52; Beut., 3, VI, 1894, 282, Plate VI, Figs. 4 and 5; Lugg., 84, 1898, 234, Figs. 155, 156; McNeill, 90, XXXII, 1900, 78, 81.

Xiphidium agile Redtenb., 110, 1891, 186. (In part.)

Orchelimum agile Scudd., 188, 1900, 73.

A medium sized, robust species, with the general color green or light reddish brown. Face light green or light brown without fuscous marks. The occiput and disk of pronotum with a reddish brown band, widening on the latter, where it is often, especially in the male, bordered on each side with a darker line. The male (as in most of our species) with two short, black dashes on each wing cover, the four forming the angles of an assumed square, enclosing the tympanum. The legs usually pale brown, the tarsi dusky. Pronotum

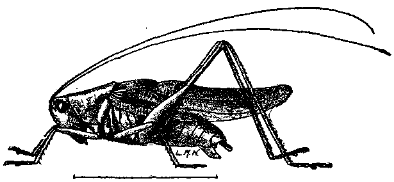


Fig. 96. *Orchelimum vulgare* Harris. Male. (After Lugger.)

long, its posterior lobe but slightly, if at all, upturned above the plane of the anterior, its hind margin broadly rounded. Tegmina reaching to or very slightly beyond the apex of hind femora, and equaling or very little shorter than the wings. Cerci of male rather long, the apex bluntly rounded, a little depressed; sub-basal tooth somewhat flattened, with the tip sharp and decurved.

Measurements: Male—Length of body, 18 mm.; of pronotum, 6 mm.; of tegmina, 21 mm.; of hind femora, 17 mm. Female—Length of body, 19 mm.; of pronotum, 6.2 mm.; of tegmina, 21 mm.; of hind femora, 18 mm.; of ovipositor, 7.5 mm.

This meadow grasshopper is probably the most abundant member of the family Locustidæ found in Indiana. It begins to reach maturity in the central part of the State about July 10th, and more frequently than any other of our species of *Orchelimum* it is found in upland localities, along fence rows, and in clover and timothy meadows. In early autumn it seems to be very fond of resting on the leaves and stems of the ironweed, *Vernonia fasciculata* Michx., so common in many blue-grass pastures.

> "The poetry of earth is never dead:
> When all the birds are faint with the hot sun,
> And hide in cooling trees, a voice will run
> From hedge to hedge about the new mown mead;
> That is the grasshopper's—he takes the lead
> In summer luxury, he has never done
> With his delights; for when tired out with fun
> He rests at ease beneath some pleasant weed."

Vulgare seems to be somewhat carnivorous in habit, as, on two occasions, I have discovered it feeding upon the bodies of small moths which in some way it had managed to capture; while on another date I surprised a female on the flowers of a golden-rod, feasting upon a soldier beetle, *Chauliognathus pennsylvanicus* DeG.

Of the call note of the male *vulgare* Scudder has written: "When about to sing on a hot, sunny day, the male mounts a stalk of grass to about a foot from the ground where it clings with its four front legs, allowing its hind legs to dangle on either side of the stalk that they may not interfere with the movements of the tegmina. Beginning with *ts* it changes almost instantly to a trill of *zr;* at first there is a crescendo movement which reaches its volume in half a second; the trill is then sustained for a period varying from one to twenty seconds (generally from six to eight seconds), and closes abruptly with *p*. This strain is followed by a series of very short staccato notes sounding like *jip, jip, jip,* repeated at half second intervals; the staccato notes and the trill alternate *ad libitum.* The staccato notes may be continued almost indefinitely, but are very rarely heard more than ten times in direct succession; it ordinarily occurs three or four times before the repetition of the phrase, but not more than two or three times when the phrase is not repeated. The night song differs from that of the day in the rarer occurrence of the intermediate notes and the less rapid trill of the phrase; the pitch of both is at B flat."

Redtenbacher places *vulgare* as a synonym of DeGeer's *Xiphidium agile,* stating as his reason for so doing that Harris and Scudder have separated the two "on account of small differences in the color and size of the wing covers, as well as in the length of the ovipositor." He may be right in thus combining them, but his relative measurements of *X. agile* as given, do not agree with the specimens of undoubted *vulgare* in my possession. Scudder, who has had ample opportunity to compare the two, says (Bost. Journ. Nat. Hist. VII

453) that the pronotum is shorter in *agile* than in *vulgare*. Redtenbacher's measurements of this organ, as well as those of the hind femora, are much less than the average measurements given above. Harris, as well as Burmeister, states that the tegmina of *agile* are 2.5 mm. shorter than the wings, while McNeill *(loc. cit.)* says that *agile* has the hind femora armed beneath. Taking all these facts into consideration, though having no typical examples of *agile* for comparison, I have concluded not to follow Redtenbacher but to retain for the species at hand the name *vulgare*, by which it is best known to the entomologists of the United States.

103. ORCHELIMUM GLABERRIMUM (Burmeister).

Xiphidium glaberrimum **Burm., 40, II, 1838, 707; Redtenb., 110, 1891, 187.**

Orchelimum glaberrimum **Scudd., 141, VII, 1862, 453; Id., 188, 1900, 73; Riley, 122, II, 1884, 186; Comst., 41, I, 1888, 114; Bl., 7, 1893, 133; Lugg., 84, 1898, 235; McNeill, 90, XXXII, 1900, 78, 81.**

Very close to and perhaps only a larger form of *O. vulgare*. The general color is the same, but the brown line on the disk of pronotum is, in the female, more plainly margined with black, while in the male the black dashes at ends of tympanum are larger and more completely enclose that organ. The tegmina of the male exceed the hind femora by about 4 mm., and are exceeded by the wings about the same distance; those of the female are proportionally a little shorter.

Measurements: Male—Length of body, 22 mm.; of pronotum, 6 mm.; of tegmina, 26 mm.; of hind femora, 19 mm. Female—Length of body, 23 mm.; of pronotum, 6.5 mm.; of tegmina, 24-27 mm.; of hind femora, 20 mm.; of ovipositor, 8.5 mm.

Burmeister's original description of this species is very short and not distinctive. It is as follows: "Verticis et pronoti medio fulvo, nigro-marginato; elytris ab alis dimidia linea superatis. Long. corp., 11'''." Burmeister knew but two species from the United States, and this short description was sufficient for him to distinguish these, but of the twenty or more species now known it is difficult to say just which one he had in mind when he wrote the above.

Glaberrimum is not a common species in Indiana. I have taken it in Vigo, Fulton, Marshall and Starke counties, but only one or two examples from each locality. All were secured from tall grass growing near the margins of ponds or lakes. It is evidently attracted by electric and other lights, as Dr. Robert Hessler took one from his office window near the center of the city of Logansport on the night of August 3, 1900. Its general range is given by Scudder as "United States from Rocky Mountains eastward."

104. ORCHELIMUM CAMPESTRE Blatchley.

Orchelimum campestre Bl., 10, XXV, 1893, 91; Id., 7, 1893, 133; Lugg., 84, 1898, 236; Scudd., 188, 1900, 73; McNeill, 90, XXXII, 1900, 78, 81.

A species of less than medium size, with wing covers narrow and of almost equal width throughout; the posterior femora unarmed beneath, and the ovipositor short, narrow, moderately upcurved, and tapering to a delicate point.

Cone of the vertex prominent, narrow, rounded at the apex; the sides of the frontal, deflexed portion rapidly converging to form a very acute wedge. Wing-covers long, slender, not narrowed in the middle as in *O. vulgare*, tapering slightly on the apical third to a rounded end; their length a little shorter than the wings in both sexes. Posterior femora with the basal half quite stout, the length less than that of the tegmina. Cerci of male slender, cylindrical, somewhat pointed, the apical half curved slightly outward, the basal tooth short and weak.

Color: Tegmina and wings almost uniform transparent olivaceous brown. The usual dark reddish brown band upon the occiput and disk of pronotum is margined on the latter with two very narrow and darker brown stripes, which extend back to the middle of the posterior lobe of the pronotum. Face, and usually the hind femora, a dirty olive brown; the latter, when dry, with a blackish longitudinal band on the exterior face. In the female the only green on the body is on the lower part of the sides of the pronotum and on the anterior femora. The males usually have the outer face of the posterior femora green, but otherwise are colored like the females. Ovipositor light reddish brown.

Measurements: Length of body, male, 17.5 mm., female, 19 mm.; of pronotum, male, 4.5 mm., female, 5 mm.; of tegmina, male, 20.5 mm., female, 24.5 mm.; of antennæ, male, 46 mm.; of posterior femora, male, 17 mm., female, 17.5 mm.; of ovipositor, 7 mm.

This modestly colored grasshopper is very common in the northern half of the State, where it abides in the tall grasses of the low prairie meadows. It has not, as yet, been taken south of Marion and Vigo counties. It is a smaller and more slender bodied insect than the common *O. vulgare* Harris, and has a shorter and narrower pronotum and a much smaller ovipositor than that species.

105. ORCHELIMUM NIGRIPES Scudder. The Black-legged Grasshopper.
Orchelimum nigripes Scudd., 151, XVII, 1875, 459; Id., 153, IV, 1875, 62; Id., 164, 1879, 12; Id., 168, XXIII, 1892, 73; Id., 188, 1900, 74; McNeill, 88, VI, 1891, 25; Id., 90, XXXII, 1900, 79, 83; Bl., 7, 1893, 135; Lugg., 84, 1898, 236.
Xiphidium nigripes Redtenb., 110, 1891, 188.

Somewhat smaller than *O. vulgare;* the body moderately robust. Pronotum short, the posterior lobe, especially in the male, rather strongly upturned. Tegmina equaling the wings in male, a little shorter in the female, surpassing slightly the hind femora. The shrilling organ of the male is unusually large and prominent with strong crossveins, and behind it the tegmina taper rapidly on both margins, their shape and the size of the tympanum causing the male to appear somewhat peculiar and much more robust than it really is. Hind femora armed on apical half of lower outer carina with one to four small spines. Cerci of male slender, tapering, the apex a little obtuse; the sub-basal tooth long, slender and a little curved. Ovipositor rather long, broadest in the middle, tapering to a delicate point. The males vary much in size.

General color green or reddish brown, the former prevailing in the male, the latter in the female. Occiput and disk of pronotum with the usual brown markings. Front and sides of head, and four front femora, reddish yellow. All the tibiæ and tarsi, together with the apical third of hind femora, black or dark brown at least on the upper side; in one specimen at hand the whole body, except the wing covers and femora, black.

Measurements: Male—Length of body, 18 mm.; of antennæ, 66 mm.; of pronotum, 5 mm.; of tegmina, 21 mm.; of hind femora, 16 mm. Female—Length of body, 19 mm.; of tegmina, 22 mm.; of hind femora, 17 mm.; of ovipositor, 9 mm.

The "black-legged grasshopper" is a lowland species, which has been taken in numbers in Vigo, Putnam, Posey, Starke, Fulton, Lake and Wells counties, and probably occurs in suitable localities throughout the State. It reaches maturity about July 20th, and is usually abundant about the margins of the larger ponds and lakes, where it frequents the tall grasses and especially the stems and leaves of the different species of *Polygonum,* or smartweed, growing in the shallow water. Examples of the parasitic hairworm *(Gordius sp?)* have been taken from the abdomens of a number of specimens.

Nigripes was described from Texas and was first recorded east of Illinois in my former paper. It has been taken by myself at Celina, Ohio, though Scudder gives its range as "Rocky Mountains to the

Mississippi River." Its song is much more faint than that of *vulgare*, the *z-e-e-e-e* being much less prolonged.

106. Orchelimum indianense Blatchley.

Orchelimum indianense Bl., **10**, XXV, 1893, 90; Id., **7**, 1893, 137; Scudd., **188**, 1900, 73; McNeill, **90**, XXXII, 1900, 79, 82.

A slender bodied insect, with a dark median streak down the face, and having the posterior femora unarmed beneath. The cone of the vertex is short, rather narrow, with a rounded apex. The tegmina, narrow, tapering, a little shorter than the wings, and of a delicate, almost gauze-like texture. Posterior femora slender, shorter than the closed tegmina. Anal cerci of male of medium size, longer than

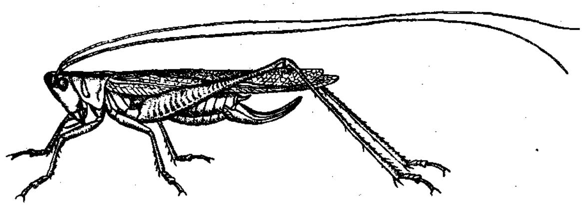


Fig. 97. *Orchelimum indianense* **Bl. Female. One and one-half times natural size. (Original.)**

the sub-genital plate, tapering to a dull point; the basal tooth short, with a broad base and a very sharp point. The ovipositor of female of less than average width and length, the apical half with a gentle upward curve.

Color: Tegmina and wings a transparent whitish tinged with green on the front or lower longitudinal nerves; the cross-nervules of the latter darker. Sides of pronotum and abdomen, and all the femora, light green; the tibiæ and tarsi of a brownish hue. Face yellowish white, with a dark reddish brown stripe the width of the labrum, starting with the mouth and passing upward to the vertex, where it narrows to the width of that organ; then, broadening on the occiput, it passes back to the front border of the pronotum, where it divides into two narrow streaks, which enclose a whitish area and extend a little beyond the posterior transverse suture, where they taper to an end. Sub-genital plate of male yellow. Basal third of ovipositor dark brown, the remainder light reddish brown.

Measurements: Length of body, male, 17 mm., female, 17.5 mm.; of pronotum, male and female, 4 mm.; of tegmina, male, 21 mm., female, 19 mm.; of hind femora, male, 14 mm., female, 15.5 mm.; of ovipositor, 7.5 mm.

This graceful and prettily marked species is quite common among the rank grasses and sedges growing about the margins of tamarack swamps and lakes in Fulton, Marshall, Starke, Lake, Kosciusko and Steuben counties, where it reaches maturity about July 20th. It is probably a species of northern range which does not occur in southern Indiana. It is the smallest and most slender of the eight species of the genus so far known to occur in the State, and its markings are very distinct from those of any of the others.

107. ORCHELIMUM DELICATUM **Bruner.**

Orchelimum gracile **Brun., 25, XXIII, 1891, 70.**

Orchelimum delicatum **Brun., 27, III, 1892, 264; Scudd., 188, 1900, 73; McNeill, 90, XXXII, 1900, 77, 80.**

"A slenderer and somewhat smaller insect than *O. vulgare,* from which it differs in the form of its pronotum and of the ovipositor. The tubercle of the vertex is short, broad, and has the apex rounded. The tegmina and wings are of moderate length, very delicate in texture, and in the male furnished with an inconspicuous musical apparatus. Legs slender, the posterior femora not quite reaching the tips of the closed tegmina. Terminal segment of the male abdomen quite broad; the anal cerci stout and acuminate, with the internal tooth minute; sub-genital plate broad and long, reaching beyond the tips of the cerci. The ovipositor unusually long, broad, nearly straight and fine pointed.

"In color it is a pale transparent green with a broad reddish brown band upon the head and pronotum, continuous from the tip of the vertex to the posterior transverse indentation of the pronotum, somewhat paler in the middle; upon the latter, rather broadly bordered by yellowish white throughout. Face and mouth parts together with the genital armature of the male ochreous; ovipositor light reddish brown. Tarsi and sometimes also the tibiæ a trifle infuscated."

"Length of body, male, 16 mm., female, 17.5 mm.; of antennæ, male and female, about 50 mm.; of pronotum, male, 3.8 mm., female, 4 mm.; of tegmina, male, 19 mm., female, 20 mm.; of hind femora, male, 14 mm., female, 15 mm.; of ovipositor, 11-12 mm."

This species was described from West Point and Lincoln, Nebraska, where Bruner found it common about the margins of ponds and along the edges of streams, also at electric lights. In Indiana it has been noted only in Marshall and Starke counties, where a half dozen specimens were secured in lowland meadows near large lakes on July 30th and August 20, 1902. It probably occurs throughout the lake region of the northern third of the State. It has not before been recorded east of Nebraska.

108. ORCHELIMUM GLADIATOR Bruner.

Orchelimum gladiator Brun., **25**, XXIII, 1891, 71; Bl., **7**, 1893, 138; Scudd., **188**, 1900, 73; McNeill, **90**, XXXII, 1900, 77, 81.

In its general structure this species resembles the more robust forms like *O. glaberrimum* and *O. nigripes.* It differs from these, however, in having shorter legs and antennæ, and in the shape of the ovipositor. The posterior femora are rather slender and unarmed beneath; the cone of the vertex is short and obtuse, with the extreme tip shallowly sulcate; the inner wings are the same length as the tegmina in the male, a little longer in the female, where they do not quite reach the tip of the ovipositor. The latter organ is broad, nearly straight and of more than ordinary length. Cerci of male stout, the basal tooth long, tapering gradually to a sharp point, its apical third a little curved.

Color: Pale transparent grass-green throughout, save the usual markings upon the occiput and disk of pronotum, which are dark brown; on the latter composed of two well defined, narrow, slightly diverging lines. Antennæ rufous, feet and extreme tip of the ovipositor tinged with rufous.

Measurements: Length of body, male, 17 mm., female, 18-20 mm.; of antennæ, male, 43 mm., female, 35 mm.; of pronotum, male, 5 mm., female, 4.75 mm.; of tegmina, male and female, 19 mm.; of hind femora, male, 14 mm., female, 15.5 mm.; of ovipositor, 10 mm.

This species has been found to be quite common in some of the northern counties, having been taken in low, damp meadows and marshes in Fulton, Starke, Marshall, Kosciusko and Steuben. It probably inhabits low damp prairies and meadows throughout the northern half of the State. It evidently begins to reach maturity about July 25th, perhaps a week sooner. A pair in coitu were secured in Marshall County on July 29th. It was described from Nebraska and has been recorded only from that State and Indiana.

109. ORCHELIMUM VOLANTUM McNeill.

Orchelimum volantum McNeill, **88**, VI, 1891, 26; Id., **90**, XXXII, 1900, 80, 83; Scudd., **188**, 1900, 74.

Orchelimum bruneri Bl., **10**, XXV, 1893, 92; Id., **7**, 1893, 139; Scudd., **188**, 1900, 73; McNeill, **90**, XXXII, 1900, 80, 83.

A species of medium size and rather slender body with the posterior femora armed beneath, and the ovipositor very broad, nearly straight and of more than average length.

Cone of the vertex narrow, moderately elevated, rounded at apex. Tegmina long and narrow, a little shorter than the wings; strongly reticulate in the female. Posterior femora rather stout, the apex, when appressed, just reaching the tip of ovipositor; armed beneath on the apical half with three or four small spines. Cerci of male stout, tapering to a point, with the internal tooth, rather broad and flat at base. Ovipositor very similar to that of *O. gladiator* Bruner, being very long and stout, nearly straight above, and with the under side of apical third sloping rapidly to the acute apex.

Color: With the exception of the ovipositor, which is a light reddish brown, and the usual stripe on occiput and disk of pronotum, the whole body is a pale, transparent brownish green, the green showing plainly only on the lower half of the side of the pronotum and on the meso- and meta-pleura.

Measurements: Length of body, male, 18 mm., female, 20.5 mm.; of tegmina, male, 21 mm., female, 25-28 mm.; of pronotum, male and female, 4.75 mm.; of hind femora, male, 16 mm., female, 19 mm.; of ovipositor, 10.5 mm.

As shown by the synonymy, this is the *O. bruneri* of my former paper, a comparison of type specimens of *volantum*, kindly loaned me by Professor McNeill, having proved the two to be identical. The Indiana specimens, however, do not show the character to which McNeill calls especial attention, namely, "the distinct angle formed by the anal area with the lateral field in the female tegmina."

In Indiana *volantum* has been taken in Vigo, Fulton, Marshall and Starke counties. It is found most abundantly during August and September on the leaves and stems of a tall, broad-leaved knot-weed, *Polygonum amphibium* L., which grows luxuriantly in the shallow waters about the margins of the larger ponds and lakes. Several other "green grasshoppers," notably among which are *Xiphidium attenuatum* Scudd. and *Orchelimum nigripes* Scudd., frequent this plant in large numbers. Keeping company with them an occasional specimen of *O. bruneri* is seen, but, being an active leaper, it often escapes amidst the dense foliage of the knot-weed before its capture can be effected.

Its less robust body, longer armed posterior femora and long tegmina will readily distinguish this species from *O. gladiator*, the only other one which, to my knowledge, has an ovipositor shaped like that of *volantum*.

Outside of Indiana, *volantum* has been taken only near Cleveland, Henry County, Illinois, where McNeill found it in small numbers on the semi-aquatic plant, *Sagittaria variabilis* Engelm, one of the arrow-heads. "Their song," says McNeill, "has a new note in it. It may be represented as follows: *zip-zip kr-ze-e-e, kr-ze-e-e*, the last part of the song not lasting more than half to three-quarters of a second and is always preceded by the sound which I represent imperfectly by *kr*."

Sub-family DECTICINÆ.

All known North American representatives of this sub-family are apterous or sub-apterous, their tegmina never extending over more than two abdominal segments. The antennæ are inserted between the eyes, nearer the summit of the occiput than the upper margin of the labrum. Slit-like foramina (hearing organs) are present near the base of the fore tibiæ, and these tibiæ bear an apical spine on their outer upper side. The tarsi are all more or less depressed; and their first two joints are sulcate lengthwise on the sides; while the first joint of those of the hind legs bears a free plantula beneath its base.

The sub-family is represented in the Western States by numerous genera and a large number of species, but east of the Mississippi River but two genera and four species belonging to it have as yet been found. In Indiana but one of these genera, *Atlanticus* Scudder, represented by two species, is known to occur. However, members of the other eastern genus, *Orchesticus* Saussure, may in time be found within the State, since one of its species is known from Tennessee and another from Missouri. From other *Decticinæ* the species of *Orchesticus* may be distinguished by the armed prosternum, the presence of four terminal spines on the lower side of hind femora, and an ovipositor which curves upward. This last character is the principal one separating them from *Atlanticus*, whose members have the ovipositor straight.

XLVIII. Atlanticus Scudder (1894).

The members of this genus are Locustidæ of large size, in which the pronotum extends back over the first joint of the abdomen, thus forming a buckler or shield for the back. Face broad, rounded, but slightly oblique. Eyes small, sub-globose. Vertex with a blunt decurved projection between the antennæ. Pronotum truncate in front, rounded behind, flattened above, bent abruptly downward on the sides. Prosternum armed with two slender, sub-acute spines. Tegmina of the females rudimentary, wholly covered by the pronotum; those of the males fairly well developed, extending in our most common species five or more mm. back of the pronotum. The shrilling organ, which is covered by the pronotum, is circular, and rather large for the size of the tegmina. Wings very rudimentary or wanting. Hind femora long and rather slender, extending, in our species, beyond the abdomen in both sexes, notably so in the males. Ovipositor as long as the body, very stout at the base, straight.

The "Shield-back Grasshoppers," so called on account of the large protective pronotum, are often quite numerous from April 1st to September 15th in dry upland woods and on sloping hillsides with a southern exposure, but are seldom, if ever, found in damp localities.

On the first warm days of early spring the young begin to emerge and in suitable places for a month or more are among the most common Orthopterans seen. They are much more active during early life than in the mature state when they crawl rather than leap. In captivity they feed as readily upon animal as upon vegetable food, and in the natural state probably feed upon the dead bodies of such small animals as they can find. The earliest hatched reach maturity in central Indiana about the first of June, and may then often be found resting on the leaves and stems of low shrubs and weeds, but seldom climb over two or three feet from the ground. The adults are far less numerous than the young, the vast majority of the latter probably falling a prey to the many ground-frequenting sparrows and other birds, as they do not hide by day as do the members of the genus *Ceuthophilus*. The two Indiana species may be separated by the following key:

KEY TO INDIANA SPECIES OF ATLANTICUS.

a. Pronotum more than half as long as hind femora, its front margin in the female much narrowed, but little more than half as wide as hind margin; exposed portion of male tegmina almost as ample as the pronotum ....110 *pachymerus*, p. 393

aa. Pronotum not more than half as long as hind femora, its front margin in the female but little narrowed, about three-fourths the width of the hind margin; exposed portion of male tegmina less than one-third as ample as the pronotum........111 *dorsalis*, p. 394

110. ATLANTICUS PACHYMERUS (Burmeister).

Decticus pachymerus Burm., 40, II, 1838, 712.

Thyreonotus pachymerus Scudd., 141, VII, 1862, 453; Coms., 41, I, 1888, 118, Fig. 106; Davis, 43, XXV, 1893, 108 (song of); Bl., 7, 1893, 150.

Atlanticus pachymerus Scudd., 170, XXVI, 1894, 179; Id., 188, 1900, 76; Lugg., 84, 1898, 245, Fig. 160.

Color: Male—Grayish or fuscous brown; the sides of pronotum and tegmina black, the former often shining, especially in the young; a narrow, curved yellowish line above the posterior lateral angle of pronotum; the exposed dorsal field of tegmina light brown; the femora with numerous minute pale spots. Female—Usually grayish or reddish brown throughout, except the yellow line on side of pronotum, which is bordered above with a dash of black.

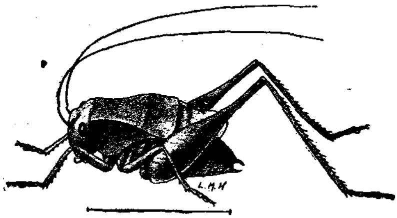


Fig. 98. *Atlanticus pachymerus* (Burm.). Male. (After Lugger.)

The lateral carinæ of the pronotum are sharper in this species than in the next; the pronotum itself is proportionally a little longer, and appears more so than it really is on account of the broadly rounded posterior lobe. The hind femora, as well as the ovipositor, are a little shorter than in *dorsalis,* and the apex of the ovipositor is more bluntly rounded from above.

Measurements: Male—Length of body, 19 mm.; of pronotum, 9.5 mm.; of hind femora, 16.5 mm. Female—Length of body, 21 mm.; of pronotum, 9.5 mm.; of hind femora, 18 mm.; of ovipositor, 18 mm.

Pachymerus is, in Indiana, by far the more common of the two species. It has been taken in Lake, Marshall, Marion, Putnam, Vigo and Crawford counties, and doubtless occurs throughout the State, frequenting the localities mentioned above under the generic description. The earliest date on which a mature specimen has been noted was June 6th, in Vigo County.

In a pleasing account of the notes and habits of the species, Mr. W. T. Davis, *loc. cit.*, has written as follows: "Its song much resembles that of *Orchelimum vulgare,* with the preliminary *zip, zip,* omitted. It is a continuous *z-e-e-e,* with an occasional short *ik,* caused by the insect getting its wing covers ready for action after a period of silence. * * * Starting with raspberries, one kept in captivity had the rest of the fruits in their season, including watermelon, of which he showed a marked appreciation. If I offered him a raspberry and then gradually drew it away, he would follow in the direction of the departing fruit, and would finally eat it from my hand."

111. ATLANTICUS DORSALIS (Burmeister).

Decticus dorsalis Burm., 40, II, 1838, 713.

Thyreonotus dorsalis Scudd., 141, VII, 1862, 454; Id., 148, 1874, 370; Comst., 122, I, 1888, 118; Bl., 7, 1893, 151.

Atlanticus dorsalis Scudd., 170, XXVI,, 1894, 179; Id., 188, 1900, 75.

Color: Male—Usually a dark sooty brown flecked everywhere with grayish; the apical third of hind femora lighter; the yellow line on lower border of pronotum indistinct or wanting. Female—Dull, yellowish brown; the posterior lobe of pronotum, dorsum of abdomen and ovipositor dark brown. A blackish spot on the face below each eye; the sides of the pronotum with obsolete fuscous markings.

The chief structural distinctions between this insect and *pachymerus* are given above in the key and under the latter species. It may be added that the hind lobe of the pronotum in *dorsalis* is quite short and has its posterior margin nearly truncate; whereas in *pachymerus* it is much longer with the hind margin broadly rounded.

Measurements: Male—Length of body, 19 mm.; of pronotum, 9 mm.; of hind femora, 19 mm. Female—Length of body, 24 mm.; of pronotum, 9.5 mm.; of hind femora, 20.5 mm.; of ovipositor, 23 mm.

Dorsalis has been taken in the State in Putnam, Vigo, Knox and Crawford counties. In the two last named counties it is more common than the other species. Its general range is more southern and it will probably be found to inhabit only the southern half of Indiana.

Sub-family GRYLLACRINÆ.

This sub-family is represented in the State by the single genus,

XLIX. Camptonotus Uhler (1864).

Form similar to *Ceuthophilus* Scudd. Head large, oval, much broader than the prothorax and not deeply sunken into it. Eyes ovate, vertical, situated on the sides but little behind the basal joint of the antennæ, and exceeding it a little in length. Maxillary palpi long, the last joint as long as the preceding one, a very little inflated at the tip. Antennæ at least five times the length of the body without the ovipositor. Pronotum trapezoidal, the sides not carried downwards as far as the lower line of the eyes, the lateral margins somewhat broadly recurved; meso- and meta-notum very small, confined to the dorsum and not prolonged downward upon their sides. Ovipositor ensiform, curved upwards, its valves compressed, acute. Legs very short, moderately stout; the anterior and middle tibiæ slightly incurved near the base, having a row of four long spines each side beneath; posterior femora armed beneath with a few short teeth. Tarsi stout, four-jointed, with split cushions beneath, the first joint equal in length to the two following ones conjoined.

A single species is known from the eastern United States.

112. CAMPTONOTUS CAROLINENSIS (Gerstacker).
Gryllacris carolinensis Gers., 59, XXVI, 1860, 276.
Neortus carolinensis Brunn., 39, 1888, 381.
Camptonotus carolinensis Scudd., 188, 1900, 79.
Camptonotus scudderi Uhler, 212, II, 1864, 549; Glov., 62, 1872, Plate VIII, Fig. 15; Riley, 122, II, 1884, 186.

A medium sized wingless Locustid, reddish brown above, yellowish white beneath. Face and all the tibiæ and tarsi yellowish, the femora, especially the two hind pair, mottled with dark brown, and a transverse bar of the same color on the three posterior dorsal segments of abdomen.

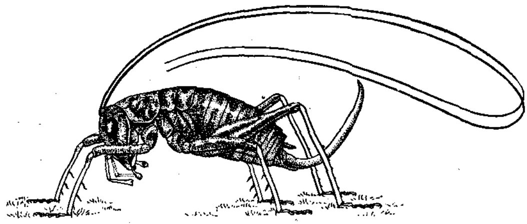


Fig. 99. *Camptonotus carolinensis* (Gerstacker). Female. Twice natural size. (Original.)

Measurements: Female—Length of body, 12 mm.; of posterior femora, 7.5 mm.; of ovipositor, 8 mm.

A single female of this curious Locustid was taken October 11, 1902, near Millersville, Marion County, by Philip Baker, of Indianapolis, who kindly presented it to me. I had seen one in Vigo County ten years before but had failed to effect its capture. It has been heretofore taken only in Maryland, Delaware and the Carolinas. Near Baltimore, according to Uhler, it appears in the larval state as early as the first of August and reaches maturity the latter part of September. It is there found upon oak trees, where it is said to spend the day time curled up in the leaves. It will probably be found to occur in small numbers on oaks throughout the southern half of Indiana.

Since the above was in type, two pairs of the half grown young of *C. carolinensis* have been taken, one pair from near Mitchell, Lawrence County, on July 15th; the other from near Montezuma, Parke County, on July 22d. Both pairs were beaten from oak bushes while collecting beetles.

Sub-family STENOPELMATINÆ.

The Indiana members of this sub-family comprise those insects which are commonly called "stone" or "camel crickets," and, so far as known, belong to the single genus *Ceuthophilus*, which is characterized below.

L. CEUTHOPHILUS Scudder (1862).

Wingless Locustidæ of medium or large size with a thick body and arched back. Head large and oval, bent downward and backward between the front legs. Antennæ long, slender, cylindrical and tapering to a fine point. Eyes sub-pyriform, the narrow end downward, placed a little above and close to the basal joint of the antennæ. Maxillary palpi long and slender; the apical joint longest, somewhat curved, split on the under side three-fourths of its length, which is nearly equal to that of the two preceding taken together. Pronotum short, not extending over the meso and meta-notum. Prosternum unarmed. Hind femora thick and heavy, turned inward at the base, channeled beneath, with the margins of the channel either serrate or spined in the males, seldom armed in the females. Ovipositor well developed, nearly straight, a little upturned at the tip, the inner valves usually strongly serrate on the under side of the apical fourth. Cerci of males long, slender, usually very hairy.

These insects are seldom seen except by the professional collector. They are nocturnal in their habits, and during the day hide beneath stones along the margins of small woodland streams, or beneath logs and chunks in damp woods, in which places seldom less than two, nor more than three or four, are found associated together. Being wingless they make no noise, and, like most other silent creatures, are supposed to be deaf, as no trace of an eardrum is visible.

That they are well-nigh omnivorous in their choice of food, I have determined by keeping them in confinement, when they fed upon meat as well as upon pieces of fruit and vegetables, seemingly preferring the latter. The majority of the species evidently reach maturity and deposit their eggs in the late summer or early autumn, as the full grown insects are more common then, but have been taken as late as December 1st. The eggs, which are supposed to be laid in the earth, usually hatch in April, but some are hatched in autumn and the young live over winter, an anomaly among the Locustidæ, as I have taken them on a number of occasions throughout the winter. Several of the species inhabit caves and are usually of larger size, with longer antennæ and smaller compound eyes than those found above ground.

The adult males of these insects are quite readily separated by the size, number and relative position of the spines on the under side of the hind femora, as well as by the degree of curvature of the corresponding tibiæ. The females, having neither the spined posterior femora nor the curved tibiæ, are less readily distinguished by the color and the relative measurements of the different organs. As the two sexes are colored alike and are usually found in close proximity there will be little difficulty in placing the female after determining the male by the key given below, which mainly pertains to that sex alone.

Seven species have, up to the present, been taken by the writer in Indiana.

KEY TO INDIANA SPECIES OF CEUTHOPHILUS.

a. Fore femora but little, if any, longer than the pronotum.

b. Hind tibiæ of male arcuate or sinuate in basal half; the hind femora of male with about 13 small, unequal spines on the outer lower carina....................113 *maculatus*, p. 399

bb. Hind tibiæ of male straight; hind femora of adult male with 8 to 11 rather large, unequal spines on the lower outer carina; a broad, dark brown or blackish stripe on either side of dorsal surface of body........................114 *latens*, p. 400

aa. Fore femora one-third or more longer than the pronotum.

c. Hind femora distinctly shorter than the corresponding tibiæ; cave inhabiting species ....115 *stygius*, p. 401

cc. Hind femora but little, if any, shorter than the corresponding tibiæ; species living above ground.

d. Lower outer carina of hind femora of male conspicuously spined.

e. Inferior sulcus of hind femora of male quite deep and of uniform width; the outer carina with seven to nine spines of unequal length and not equidistant ....116 *blatchleyi*, p. 403

ee. Inferior sulcus of hind femora of male shallow and broad; wider at base than at distal end; the spines of the outer, lower carina sub-equal in size and equi-distant ....117 *uhleri*, p. 404

dd. Lower outer carina of hind femora of male never conspicuously spined.

f. General color clear reddish brown, mottled with paler; hind femora of male more than twice as long as the fore femora; each of the lower carinæ with about 25 crowded minute teeth................ 118 *terrestris*, p. 406

ff. General color dull sooty brown with numerous paler spots; hind femora of male about twice as long as the fore femora, with seven to 15 small but distinct teeth on each of the carinæ................. 119 *brevipes*, p. 406

113. CEUTHOPHILUS MACULATUS (Say). The Spotted Camel Cricket.

Raphidophora maculata (Say MS.), Harris, 71 1841, 126; Scudd., 140, VIII, 1861, 7, 11, 14.

Phalangopsis maculata Harris, 72, 1862, 155, Fig. 73.

Ceuthophilus maculatus Scudd., 141, VII, 1862, 434; Id., 171, XXX, 1894, 27, 68; Id., 188, 1900, 82; Glov., 62, 1872, Plate III, Fig. 5; Pack., 104, 1883, 565; Riley, 122, II, 1884, 184, Fig. 259; Brunn., 39, 1888, 307; Bl., 7, 1893, 142; Id., 16, 1899, 222, Fig. 53; Lugg., 84, 1898, 249, Fig. 163.

General color: Above, dark sooty brown, with often a median stripe of lighter brown on the thoracic segments; below a yellowish brown. The abdominal segments bear on their dorsal surface a number of small yellow dots, often confluent and sometimes in regular transverse rows. Antennæ and legs light reddish brown, the hind femora cross-barred with narrow darker brown bars arranged in parallel rows.

Anterior femora a little longer than pronotum, the inner carina with one or two rather long sub-apical spines. Hind femora about the length of the body; the lower sulcus narrow and of medium depth, its outer carina in the male with twelve to fifteen unequal, rather coarse spines; the inner carina with about the same number

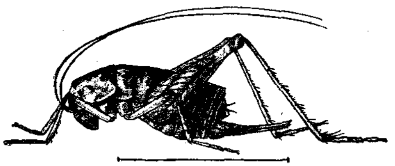


Fig. 100. *Ceuthophilus maculatus* (Say). Female. (Afer Lugger).

of smaller and sub-equal spines; the female with a number of small, inconspicuous spinules on each carina. Hind tibiæ a little longer than the femora, the basal third distinctly arcuate or bowed in the male. Cerci with the basal half stout, tapering beyond. Ovipositor two-thirds as long as the hind femora, gently tapering to the tip, which is slightly upturned, the teeth of the inner valve sharp.

Measurements: Male—Length of body, 14 mm.; of pronotum, 5 mm.; of front femora, 6 mm.; of hind femora, 15 mm.; of hind tibiæ, 17 mm. Female—Length of body, 16 mm.; of pronotum, 5 mm.; of front femora, 6 mm.; of hind femora, 16 mm.; of ovipositor, 10 mm.

This "spotted wingless grasshopper" has the widest range of any of the 56 species of Ceuthophilus listed by Scudder, having been recorded from nearly every State east of the Great Plains. In Indiana it is, as far as my observation goes, much less common than some of the other species of the genus, having so far been taken only in Crawford and Putnam counties. In the former county a number of specimens were secured in June and July from beneath logs and chunks in dry upland woods. In Putnam County it was found on August 1st beneath a log in a damp ravine. It probably occurs sparingly in like situations throughout the State.

114. CEUTHOPHILUS LATENS Scudder. The Black-sided Camel Cricket.
Ceuthophilus latens Scudd., 141, VII, 1862, 437; Id., 171, XXX, 1894, 29, 64; Id., 188, 1900, 82; Bl. 7, 1893, 143.

General color: Light reddish brown; two broad bands of dark fuscous or blackish along the thorax and one or more of the basal segments of abdomen, extending half way down the sides and separated from one another by a median stripe of light reddish brown. Below the black stripes the sides are pale yellowish brown; while the greater part of the abdomen, as well as the outer face of the hind femora, is dotted with brownish yellow, the dots sometimes confluent, sometimes in apparently regular rows. The legs are light brown, the tips of the hind femora infuscated.

The fore femora a little stouter than the middle pair, nearly a third longer than the pronotum in the male; but little longer in the female, the inner carina with two or three spines. Middle femora with two to four spines on each carina beneath. Hind femora thick and stout, the inferior sulcus of average width and depth, the margins with several minute spines in the females; the outer carina of adult males with eight or nine spines, the four or five middle ones of which are quite strong and prominent, the inner carina with 11 to 14 small and sub-equal spines.

Hind tibiæ straight, very little, if any, longer than the femora; the inner calcaria much longer than the outer, and as long as the first tarsal joint. Cerci slender, gently tapering throughout, longer than the greatest width of hind femora. Ovipositor nearly twice as long as fore femora, straight, the tip a little upturned and acute.

Measurements: Length of body, male, 22 mm., female, 24 mm.; of pronotum, male and female, 6.5 mm.; of front femora, male, 8.5 mm., female, 7 mm.; hind femora, male and female, 19 mm.; of hind tibiæ, male, 21 mm., female, 20 mm; of ovipositor, 11 mm.

Mr. Scudder has evidently described this species from immature specimens of both sexes. As a consequence, his measurements are much less than those given above. The spines on lower outer carinæ of males are more numerous and more prominent in the adults than in the two-thirds grown young, where they are sub-equal in size. The black markings at base of tibial spines, used by Scudder in his key, are seldom present in the adults and are therefore of no value as a distinguishing character. I have, in recent years, taken numerous specimens of the large form mentioned in my former paper, and described herewith, in company with the immature forms described by Scudder, and there is no doubt but that the two are the same.

C. latens has proven to be a rather common species in Indiana, having been taken in Vigo, Putnam, Crawford, Kosciusko and Steuben counties. It is most commonly found beneath small chunks or flat stones in rather dry sandy localities. Sometimes a half dozen will be found in company beneath the same shelter. It reaches maturity about July 20th, probably from specimens hatched in spring, though I have taken the young on two different occasions in February. The species is sometimes affected by the parasitic hairworm, *Gordius sp.?* According to Scudder, it ranges from "New York to Texas."

115. CEUTHOPHILUS STYGIUS (Scudder). The Cave Camel Cricket.

Raphidophora stygia Scudd., 140, VIII, 1861, 9.

Ceuthophilus stygius Scudd., 141, VII, 1862, 438; Id., 171, XXX, 1894, 24, 33; Id., 188, 1900, 84; Pack., 104, 1869, 565; Id., 106, IV, 1888, 70, 83; Riley, 122, II, 1884, 184; Brunn., 39, 1888, 309; Bl., 7, 1893, 148; Id., 14, 1897, 198; Id., 16, 1899, 175.

Ceuthophilus sloanii Pack., 105, V, 1873, 93; Id., 106, IV, 1888, 71, 83.

Pale, reddish brown, the hind border of each segment with a dark brown band, the pronotum with a similar band on the front margin, and an indistinct, dark median band connecting the two. Face pale with usually a black dash below each eye, and a shorter median one. Antennæ brownish yellow, paler toward the tip, of excessive length, averaging four times the length of body. Legs all very long and slender. Front femora, in the specimens at hand, double the length of the pronotum, with two to five spines on the lower front carina. Middle femora shorter than the anterior with both of the lower carinæ armed with three or four distinct spines. Hind femora rather slender, nearly as long as the body, the lower, outer carina prominent; the inferior sulcus narrow and of average depth; both margins armed with numerous small spines, those on the outer carina of male double the size of those on the inner. Hind tibiæ straight, longer than the corresponding femora. Hind tarsi two-fifths the length of the tibiæ. Cerci slender and tapering, nearly half as long as hind femora. Ovipositor straight, the apical two-thirds of nearly the same diameter, the tip scarcely upturned; the teeth of inner valve feebly crenate.

Measurements: Length of body, male, 30 mm., female, 26 mm.; of pronotum, male, 7.5 mm., female, 6.5 mm.; of front femora, male, 15 mm., female, 12.5 mm.; of hind femora, male, 26 mm., female, 24 mm.; hind tibiæ, male, 27.5 mm., female, 25 mm.; of antennæ, male, 103 mm., female, 96 mm.; of ovipositor, 16 mm.

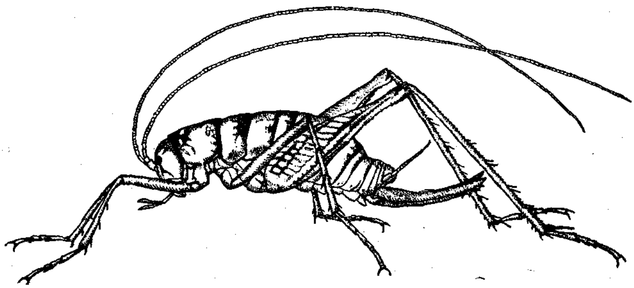


Fig. 101. *Ceuthophilus stygius* (Scudder). Female. One and one-fourth times natural size. The antennæ are half as long again as shown in the cut. (Original.)

This "cave cricket" occurs abundantly in crevices in the walls and roof near the mouths of Wyandotte, Little Wyandotte, Sibert's Well Cave and Saltpetre Cave, Crawford County, and a few immature specimens, pronounced by Mr. S. H. Scudder to be the same species, have been taken in Porter's Cave, Owen County and Truett's and Strong's caves, Monroe County, 80 miles farther north. In the Crawford County caves no specimens were found further back than 250 feet from the mouth, except in Wyandotte, where a few have been taken on "Monument Mountain," one-half mile from the mouth. In the other caves they were found back beyond the reach of any rays of light.

The adults of this species are the largest "stone" or "Camel crickets" occurring in the State and seem to be more or less gregarious. In one instance, in Sibert's Well Cave, more than 20 were found in a small cranny in the wall. They were grouped in a circle, in a space about six inches square, with their antennæ pointing toward the center of the circle, and appeared to be holding a conference or cricket convention.

In regard to the life history of this insect, but little is known. I found a number of specimens of half grown young in Sibert's Cave on May 16, 1895. The adults were common in July, 1896; and in November, the young about one-third the size of mature specimens were frequent in Saltpetre Cave, but could not be found elsewhere.

The species may be represented in winter by the eggs as well as by the young, as is the case among some other members of the genus.

In Saltpetre Cave, where in July *stygius* was very plentiful, all were found within 100 feet of the entrance. They were never seen on the floor, unless they leaped there when disturbed, but were found resting on the sides of small projections and in small cavities of the walls or roof, with their antennæ spread out before them. If a lighted candle was held close to them they paid no attention to it, but were very sensitive to its heat and to touch. When disturbed they leap with agility, sometimes to a distance of six feet, but with a little care can usually be readily picked up with the fingers before they become frightened.

The immature specimens from caves in Monroe and Owen counties were darker than typical *stygius*, and were found on the floors of the caves—in one or two instances beneath loose rocks. From their habits I am somewhat inclined to doubt their being *stygius*, since it is quite difficult to name correctly the young of any species of *Ceuthophilus*.

116. CEUTHOPHILUS BLATCHLEYI Scudder.

Ceuthophilus blatchleyi Scudd., 171, XXX, 1894, 26, 57; Id., 188, 1900, 81; Lugg., 84, 1888, 249.

Ceuthophilus uhleri Bl., 7, 1893, 144. (Not *C. uhleri* Scudd.)

General color: Light reddish brown, the meso and meta-notum usually darker. The pronotum rather thickly and irregularly mottled with paler spots; the other segments with the pale spots for the most part in a transverse row near the hind margin. The legs yel-

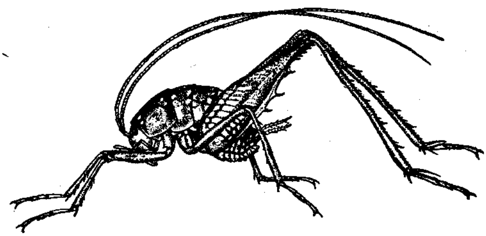


Fig. 102. *Ceuthophilus blatchleyi* Scudd. Male. One and one-fourth times natural size. (Original.)

lowish brown, the hind femora with the apex a little dusky above and with numerous oblique transverse dusky bars on the outer face. In a few specimens the general color is much darker and the outer face of the hind femora is a fuscous brown almost black in hue.

The anterior femora are but little longer than the pronotum; the lower front margin armed with from one to four spines. Hind femora of the male of average width but rather slender and tapering; the inner surface of the upper portion of the apical half with numerous raised points; the lower outer carina prominent, with the inferior sulcus rather narrow and very deep, the sides meeting at an angle above. The spines of the outer carina are usually arranged in three sets, the basal set containing two to four equidistant graduated spines, the distal one largest; the middle set contains but a single strong spine equal in size to the one before it and separated from it as well as from the first one of the apical set, by a space almost twice as great as between the members of the basal set; the apical set of four small, sub-equal spines. The inner carina is armed with about 16 small sub-equal spines. The female has the inner carina also armed in like manner with still smaller spines. Hind tibiæ of male straight, a little longer than the femora; distinctly longer in the female. Cerci gradually tapering from a rather stout base, about as long as the breadth of the hind femora. Ovipositor about two-thirds the length of hind femora.

Measurements: Length of body, male, 14 mm., of female, 16 mm.; of pronotum, male and female, 5 mm.; of fore femora, male, 6.5 mm., female, 6 mm.; of hind femora, male, 15 mm., of female, 13.5 mm.; of hind tibiæ, male and female, 16 mm.; of ovipositor, 9 mm.

This species may be readily known from the next, its closest ally, by the more slender hind femora of the male, the narrower inferior sulcus of these femora, and by the different armature of their lower outer carina.

In central Indiana, *blatchleyi* is the most common species of *Ceuthophilus*. It is usually found from July to November in small colonies of three to six or more, beneath rails and logs in rather dry situations. It is especially fond of low, open second bottom woods, with a loamy or sandy soil. The young have been taken in similar places in December and February, but evidently the larger number of eggs do not hatch until spring. It has not, as yet, been taken in either the northern or southern third of the State, but probably occurs throughout as it has been recorded from New York, Minnesota and Iowa.

117. CEUTHOPHILUS UHLERI Scudder. Uhler's Camel Cricket.

Ceuthophilus uhleri Scudd., 141, VII, 1862, 435; Id., 171, XXX, 1894, 26, 56; Id., 188, 1900, 84; Glov., 62, 1872, Plate VIII, Fig. 8; Riley, 122, II, 1884, 184; Brunn., 39, 1888, 64, Fig. 33b.

Ceuthophilus latisulcus Bl., 7, 1893, 146.

General color: Light brownish or clay yellow, irregularly flecked with fuscous, especially on the pronotum and abdomen; the female somewhat darker. Legs light brown, more or less infuscated on the apical portions of the femora. The anterior femora more than a third longer than the pronotum in the male, shorter in the female, with two sub-equal spines near the apex of the lower front carina. The intermediate femora with three spines on each of the lower carinæ. The hind femora shorter and not so broad as in the preceding, the outer lower carina much less prominent; the upper half of the exterior face very scabrous, with small projections. The inferior sulcus exceptionally broad and shallow, about twice the breadth and one-half the depth of that of *C. blatchleyi;* the sides not meeting in an angle as there, but the top of the sulcus flat. The outer carina with seven or eight sub-equal spines borne at equal distances apart on the apical half; the middle two slightly the larger but much less strong than the corresponding one of *C. blatchleyi.* The inner carina armed with 16 to 20 very small teeth. In the female the inferior sulcus is much less broad and the carinæ bear only a few small teeth on their apical half. The hind tibiæ of male with a very slight curve just below the base; a little longer than the corresponding femora in both sexes. Cerci rather stout, shorter than the femoral breadth. Ovipositor but little more than half as long as hind femora, the tip considerably upturned and finely acuminate.

Measurements: Length of body, male, 15 mm., female, 16 mm.; of pronotum, male and female, 5 mm.; of front femora, male, 7.5 mm., female, 6 mm.; of hind femora, male, 17.5 mm., female, 13.5 mm.; of hind tibiæ, male, 18.5 mm., female, 15.5 mm.; ovipositor, 8 mm.

From *C. blatchleyi,* which it most resembles, this species may at once be known by the longer anterior femora, the much broader and shallower sulcus of the hind femora, as well as by the difference in size and arrangement of the teeth upon the latter. The adult male is larger, with shorter and broader hind limbs than those of *blatchleyi,* though the males of both these species are much more robust when mature than those of *C. maculatus* and *C. terrestris* which have come under my notice.

In Indiana, *uhleri* is much less common than the preceding species, having been taken in small numbers only in Vigo and Marion counties, where it occurs mature in August beneath logs and rubbish in dry sandy localities. It has been recorded from the Middle States, Maryland and Georgia.

118. CEUTHOPHILUS TERRESTRIS Scudder.

Ceuthophilus terrestris Scudd., 171, 1894, 26, 46; Id., 188, 1900, 84.
Raphidophora lapidicola Scudd., 140, VIII, 1861, 7.
Ceuthophilus lapidicolus Scudd., 141, VII, 1862, 435; Glov., 62, 1872, Plate VII, Figs. 4, 5; Riley, 122, II, 1884, 184; Bl., 7, 1893, 147.

Clear reddish brown, mottled with small pale spots, especially on the abdomen, where the spots have a tendency to arrange themselves in longitudinal rows. Often, but not always, a median light stripe on the dorsal portion of the pronotum, bordered by darker fuscous blotches. The legs paler, the exterior face of the hind femora with the usual darker transverse bars, but not so prominent as in *C. maculatus*.

Anterior femora a little longer than pronotum, unarmed beneath. Intermediate femora also unarmed or with a single apical spine on front margin. Hind femora about equaling the body, rather stout, the inferior sulcus of average width, rather deep; both carinæ of male bearing numerous small serrations, like the fine teeth of a saw, about 25 in number and crowded on the apical two-thirds of the segment; those of the female unarmed or with a few very fine teeth on the apical third. Hind tibiæ straight, a little shorter than the femora. Ovipositor less than three-fifths the length of hind femora, the tip upturned a little and pointed.

Measurements: Male—Length of body, 13 mm.; of pronotum, 5 mm.; of front femora, 6 mm.; of hind femora, 14 mm.; of hind tibiæ, 15 mm. Female—Length of body, 16 mm.; of fore femora, 6.5 mm.; of hind femora, 15 mm.; of ovipositor, 8 mm.

C. terrestris is in Indiana less common than any other species of the genus, having been taken only in Putnam and Vigo counties. The most of those secured were in April and the specimens were probably only about half grown. Its general range includes the northern United States and Canada, east of the Mississippi River.

119. CEUTHOPHILUS BREVIPES Scudder.

Ceuthophilus brevipes Scudd., 141, VII, 1862, 434; Id., 171, XXX, 1894, 26, 49; Id., 188, 1900, 81; Bl., 7, 1893, 148.

Dull sooty brown, a little darker on the dorsum of the thorax where there is usually a narrow median line of clay yellow. Very profusely spotted with dull yellow spots, especially on the posterior margins of the abdominal segments. Near the apex of the hind femora, these spots nearly form an annulation of yellow, more noticeable on account of the more or less dark band beyond.

Body robust; front femora a third or more longer than the pronotum, with a single spine on lower front carina. Hind femora short and stout; the inferior sulcus of average width and depth; both carinæ of male armed on apical half with seven to 15 small saw-like teeth; those of female with similar but smaller serrulations. Hind tibiæ straight, distinctly longer than the femora, the inner calcaria considerably longer than the outer, but shorter than the first tarsal joint. Cerci tapering from a rather stout base, a little longer than the femoral breadth. Ovipositor rather slender, two-thirds the length of hind femora, its apical third very slightly arcuate, the tip but little upturned; teeth of the inner valve small and distant from one another.

Measurements: Male—Length of body, 16.5 mm.; of pronotum, 5.5 mm.; of front femora, 8.5 mm.; of hind femora, 16 mm.; of hind tibiæ, 18.5 mm. Female—Length of body, 16 mm.; of pronotum, 5.5 mm.; of fore femora, 6.5 mm.; of hind femora, 15.5 mm.; of hind tibiæ, 17 mm.; of ovipositor, 10.5 mm.

This is another species where the measurements of Indiana specimens greatly exceed those given by Mr Scudder in his Monograph. It is not common in the State, being represented in my collection only by specimens from Vigo and Orange counties; those from the former county, taken in September and October, being full grown, while those from Orange County, taken in May, are but little more than half as large.

Aside from these Indiana localities, the species has been recorded only from Maine and New Brunswick.

Family GRYLLIDÆ.

The third family of Orthoptera belonging to the sub-order *Saltatoria* comprises the *Gryllidæ* or crickets. From the other Orthopterous insects they may be distinguished by having the wing covers flat above and bent abruptly downward at the sides; the tarsi or feet, three jointed, without pads between the claws; the fore coxæ longer than broad. Ocelli or simple eyes are present in the majority of species; while the antennæ, like those of the *Locustidæ*, are long, slender and many jointed. The hearing organ, when present, is, as there, situated on the base of the fore tibiæ.

The tympanum or calling organ of the male is also, as in the *Locustidæ*, located near the base of the dorsal surface of the tegmina, but is wider and broader than in the preceding family, extending across both anal and median areas of the tegmina. The chirps or love calls of the different species of crickets make up the greater part of that ceaseless thrill which fills the air, usually at night, from mid-August until after frost. These sounds are made only by the males, and are not vocal, as most persons suppose; but are produced by the tympanum, the insect rubbing the veins in the middle of one wing cover over those of the other. It is often difficult to locate one of these chirpers by its song. The distance and even the direction are often most deceiving; the crickets being exceedingly shy, much more so than katydids and grasshoppers. Those which live in the ground generally chirp near the entrance to their burrows, and retreat thereto at every approaching footstep. Those which live upon trees or shrubs resemble closely the hues of bark or foliage, and are therefore difficult to find even when close at hand; while the majority, dwelling as they do, among grasses and beneath logs and chips, find also a safe protection in their color, which is usually closely like that of the objects beneath which they rest while sounding their cymbals.

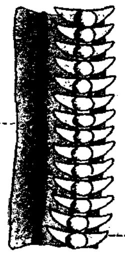


Fig. 103. Stridulating ridges in a house-cricket; *s*, stridulating ridge; *st*, stridulating teeth. (After Landois.)

The inner wings of the crickets are, for the most part, short, weak, and comparatively useless as flying organs, though sometimes they are nearly twice as long as the outer pair. Like their nearest relatives, the grasshoppers and katydids, these insects, therefore, travel mostly by leaps and, in the course of time, their hind femora have thus become greatly enlarged.

The ovipositor of the female, when exposed, is usually a long, cylindrical spear-shaped organ, consisting apparently of two pieces. Each of these halves, however, when closely examined, is seen to be made up of two pieces so united as to form a groove on the inner side, so that when the two halves are fitted together, a tube is produced, down which the eggs pass to the repository in the earth or twig, fitted to receive them.

The eggs of most crickets are laid singly in the ground. A few of the burrowing species deposit them in irregular masses in underground cavities. The tree crickets place them uniformily in a single row in the pith of twigs. Most species are represented in winter by the eggs alone. A few, however, pass the cold season as nymphs, or as adults. The mole crickets are said to exist for several years.

Among the families of Orthoptera the *Gryllidæ* and *Locustidæ* take a rank superior to all others. The high specialization of the ovipositor of the female and the perfection of structure of the stridulating organ of the male place these two families above all others in the scale of Orthopteran life. That the two are very closely related can be readily seen by any one who will carefully compare them, organ with organ. The *Gryllidæ* are placed first, however, by most entomologists, as the great variety of form of almost any given organ among them, when compared with its relative uniformity of structure among the *Locustidæ,* seems to indicate the higher rank of the former.

About 67 species of Gryllidæ are known from the United States. These are divided among six sub-families and 17 genera. All of the sub-families and 12 of the genera are represented among the species known to occur in Indiana. The sub-families may be distinguished by the following table:

A SYNOPSIS OF THE SUB-FAMILIES OF GRYLLIDÆ KNOWN TO OCCUR IN INDIANA.

a. Tarsi compressed, the second joint minute, compressed.
- *b.* Fore tibiæ enlarged, fitted for digging; female without exposed ovipositor (Mole and sand crickets)....GRYLLOTALPINÆ, p. 410
- *bb.* Fore tibiæ not enlarged; female with well developed external ovipositor.
  - *c.* Hind tibiæ bearing two rows of minute teeth and a few movable spines. Body very small, sub-spherical; hind femora short, much swollen. (Our species living in ants' nests) ........................MYRMECOPHILINÆ, p. 415
  - *cc.* Hind tibiæ bearing two rows of spines; body of larger size, sub-elongate, with longer and more slender hind femora.
    - *d.* Hind tibiæ rather stout, armed with stout spines without teeth between them. (Ground and field crickets) ....GRYLLINÆ, p. 418
    - *dd.* Hind tibiæ slender, armed with delicate spines (except in the genus *Xabea*), with minute teeth between them. (White tree crickets)................ ŒCANTHINÆ, p. 443

aa. Second tarsal joint distinct, depressed, cordiform.
- *e.* Hind tibiæ bearing two rows of spines without teeth between them. Ovipositor in our species compressed and curved upward. (Small black or brown tree crickets).................. TRIGONIDIINÆ, p. 454
- *ee.* Hind tibiæ bearing two rows of spines with small teeth between them. Ovipositor in our species cylindrical, but little upcurved. (Larger brown tree crickets)..................... ENEOPTERINÆ, p. 457

Sub-family GRYLLOTALPINÆ.

This sub-family includes the burrowers among our crickets. The species have the fore limbs so modified that they can make their way readily beneath the surface. The antennæ are much shorter and less tapering than in the species living above ground. The ovipositor of the female is not visible externally.

Three genera are represented in Indiana which may be separated by the following key:

KEY TO GENERA OF INDIANA GRYLLOTALPINÆ.

a. Species of large size; fore tibiæ broadly expanded, the claws prominent; two large ocelli present; hind femora slender; tarsi three-jointed ....LI. GRYLLOTALPA, p. 410

aa. Species of small size; fore tibiæ not broadly expanded but bearing three or four spines at the apex; three small ocelli present; hind femora much swollen; tarsi one-jointed or wanting.

b. Species more than 5.5 mm. in length; pronotum with a weak transverse sulcus; hind tibiæ with four pairs of long slender plates used in swimming; hind tarsi one-jointed............. LII. TRIDACTYLUS, p. 413

bb. Species less than 5.5 mm. in length; pronotum with no transverse sulcus; hind tibiæ with a single pair of short plates used in swimming; hind tarsi wholly wanting.............. LIII. ELLIPES, p. 415

LI. GRYLLOTALPA Linnæus (1767).

Among all the Gryllidæ found in Indiana the mole crickets rank first in size and singularity of structure. When full grown they measure from an inch and a fourth to an inch and a half in length; are light brown in color and have the body covered with very short hairs, giving it a soft, velvety appearance. The females have no visible ovipositor, and, externally, may be separated from the males only by the difference in the veining of the uppermost of the wing covers, due to the presence of a tympanum in the latter sex. By their habit of burrowing beneath the soil in search of such food as the tender roots of plants, earthworms and the larvæ of various insects, the anterior tibiæ of these crickets have, in the course of ages, become so modified in structure as to closely resemble the front feet of the common mole, whence the generic name, *Gryllotalpa*, from *"gryllus,"* a cricket, and *"talpa,"* a mole. The dactyls or claws of these tibiæ are four in number, the upper two, the larger, being movable; the others immovable. The compound eyes have, on account of the underground life, become much aborted, being not more than one-fourth the size of those of the common field crickets, of the genus *Gryllus*. As the mole crickets crawl rather than leap, the hind femora are but little enlarged, and are always shorter than the pronotum. The hind tarsi are short, seldom exceeding half the width of the pronotum. But one species occurs in Indiana.

120. GRYLLOTALPA BOREALIS Burmeister. The Northern Mole Cricket.

Gryllotalpa borealis Burm., 40, II, 1838, 740; Scudd., 145, I, 1869, 25, Plate I, Figs. 9, 34, 35; Id., 148, 1874, 363, Plate A, Fig. 7; Id., 154, X, 1876, 97 (note of to music); Id., 168, XXIII, 1893, 63 (note of to music); Id., 188, 1900, 86; Glov., 62, 1872, Plate VII, Fig. 13; Id., 63, 1874, 143, Fig. 17; Pack., 104, 1883, 563; Comst., 41, I, 1888, 120, Fig. 121; Fletch., 54, XXIV, 1892, 23, Fig. 1; Doran, 47, XXIV, 1892, 270; Bl., 5, 1892, 130; Id., 16, 1899, 223, Fig. 54; Beut., 3, VI, 1894, 264; Lugg., 84, 1898, 257, Fig. 167b.

Gryllotalpa brevipennis Serv., 196, 1839, 368; Harris, 62, 1862, 149, Fig. 68; Rathv., 109, 1862, 378, Fig. 12.

Gryllotalpa longipennis Scudd., 141, VII, 1862, 426.

Gryllotalpa columbia Scudd., 145, I, 1869, 26, Plate I, Figs. 15, 36; Beut., 3, VI, 1894, 264, Plate V, Fig. 5; Lugg., 84, 1898, 257, Fig. 167.

Gryllotalpa columbiana Bl., 5, 1892, 131.

Color: Cinnamon brown, covered with short, fine hairs of the same hue; claws and veins of tegmina darker.

Tegmina covering one-half to three-fourths of abdomen. Inner wings slightly exceeding tegmina in short winged form, extending beyond tip of abdomen in long winged form (*columbia* Scudd.).

Measurements: Length of body, 30 mm.; of pronotum, 9 mm.; of tegmina, 9-12 mm.; of hind femora, 7.5 mm.; of cerci, 11 mm.

Fig. 104. *Gryllotalpa borealis* Burm. Long-winged Male.

The northern mole cricket has been taken by the writer in Marshall, Starke, Kosciusko, Putnam, Clinton, Vigo, Tippecanoe, Marion and Monroe counties, and doubtless occurs throughout the State, as it is found over the United States and Canada east of the Rocky Mountains. About one-third of those noted in the State are of the long winged form. On one occasion a log deeply buried in the sand on the southern shore of Lake Maxinkuckee was overturned and nine specimens were secured. Of these, however, six were long winged and three short winged.

In the moist mud and sand along the margins of the smaller streams and ponds the runs or burrows of this cricket, exactly like those of a mole though much smaller, can in late summer and early autumn be seen by those interested enough to search for them. The burrows are, in the main, very superficial, lying just beneath the surface and running in very irregular directions. They frequently fork, and often end beneath a stone or small stick. The insects themselves are seldom seen, as they are nocturnal, forming their burrows by night, and scarcely ever emerging from beneath the ground. Moreover, like a mole, they move backward as readily as forward, and so easily escape their enemies. Apparently one insect, or a single pair occupy these burrows; the males, though several are often heard at the same time, being usually at quite a distance apart.

The burrows occasionally enlarge into side cavities large enough for the insect to turn around, and in such lateral chambers the eggs are sometimes found in masses of 60 to 100, adhering to the rootlets of various plants. These eggs are spherical, white or almost colorless, and have a diameter of 0.7 mm. The young are active leapers, and are said to be about three years in reaching maturity. On July 19, 1894, a hundred or more of the half-grown young were captured in a small meshed seine while collecting fishes in a small stream in Montgomery County. They were evidently burrowing in the soft mud close to shore or perhaps in the mud beneath the shallow water. Just a year later a number of young were also taken in a seine from the waters of the outlet of Lake Wawasee, Kosciusko County. Since they feed, during their lives, mainly upon the tender roots of various plants, they are necessarily very injurious and it is fortunate that with us they are not more common than they are.

The note of the male mole cricket is a sharp di-syllabic chirp, continuously repeated and loud enough to be heard several rods away. It is usually attributed, by those who have given little attention to insect sounds, to the field cricket or to some of the smaller frogs. The cricket is very difficult to locate by this note, and the writer has on several occasions approached cautiously, on hands and knees, a certain spot, and has remained silent for several minutes while the chirping went on apparently beneath his very eyes; yet, when the supposed exact position of the chirper was determined and a quick movement was made to unearth him, he could not be found. Indeed, it is only by chance, as by the sudden turning over of a log in a soft mucky place, that a person can happen upon one of them unawares. Even then quick motion is necessary to capture him before he scrambles into the open mouth of one of the burrows which he has ever in readiness. I have heard their note in the forenoon of cloudy days, but it is much more common in the afternoon, and Mr. Scudder, who has given especial attention to the sounds of insects, has written of it as follows: "Our common mole cricket usually begins its daily chirp at about four o'clock in the afternoon, but stridulates most actively at about dusk. On a cloudy day, however, it may be heard as early as two or three o'clock; this recognition of the weather is rather remarkable in a burrowing insect, and the more so as it does not appear to come to the surface to stridulate, but remains in its burrow, usually an inch below the surface of the ground. Its chirp is a guttural sort of sound, like *grü* or *greeu*, repeated in a trill indefinitely, but seldom for more than two or three minutes, and often for less time. It is pitched at two octaves above middle C, and the notes are usually repeated at the rate of about 130 or 135 per minute; sometimes, when many are singing, as rapidly as 150 per minute. Often, when it first begins to chirp, it gives a single prolonged trill of more slowly repeated notes, when the composite character of the chirp is much more readily detected, and afterward is quiet for a long time. When most actively chirping, however, the beginning of a strain is less vigorous than its full swell, and the notes are then repeated at the rate of about 120 per minute; it steadily gains its normal velocity. It sounds not unlike a feeble distinct croak of toads at spawning season."

LII. Tridactylus Olivier (1789).

To this genus and the next belong the "sand crickets" which are among the smallest of the Gryllidæ, no one of the three species found in the United States being more than 10 mm., or two-fifths of an inch in length. The principal distinguishing characters of the genus are given in the key to the genera of *Gryllotalpinæ*.

The fore tibia of the males of *Tridactylus* has been shown by Morse to vary much in structure. It is usually more "or less irregularly ovate in outline and terminating apically in four prominent equidistant teeth, with the convex outer face thickly set with hairs, * * * the tarsus being inserted between the first and second teeth and lying on the anterior face." From this normal form it varies in progressive degree to a remarkably bifurcate organ in which the inner limb is elongated and devoid of hairs, the innermost tooth nearly disappears, the second is greatly prolonged into a claw-like organ, while the femur acquires tooth-like projections on its upper, inner ventral angle and becomes greatly enlarged. The outer wings or tegmina are horny and opaque and do not reach the end of the abdomen, while the inner wings are longer and folded lengthwise like a fan. The hind femora are much enlarged and the insects are active leapers.

"These sand crickets," says Scudder, "are in general appearance, miniature Gryllotalpas, though, not being heavy bodied, they can leap vigorously, bounding high in the air. Nothing is more curious than these lively and pigmy mole-crickets; they live in similar places, and make burrows like the mole-crickets, but their forelegs, though constructed for burrowing, are very different in detail. They are not, however, found in quite such wet spots as the mole-cricket haunts, preferring the sandy margins of ponds rather than muddy ones. Their burrows are at first vertical, but immediately turn, running not more than an inch below the surface of the ground, and are very narrow, as would be expected of such little creatures; one measured was hardly a twentieth of an inch in diameter. The males are not provided with any tambourine upon the wings, and therefore can not sing."

But one species of *Tridactylus* is known from Indiana.

121. TRIDACTYLUS APICALIS Say. The Larger Sand Cricket.
Tridactylus apicalis Say, 138, IV, 1825, 310; Id., 139, II, 1859, 239; Scudd., 141, VII, 1862, 425; Id., 188, 1900, 86; Id., 195. IX, 1902, 309; Pack., 104, 1883, 563; Riley, 122, II, 1884, 180; Bl., 5, 1892, 129; Lugg., 84, 1898, 259, Fig. 168.
Xya mixtus Hald., 65, VI, 1853, 364.

This is the largest of the three species of sand crickets occurring in the United States, its length being 8 or 9 mm. The body is black or dark brown, the head and thorax with some white markings, and the tegmina with their outer edge and a spot behind the middle white. The hind femora are whitish with the upper half of outer face brownish or with three dark cross-bars. The wings of the male extend 3 mm. beyond the tip of the abdomen. The fore tibiæ of the males of Indiana specimens I find to vary in like manner as those of *T. terminalis* mentioned by Morse.

Fig. 105. *Tridactylus apicalis* Say. (After Lugger.)

Measurements: Length of body, 9 mm.; of tegmina, 3 mm.; of inner wings, 7.5 mm.; of posterior femora, 5 mm.

Apicalis has been noted in Indiana only in Putnam and Vigo counties. In the former it was taken in numbers in August, 1893, and again in June, 1894, from a damp sandbar along Walnut Creek, two miles east of Bainbridge. Both here and in Vigo County it was in company with the next species. It occupied small pits or burrows in the sand, and would sometimes be seen resting with the head and half the body outside the opening of the pit, into which it backed as one drew near. Usually, however, it was at a distance from any visible pit and would then leap vigorously when approached, often to a height of five feet and a distance twice as great. By close search it will probably be found to occur along damp sandbars in all portions of the State, as its general range includes the United States east of the Great Plains.

LIII. Ellipes Scudder (1902).

This genus was but recently separated from *Tridactylus*. The main distinguishing characters are given in the key. But one species, *E. minuta* (Scudder), ranging from Minnesota to Cuba and Mexico, and from Indiana to California, is known from the United States.

122. **Ellipes minuta** (Scudder). The Smaller Sand Cricket.
Tridactylus minutus Scudd., **141**, VII, 1862, 425; Id., **188**, 1900, 87; Lugg., **84**, 1898, 259.
Ellipes minuta Scudd., **195**, IX, 1902, 309; Bl., **18**, 1902, 129, 223.

General color a dark brown or black; middle femora and tibiæ and posterior femora with narrow white crossbars. Pronotum and segments of abdomen with their hind margins whitish. The wings cover about three-fourths of the abdomen; the tegmina, half of the wings.

Measurements: Length of body, 5 mm.; of hind femora, 3.5 mm.

In Indiana this small sand cricket has been taken in Spencer, Vigo, Putnam and Lake counties. It frequents damp sandy places which are sparsely covered with grass or other vegetation, where it is often found in company with the grouse locusts or with the larger sand cricket, *Tridactylus apicalis* Say. While more active in its movements it does not leap as high nor as far as that species. The best way to capture them, after discovering a colony, is to sweep rapidly just above the ground with a net of cheese cloth or other close meshed material.

Sub-family MYRMECOPHILINÆ.

The Indiana members of this sub-family are very small, subspherical crickets, which bear a general resemblance to the young of cockroaches but leap actively when disturbed. They live with colonies of ants in or beneath rotten stumps and logs and under stones. They belong to the single genus, *Myrmecophila,* characterized as follows:

LIV. Myrmecophila Latreille (1807).

Body sub-spherical or ovate, greatly convex above, wingless. Eyes very small, resembling ocelli. Antennæ rather stout, as long as the body. Occiput almost hidden by the pronotum, which is large, wider behind than in front, the anterior and posterior margins straight; meso and metanotum, similar to the segments of the abdomen, sometimes a little wider. Anterior tibiæ without hearing organ, unarmed. Hind femora, ovate, greatly enlarged. Hind tibiæ stout, shorter than femora, compressed, the upper margin ciliate; the inner carina with four movable spines, the outer with two; the apex with three or four rather long, terminal spurs. Cerci as long as or longer

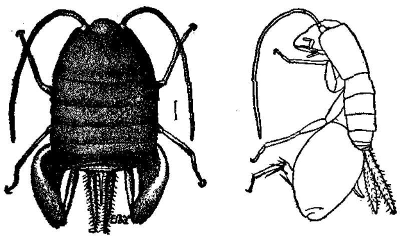


Fig. 106. *Myrmecophila nebrascensis* Brun. (After Lugger.)

than the abdomen. Ovipositor short and stout. The male is more slender and smaller in size than the female.

A very interesting account of the habits of these little crickets has been published* by W. M. Wheeler, of Austin, Texas, from which I quote at length as follows: "My observations on the habits of Myrmecophila began early in the March of the present year. The little crickets were taken from the Formica or red ants' nests and placed in artificial nests of the agricultural ant, an insect of much larger size, slower movements and in many other respects more satisfactory for purposes of observation than the Formica.

"On April 3d I placed in the artificial nest twenty Myrmecophilas, eight or ten of which had been squeezed or had lost one or both saltatory legs during capture. All the disabled individuals were at once seized and dispatched in so vindictive a manner, that I could not doubt that the ants were irritated by the pungent red ant nest-odor still clinging to the crickets. In an instant all the ants in the compartment of the nest had gathered in little groups, each devouring a Myrmecophila. The uninjured crickets made not the slightest attempt to escape, but felt themselves perfectly at home as soon as

* Psyche, IX, 1900, p. 111, *et seq.*

they set foot on the floor of the nest. Their adaptation to a new nest and to an ant of a larger size and belonging to an entirely different sub-family from their former host, was immediate and complete. With constantly vibrating antennæ they began dodging in and out among the little groups of assembled ants. From time to time one of them would be seen cautiously approaching an ant, that was busy with its dinner of Myrmecophila, and fall to nibbling at its legs or the tip of its abdomen. There could be no doubt that the cricket derived some benefit from the oily secretion covering the surface of the ant's body. At first the ant disregarded this nibbling, which probably resembles the attentions of the toilet habitually received from sister ants, but the cricket's scraping mandibles and maxillæ soon grew annoying and the ant would either move away or turn its head, open its mandibles and make a lunge at the Myrmecophila like a large dog annoyed by a puppy. But before the huge mandibles had closed, the cricket was far away, already nibbling at the abdomen of some other ant. The cricket can get at only the legs and abdomen of its host, since the spreading legs prevent it from reaching the thorax. It often stands on its hind legs, and places its forelegs on the ant's leg, in order to reach the femur or tibia. For very obvious reasons, it avoids nibbling at or even approaching the ant's head. It is always alert, as if perpetually aware of danger and ready to dodge at the slightest movement made by the ant.

"Occasionally in the narrow confines of an artificial nest the ants do succeed in capturing and devouring one of their vigilant little guests, but the fact that of the eleven sound crickets left after the above observation was made, eight were still alive June 22d, when I had to discontinue my observations for the summer, shows that the crickets are extremely expert in keeping out of danger. The attitude of the ants during all this time underwent no change as far as I could observe, for they would still occasionally make lunges at the crickets.

"The crickets do not derive all their substance from cleansing their hosts. In earthen nests they are often seen haunting even the galleries that have been abandoned by the ants, scrutinizing the walls and nibbling at them from time to time. There can be no doubt that they find here the same substance which covers the ants, for the walls of the galleries of a populous nest soon become greasy from the attrition of the constantly passing ants. Sometimes the crickets may be seen nibbling at dead ants that have been temporarily abandoned in the galleries or placed on the kitchen-midden of the nest. The intestine of a Myrmecophila which I dissected was found to contain oil-globules and a granular whitish substance."

Five species of *Myrmecophila* are known from the United States. Of these but one occurs east of the Mississippi River, and it was known only from Maryland, Georgia and the District of Columbia until 1901, when it was found in numbers in southern Indiana.

123. MYRMECOPHILA PERGANDEI Bruner.

Myrmecophila pergandei Brun., 21, XVI, 1884, 42, Fig. 4; Riley, 122, II, 1884, 181; Scudd., 187, VIII, 1899, 424, 425; Id., 188, 1900, 87.

Color: Dark reddish brown, the front and hind margins of pronotum, the hind margins of the other dorsal segments as well as the apex of ovipositor, a darker piceous brown; the legs, cerci and base of antennæ and ovipositor a paler brown. The young are generally paler than the adults.

Body broad oval, depressed; nearly twice as long as broad; hind femora pyriform, more arcuate below than above. Ovipositor rather stout, straight, the inner valves a little shorter than the outer.

Measurements: Length of body, male 3-4 mm., of female, 4-5 mm.; of hind femora, female, 3 mm.; of ovipositor, 2.5 mm.

This small ant-loving gryllid was first taken in Indiana near New Harmony, Posey County, on April 26, 1901. It was afterward found to be rather common in the region thereabouts as well as in Knox, Perry, Dubois, Crawford, Orange and Lawrence counties; the northernmost point at which it has been observed being near Mitchell, Lawrence County. Since its known general range is southern it probably does not occur in the northern half of the State. With us it is found in company with a half dozen species of ants, the most common of which is a rather large yellowish-red form, probably *Camponotus melleus* Say. The cricket seems to be always on the move, and when disturbed leaps with great agility. Those taken in Crawford County in September were almost double the size of those noted in the spring and probably more accurately represent the mature insect. But little is as yet known of the life habits of these interesting insects and the subject is well worthy of prolonged observation.

Sub-family GRYLLINÆ.

This sub-family comprises the ground and field crickets. They are among the most common members of the order Orthoptera; abounding everywhere in temperate and torrid climates. The main distinguishing characters of the sub-family are given in the key. Many of the species are dimorphic as regards the length of the wings, and on this account much confusion in synonymy has resulted in the past. But three genera of the sub-family occur in the United States, all of which are represented in Indiana. These genera may be distinguished by the following key:

KEY TO GENERA OF INDIANA GRYLLINÆ.

a. Species of small size; last joint of the maxillary palpi double the length of the one preceding; hind tibiæ furnished with long, movable, pilose spines; first joint of hind tarsi unarmed above or with one row of small teeth ....LV. NEMOBIUS, p. 419

aa. Species of medium or large size; last joint of maxillary palpi but little, if any, longer than the one preceding; hind tibiæ armed with stout, immovable spines; first joint of hind tarsi sulcate above, with a row of teeth on each side.

- *b.* Species of large size; fore tibiæ provided with a hearing organ on both faces ....LVI. GRYLLUS, p. 429
- *bb.* Species of medium size; fore tibiæ with hearing organ on outer face only ....LVII. MIOGRYLLUS, p. 442

LV. NEMOBIUS Serville (1839).

Of all the Gryllidæ which occur with us, the little brown ground crickets of the genus *Nemobius* are the most numerous and the most social. Unlike their larger cousins, the field crickets, they do not wait for darkness before seeking their food, but wherever the grass has been cropped short, whether on shaded hillside or in the full glare of the noonday sun along the beaten roadway, mature specimens may be seen by hundreds during the days of early autumn. Even the tangled masses of sphagnum mosses and other semi-aquatic growth of fen and marsh furnish shelter and food to certain species which, in the ages of the past, have become adapted to a life of such surroundings.

These ground crickets are all of small size, being never more than half an inch in length. The color is usually a dark brown or pitch black, and the bodies and legs are sparsely clothed with brown hairs. The head and thorax are of nearly equal breadth. The last segment of the maxillary palpus is twice the length of the one preceding it, and enlarged at the outer end. The anterior tibiæ bear near their base a small oval hearing organ on the outer face. The veins of the wing covers of the female run lengthwise, while in the females of the larger field crickets they run obliquely from both sides.

While the individuals of *Nemobius* are so plentiful, their size is so small that they have received but little attention from the average collector. Moreover, so similar in general appearance are they that very close observation by the student is necessary to separate the species one from another. As a consequence but 15 have hitherto been described from the whole United States. Up to May, 1900, when the writer described three new species from Indiana* but three had been accredited to the States north of Florida and east of the Rocky Mountains. McNeill listed but one from Illinois. Bruner mentions three, two without names, from Nebraska, while Scudder, in his most recent paper on the group, accredits three, viz.: *N. fasciatus, N. cubensis* and *N. carolinus* to the central and eastern States.

Within the past ten years many specimens have been collected in different parts of Indiana. A careful study of these reveals the presence of at least eight species. There is little doubt but that the right kind of investigation will show the presence of as many or more in almost any State east of the Rocky Mountains. Those known to occur in Indiana may be separated by the following key:

KEY TO INDIANA SPECIES OF NEMOBIUS.

a. Ovipositor as long as or barely shorter than the hind femora; straight or nearly so.

- *b.* Ovipositor distinctly longer than hind femora; cross-veinlets of tegmina of female very prominent; black of body arranged in lengthwise bars.
  - *c.* Color blackish or fuscous; the dark stripes on occiput always visible, though sometimes indistinct in very dark specimens ....124 *fasciatus*, p. 421
  - *cc.* Color light reddish brown or grayish; without dark stripes on occiput ....125 *canus*, p. 423
- *bb.* Ovipositor no longer than hind femora; cross-veinlets of female tegmina not prominent; black of body scattered in blotches and dashes ....126 *maculatus*, p. 424

aa. Ovipositor distinctly shorter than hind femora; usually more or less arcuate.

- *d.* Tegmina of female nearly or quite as long as abdomen; wings generally twice as long as tegmina.......127 *cubensis*, p. 425
- *dd.* Tegmina of female shorter than abdomen, wings wanting.
  - *e.* Tegmina of males reaching tip of abdomen, their ground color yellowish brown.
    - *f.* Dorsal field of pronotum and all the legs a uniform brownish yellow; tegmina of males wider than abdomen ....128 *exiguus*, p. 426

*Psyche, IX, 1900, p. 51, *et seq.*

ff. Dorsal field of pronotum and all the legs more or less mottled with black; tegmina of males no wider than abdomen..........129 *carolinus*, p. 427

ee. Tegmina of males covering only two-thirds to three-fourths of abdomen, their color wholly black or very dark brown.

g. Length of body of female less than 6.5 mm.; last two joints of maxillary palpi of female dark brown; inner face of hind femora of male not barred with black............130 *palustris*, p. 427

gg. Length of body of female more than 7 mm.; last two joints of maxillary palpi of female white; inner face of hind femora of male barred with black.... 131 *confusus*, p. 428

124. NEMOBIUS FASCIATUS (DeGeer). The Striped Ground Cricket.

Gryllus fasciatus DeG., 57, III, 1773, 522, Plate 43, Fig. 5.

Nemobius fasciatus Scudd., 141, VII, 1862, 430; Id., 175, IV, 1896, 100, 102; Id., 176, VII, 1896, 432; Id., 188, 1900, 88; Glov., 62, 1872, Plate VI, Fig. 13; Sauss., 132, VI, 1874, 389; Id., 133, II, 1877, 242; Bl., 5, 1892, 136; Id., 16, 1899, 227, Fig. 56; Id., 17, IX, 1900, 51; Beut., 3, VI, 1894, 266, Plate V, Fig. 9; Lugg., 84, 1898, 261.

Acheta vittata Harr., 72, 1862, 152, Fig. 70; Rathv., 109, 1862, 380, Fig. 16.

Nemobius vittatus Scudd., 141, VII, 1862, 430; Id., 142, II, 1868, 115, 120 (song of to music); Id., 148, 1874, 364 (chirp set to music); Glov., 62, 1872, Plate III, Figs. 9, 10; Sauss., 132, VI, 1874, 389; Pack., 104, 1883, 564; Comst., 41, I, 1888, 121; Bl., 5, 1892, 135.

Nemobius fasciatus vittatus Beut., 3, VI, 1894, 267, Plate V, Fig. 10; Lugg., 84, 1898, 262, Fig. 170; Bl., 17, IX, 1900, 52.

Nemobius exiguus Scudd., 141, VII, 1862, 429.

Two forms of this, our largest and most common *Nemobius*, occur in Indiana. In one *(fasciatus)* the tegmina reach to the end of the abdomen while the inner wings extend to the tip of ovipositor. In the other *(vittatus)* the tegmina of the female cover a little more than half the abdomen and their cross-veinlets are coarser and much more prominent than in *N. maculatus*. Those of the male cover three-fourths of the abdomen. In this form the inner wings are wholly wanting in both sexes. As in most of the other species the head and thorax bear many coarse, stiff black hairs. The ovipositor is longer than in any other Indiana species, being about one-eighth longer than the hind femora.

The short winged form varies in color from a dusky brown to a rusty black. When of the latter hue the black stripes on the head, to which it owes its varietal name, are very dim or wholly invisible. The long winged form is always black.

Measurements: Length of body, male, 10 mm., female, 11 mm.; of pronotum, male and female, 3 mm.; of tegmina, male, 5.5 mm., female, 4 mm.; of wings, long-winged form, 13 mm.; of hind femora, male and female, 7.5 mm.; of ovipositor, 8.5 mm.

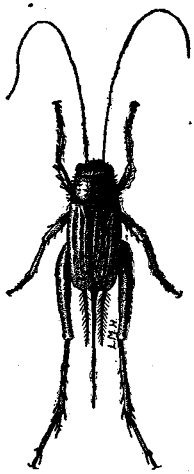


Fig. 107. *Nemobius fasciatus* (DeG.). Female. Short-winged form. (After Lugger.)

No intermediate short winged forms connecting *fasciatus* with *vittatus* have been seen by me, nor have any been recorded to my knowledge. The two are, however, regarded as dimorphic forms of the same species by the leading authorities, Saussure and Scudder.

During hundreds of days spent in field collecting not a single specimen of the long winged form was taken until August 1, 1902, when it was found in numbers on the stems of long grass in a marsh bordering Round Lake, Whitley County. Many, however, have been taken from the walks and streets of Indianapolis, Fort Wayne and other cities and towns in the northern part of the State, but none, as yet, in the southern half, not even in Terre Haute, where I resided for seven years. Where the insect breeds, and feeds by day is to me unknown. It appears to reach maturity about July 15th and, at times, as in the first week in August, 1899, swarms composed of myriads have appeared about the lights of some of the cities. The newspapers the next day had a column or more devoted to the insects but nothing, except wild guesses, as to whence they came.

The short winged form *vittatus* begins to reach maturity in central Indiana about July 15th. Living specimens have been seen as late as December 1st. Although present in vast numbers, but little is known of its life habits. When disturbed they are very difficult to capture, making enormous leaps with their stout hind legs, no sooner striking the ground than they are up again, even if not pursued, until they find a leaf or other shelter beneath which to take refuge.

They appear to be omnivorous, feeding upon carrion, cow dung and grasses with equal avidity. Though small in size, their enormous numbers as well as the fact that they are constant, greedy feeders from the time the eggs hatch in spring until laid low by the hoar frost of autumn, renders them particularly injurious. The aggregate damage which they cause to grass and kindred plants in the course of a single season must be great, and there is little doubt but that this, as well as the other species of the geuns, should be classed among those insects highly destructive to forage plants.*

Mr. S. H. Scudder has given the following pleasing account of the sounds made by this species: "The chirping of the striped cricket is very similar to that of the black field cricket; and may be expressed by *r-r-r-u*, pronounced as though it were a French word. The note is trilled forcibly, and lasts a variable length of time. One of these insects was once observed while singing to its mate. At first the song was mild and frequently broken; afterwards it grew impetuous, forcible and more prolonged; then it decreased in volume and extent until it became quite soft and feeble. At this point the male began to approach the female, uttering a series of twittering chirps; the female ran away, and the male, after a short chase, returned to his old haunt, singing with the same vigor but with more frequent pauses. At length, finding all persuasions unavailing, he brought his serenade to a close."

125. NEMOBIUS CANUS Scudder.

Nemobius canus Scudd., **175**, IV, 1896, 100, 103; Id., **176**, VII, 1896, 432; Id., **188**, 1900, 88.

Size, large; the head prominent, both it and the thorax sparingly beset with black bristles. Head reddish or yellowish brown in color; sparingly or not at all marked with fuscous and without trace of black bars on occiput. Eyes shorter, smaller and more globose than in *N. fasciatus*. Antennæ and palpi yellowish brown. Pronotum broader than long, the sides a little convex; yellowish brown in female, darker in male, the sides in latter with a fuscous bar on their posterior half. Tegmina of male covering three-fourths of abdomen, yellowish brown above, darker on basal third, the sides with a shining piceous bar along their upper third; those of female covering half or a little more of abdomen, the stripe on sides narrower and less shining than in male, sometimes with an additional one on dorsal field. Abdomen reddish brown with a median dark stripe on dorsal surface, and a similar one along each side. Hind femora short and very stout, a uniform reddish brown, sometimes darker in the male. Ovipositor distinctly longer than hind femora, straight or nearly so, the tip acute, the serrated portion short, the teeth sharp, not crowded.

---

*For other accounts of the destruction wrought by the species of Nemobius see Rathvon, U. S. Agricultural Report, 1862, p. 380, and Osborne's Bulletin, 23, U. S. Division Entomology, p. 59.

Measurements: Length of body, male, 8.5 mm., female, 12 mm.; of pronotum, male, 2.5 mm., female, 3 mm.; of tegmina, male, 6.5 mm., female, 5 mm.; of hind femora, male, 7.5 mm., female, 8.5 mm.; of ovipositor, 9.5 mm.

This is a southern species heretofore known only from Texas, which occurs sparingly throughout southern Indiana, being most abundant in the counties bordering the Ohio River. Our specimens differ from types from Texas in having smaller eyes, and in being yellowish brown rather than grayish in hue. Specimens were sent to Professor Morse for comparison with Scudder's type, and by him pronounced the same. In Crawford County the species frequents roadsides and high dry open fields and meadows. From the short winged form of *fasciatus* it may at once be separated by the lighter color, unstriped occiput, smaller, more globose eyes and shorter hind femora.

126. NEMOBIUS MACULATUS Blatchley. The Spotted Ground Cricket.
Nemobius maculatus Bl., 17, IX, 1900, 52.

Size, medium; head rather prominent, dark reddish brown, more or less dotted with pitch black, especially on forehead and cheeks; eyes rather large, prominent. Antennæ dull yellowish brown, the basal third lighter; maxillary palpi of the same color, the apical half of terminal joint darker. Pronotum broader than long, faintly tapering anteriorly; the dorsal field chestnut brown with numerous dark points; the front margin and lateral field sparingly beset with stiff black bristles. A black stripe starts back of the eye and covers the upper two-thirds of lateral field of both pronotum and tegmina. The latter with a yellowish vein separating the dorsal and lateral fields, more prominent in the male. The dorsal field brownish yellow, sometimes with blackish dots; in female covering one-third of abdomen, in male, two-thirds; wings absent. Legs and dorsal surface of abdomen brownish yellow sprinkled with fuscous, which on dorsal surface of hind femora is sometimes in crossbars. Ovipositor almost straight, equaling in length or very slightly shorter than hind femora; the apical blades rather long, tapering evenly to a fine point; above, evenly and sharply serrulate.

Measurements: Length of body, male, 7 mm., female, 8 mm.; of pronotum, 2.5 mm.; of tegmina, male, 4 mm., female, 2.8 mm.; of hind femora, male, 5.5 mm., female, 6.5 mm.; of ovipositor, 6.5 mm. Width of pronotum, 3 mm.

N. maculatus is readily distinguished from the short winged form of *N. fasciatus* by its average smaller size, shorter tegmina of female, shorter and straighter ovipositor, fewer hairs on head and pronotum and finer cross-veinlets of female tegmina. The serrulations of the ovipositor are sharper than in *fasciatus*. The two also differ in color, the ground of *maculatus* being lighter and the piceous more generally sprinkled where in *fasciātus* it is in lengthwise bars. *Maculatus* has, as yet, been taken in small numbers only in Marion and Vigo counties. It is found in low open woods, usually in the vicinity of or beneath logs.

127. Nemobius cubensis Saussure.

Nemobius cubensis Sauss., 132, VI, 1874, 384, Plate 7, Fig. 5; Scudd., 175, IV, 1896, 100, 105; Id., 176, VII, 1896, 432; Id., 188, 1900, 88; Bl., 17, IX, 1900, 54.

Nemobius volaticus Scudd., 160, XIX, 1877, 36; Id., 161, VI, 1878, 14.

Head rather full and convex, projecting above the surface of the pronotum, black, with bristly hairs; antennæ dark brown, the margins of its segments paler; palpi varying irregularly from pallid to dusky, the terminal joint nearly twice as long as the third, and about three times longer than the fourth. Pronotum black, broader than long, slightly broader behind than in front, the anterior half or more with a distinct median furrow, the whole surface with scattered black bristles. Tegmina narrow, nearly as long as the abdomen, pitch black in color; wings very long, the tip of the closed tegmina lying midway between the tip of the wings and the front of the head. Legs brownish yellow, more or less infuscated, especially above, the hind femora rather slender, the tibial spines slightly paler at tip. Cerci slender, dusky, about as long as the hind tibiæ; ovipositor very much as in *N. carolinus;* dark brown, similarly armed at tip.

Measurements: Length of body, male, 6.5 mm., female, 6.75 mm.; of antennæ, male, 13 mm., female, 14 mm.; of tegmina, male, 4 mm., female, 4.4 mm.; of hind femora, male, 5 mm.; of hind tibiæ, male, 3.75 mm., female, 3 mm.; of ovipositor, 3 mm.

I have not seen the females from Indiana and the above description is therefore copied in part from Scudder. Two males distinct from any others found in the State were taken October 9, 1893, from the sandy bed of the old canal north of Terre Haute, Indiana. They were sent to Mr. Scudder, who pronounced them the short winged form of *N. cubensis.* In life they were shining black with a bright yellow line separating the dorsal and lateral fields of the tegmina. The general range of *cubensis* is southward; it having been recorded from a number of the Gulf States as well as Cuba and Brazil, South America. Scudder records two females as having been taken in Illinois.

128. NEMOBIUS EXIGUUS Blatchley.
Nemobius exiguus Bl., 5, 1892, 136; Id., 17, IX, 1900, 53.

Size, medium; body, slender; head rather large, but slightly tumid. Eyes small but prominent. Antennæ, head, pronotum and femora brownish yellow. Maxillary palpi light yellow throughout or with the apical third of terminal joint infuscated. Tegmina of male reaching tip of abdomen; the dorsal field expanded so that they extend beyond the sides of abdomen; brownish yellow in color with a narrow piceous bar on upper third of lateral field and with basal third of dorsal field often more or less pitch black. Tegmina of female covering one-half or more of abdomen, the dorsal field usually heavily shaded with blackish; wings absent in both sexes. Upper surface of abdomen blackish, lower surface brownish yellow or luteous. Ovipositor a third or more shorter than hind femora, distinctly arcuate, the apical blade not enlarged at the base, armed above with very small and rather dull teeth, which are irregularly distant one from another.

Measurements: Length of body, male, 7 mm., of female, 7.5 mm.; of tegmina, male, 5 mm., of female, 4 mm.; of hind femora, male, 5.2 mm., of female, 6.3 mm.; of ovipositor, 3.5 mm.

This is the "*N. exiguus* Scudder" of my paper on the "Gryllidæ of Indiana," *loc. cit.* It appears, however, that Scudder had not described a species as *exiguus* but had merely mentioned a form of *N. fasciatus* under the name. Beutenmuller afterwards* described *N. affinis* from New York, which he stated was the insect mentioned by me, but which, according to Scudder,† is *N. carolinus*.

Exiguus is longer and proportionally more slender than the next species, *N. carolinus* Scudd., though the tegmina of the male are broader. The pronotum and femora are not mottled or marked with fuscous as in that species. The serrations of the ovipositor of *carolinus* are smaller, sharper and more evenly separated than in *exiguus*. The latter species occurs in all parts of the State and is fully one-half as common as the short winged form of *N. fasciatus*. Its habits, time of appearance and local habitat are also essentially the same. However, the smaller size, short ovipositor, yellowish maxillary palpi, and other differences in color, readily distinguish it from that insect.

* Bulletin American Museum Natural History, VI, 1894, pp. 250, 267, Plate V, Fig, 11.
† Journal New York Entomological Society, IV, 1896, 107.

129. NEMOBIUS CAROLINUS Scudder.

Nemobius carolinus Scudd., 160, XIX, 1877, 36; Id., 161, VI, 1878, 14; Id., 175, IV, 1896, 100, 107; Id., 176, VII, 1896, 433; Id., 188, 1900, 88; Bl., 17, IX, 1900, 53.
Cyrtoxiphus variegatus Brun., 29, III, 1893, 32.
Nemobius affinis Beut., 2, VI, 1894, 249; Id., 3, 267, Plate V, Fig. 11.

Head and antennæ varying from dull yellow to dusky brown, furnished with rather long, curving, distant, black, bristly hairs. Pronotum of the color of the head, but more or less mottled with blackish, a little broader than long, supplied with long bristly black hairs, its anterior two-thirds with a distinctly impressed median line. Tegmina brownish yellow, the upper third of lateral field with a blackish bar; the dorsal field often with black fleckings; the mottled appearance sometimes due, however, to the black of dorsal surface of abdomen shining through them; those of the male rather ample and reaching the tip of the abdomen, those of the female covering but half of the abdomen; wings wanting. All the legs dull brownish yellow, more or less mottled with blackish; the tibial spines pale near the tip. Dorsal surface of abdomen of female with its basal two-thirds black; the last two or three segments brownish yellow with a sprinkling of small black spots. Cerci brownish, very slender, as long as the abdomen; ovipositor dark brown, a little upcurved, moderately stout, shorter than the hind tibiæ, the apical denticular field longer than usual and nearly equaling one-fourth the entire length of the ovipositor.

Measurements: Length of body, male, 7 mm., female, 8.5 mm.; of tegmina, male, 4.2 mm., female, 3.5 mm.; of hind femora, male, 5.3 mm., female, 6.2 mm.; of ovipositor, 3.8 mm.

This prettily marked little species has been found to be rather common on the grass covered banks of streams and along the fence rows of open woods in Vigo, Putnam and Monroe counties, and it probably occurs in like situations throughout the State. In general appearance it is a diminutive form of *N. maculatus* above described, but its small size and short arcuate ovipositor at once distinguish it. According to Scudder, *carolinus* ranges from New England to Nebraska and Texas.

130. NEMOBIUS PALUSTRIS Blatchley. The Marsh Ground Cricket.

Nemobius palustris Bl., 17, IX, 1900, 53.

Size, small; the body of male especially short and broad. Head tumid; eyes large, but not prominent. Pronotum one-third broader than long, the sides sub-equal, rather thickly beset with stiff black bristles, as are also the forehead and dorsal surface of the two front femora. Head, tegmina and body of most specimens a uniform dark piceous; disk of pronotum piceous or fuscous sprinkled with piceous. Antennæ, legs and ovipositor fuscous. Maxillary palpi yellowish except the apical joint which is wholly piceous. Tegmina of female covering a little more than half the abdomen; those of the male hardly reaching its tip. Ovipositor almost a third shorter than hind femora, distinctly though feebly arcuate, the apical blades but little enlarged at the base, very finely serrulate with dull, rasp-like teeth.

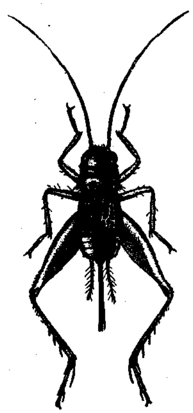


Fig. 108. *Nemobius palustris* Bl. Female. Three times natural size. (Original.)

Measurements: Length of body, male, 5.8 mm., female, 6.2 mm.; tegmina, male, 4 mm., of female, 3 mm.; of hind femora, male 4.5 mm., of female, 5 mm.; of ovipositor, 3.5 mm.

This handsome little pitch brown Nemobid has been found only among the tamarack swamps and cranberry bogs of the northern part of the State, where it finds a congenial home in the midst of the dense, damp sphagnum mosses. Sometimes they are so plentiful that a half dozen or more are seen in an area a foot square. Like the other members of the genus they are very active, when disturbed leaping vigorously, a few inches at a time, and finally seeking safety by burrowing in the masses of mosses. It has been taken in Marshall, Fulton and Starke counties and probably occurs wherever peat bogs and sphagnum mosses are present.

131. NEMOBIUS CONFUSUS sp. nov.

Body broad and rather stout; the head but little prominent; the face and antennæ fuscous in color; the vertex, disk of pronotum and two front pairs of femora with scattered, black, stiff hairs. Last two joints of maxillary palpi of the female white, very noticeable in living specimens; the same segments in the males whitish to fuscous, the apical half of terminal joint darker. Pronotum broader than long, with a median impressed line on its front half, more prominent in the female; the disk usually a dark smoky brown in color except along the front half of each lateral carina, where there are some light brown spots; the sides darker. Tegmina of female covering half, those of male, three-fourths of abdomen, piceous throughout except the carina separating the dorsal from the lateral field, which is fuscous or smoky brown. Dorsal surface of abdomen black, with often a few small dots of yellowish brown on the last three segments.

All the femora of female and the fore and middle pair of male fuscous, sometimes with a few lighter dots on their upper surface; the hind femora of male blackish on outer face, the dark color passing over the upper side and half way down the inner face where it is broken, thus forming bars or blotches plainly visible on the lighter color. The tibiæ usually reddish brown, more or less mottled with fuscous. The basal joint of front tarsus whitish in the female. Ovipositor but little more than half as long as the hind femora, dark brown in color, its apical third wider and a little upturned; the armed portion longer than in any other Indiana species; the teeth fine, sharp, and more than usually distant one from another.

Measurements: Length of body, male, 7.2 mm., female, 7.5 mm.; of tegmina, male, 4 mm., female, 3 mm.; of hind femora, male and female, 6 mm.; of ovipositor, 3.3 mm.

This is a larger and broader insect than *N. palustris.* The main differences between the two species are set out in the key. The armed portion of the ovipositor is wider and longer and the teeth more distant and sharper in *confusus* than in *palustris.*

N. confusus has been taken in Kosciusko and Posey counties. In the former it was found on August 26, 1902, to be quite common in some low, damp woods bordering Tippecanoe Lake. Here it had its home among the fallen leaves and beneath small chunks and chips. From Posey County a single specimen was secured also from a tract of low woods.

It seems that the different species of this genus noted above have each a special abiding place. *Fasciatus* and *exiguus* are the only ones which may be looked for anywhere in open fields and along roadways. *Maculatus* occurs in open woods in dry situations; *cubensis* in sandy districts; *carolinus* along the banks of streams and on gravelly hillsides; *palustris* nowhere except among the sphagnum mosses of dense swamps and bogs, while *confusus* likes best the shadows of dense woods which are low and moist. Each species has, therefore, its special habitat where the food on which it thrives is most abundant, and where, during the ages past, it has become so modified in organ and hue as to receive from man a distinctive specific name.

LVI. Gryllus Linnæus (1758).

To this genus belong those dark colored thick-bodied insects known as house and field crickets. The latter are the best known examples of the family Gryllidæ and are abundant from June 1st till after heavy frosts, beneath logs, boards, stones, and especially beneath rails in the corners of the old-fashioned and rapidly disappearing Virginia rail fences.

All members of the genus Gryllus have the head large and globose; the eyes large and rounded; the antennæ thread-like and longer than the body; the pronotum broader than long and about the width of the head; the hind femora of medium length but much enlarged and well-fitted for leaping; the hind tibiæ with two rows of strong fixed spines, those nearest the apex being the longer; and the hind tarsi with its first joint sulcate above with a row of minute teeth along each carina. The ovipositor is, in all the species, as long as or longer than the hind femora, and in the same species varies but little in length. Most of the species are, however, dimorphic as regards wing length, though among our Indiana species the short winged forms greatly outnumber the long winged ones. The inner wings vary much more than the outer and sometimes are wholly lacking.

Regarding the general habits of the field crickets Prof. Lawrence Bruner has written: "Usually most of our North American Grylli live singly or in pairs in burrows which they dig for themselves. These are used as retreats during the day time and serve as shelter from ordinary inclemencies of weather. These burrows are generally forsaken about midsummer for some sort of above-ground shelter. From this time on, until fall, they appear to be more social and live in colonies under various sorts of rubbish. Grain shocks are a favorite haunt for them, and since twine has been used for binding, the crickets have been quite troublesome by cutting the bands. During late summer and fall the females commence preparations for the continuance of their kind, by thrusting their long, slender ovipositors into the loose soil and dropping their eggs. These sometimes hatch the same year, but, as a rule, lie over until the following spring. The young generally live above ground, where they hide among fallen leaves, grasses and other debris, though sometimes they also creep into chinks and crevices in the earth."

The remarks of Mr. Bruner apply mostly to *G. abbreviatus,* one of our largest and only social species. The young of *G. pennsylvanicus* and *G. americanus* are, for the most part, hatched in autumn and survive the winter in the nymph stages, while *G. domesticus,* the house cricket, passes the winter either as adult or nymph.

The synonymy of the American species of this genus has become greatly confused, due largely to the fact that foreign writers have attempted to monograph the genus with but a limited number of specimens at hand; and again to the fact that the species, especially the males, are very difficult to separate.

Mr. Scudder, in two recent papers,* has in part straightened out this difficulty. However, he, as well as the European writers, has written mainly of specimens collected by others, and has not studied the insects in the field. For this reason Mr. Scudder has stated that but three species occur in the northern and central United States, east of the Mississippi River. A long series of observations in the field, coupled with a careful examination of a large number of individuals, has convinced me that at least six species occur in Indiana.† Of these, two are believed to be undescribed. The following key, based largely on the females, may be used in their separation:

KEY TO INDIANA SPECIES OF GRYLLUS.

a. Black species, the tegmina and parts of the body sometimes dull reddish brown; first joint of antennæ not projecting beyond front of head. (Field crickets.)

- *b.* Very large species, about 25 mm. long; the hind margin of pronotum convex; hind tibiæ with seven to eight spines on each side ....132 *firmus*, p. 432
- *bb.* Medium or small-sized species, the body seldom exceeding 20 mm. in length; hind margin of pronotum truncate; hind tibiæ with five to six spines on each side.
  - *c.* Ovipositor but little, if any, longer than hind femora, never more than 12 mm. in length; tegmina of female with only their basal halves overlapping or attingent, the apical halves spread apart so as to leave a wide V-shaped notch between them......133 *americanus*, p. 433
  - *cc.* Ovipositor plainly longer than the hind femora, always 13 or more mm. in length; tegmina of female with their inner edges either overlapping or attingent their full length.
    - *d.* Body slender; the pronotum never more than 5 mm. in width; the tegmina, cerci, ovipositor and legs reddish brown in color.......134 *arenaceus*, p. 434
    - *dd.* Heavy bodied species; the pronotum always more than 6 mm. in width; the tegmina, cerci, ovipositor and tibiæ black; the hind femora often with the basal half of the under side reddish brown.
      - *e.* Ovipositor nearly or fully half as long again as hind femora, always exceeding 18 mm. in length; the male stout, with large and broad head ....135 *abbreviatus*, p. 435

*"The Species of Gryllus on the Pacific Coast,"—Psyche, IX, 1901, 267, *et seq.*, and "The Species of Gryllus found in the United States East of the Sierra Nevadas,"—Psyche, IX, 1902, 291, *et seq.*

†Including *G. firmus* Scudder, of which, however, I have seen no specimen from this State.

ee. Ovipositor seldom, if ever, more than 14 mm. or less than 13 mm. in length, rarely more than one-fourth as long again as hind femora; the male more slender, with narrower and less swollen head ......136 *pennsylvanicus*, p. 437

aa. Straw-colored species, with some dark brown or blackish markings on head and thorax; first joint of antennæ projecting slightly beyond front of head. (House crickets)........137 *domesticus*, p. 439

132. GRYLLUS FIRMUS Scudder.
Gryllus firmus Scudd., 194, IX, 1902, 295.

Large and stout, with piceous body. Head large, tumid, with prominent vertex, scarcely broader than the pronotum, wholly black. Pronotum stout, black, most delicately margined anteriorly with reddish brown, broadest in advance of the middle, the sides being slightly and not quite uniformly convex, half as broad again as long, the front margin with scarcely perceptible concavity, the hind margin slightly but distinctly and broadly convex, with a median impressed line scarcely or not visible on posterior third, the lower margin of the lateral lobes oblique and nearly straight. Tegmina nearly or quite covering the abdomen, testaceous, more or less infuscated, often in the female with a clear testaceous humeral stripe, the mediastinal vein with three or four branches; wings generally no longer than the body, but sometimes caudate in the female. Legs reddish or yellowish brown, often more or less infuscated, the hind femora stout, the hind tibiæ with generally six or seven rather long spines on the outer side, the upper inner calcar very long and almost as long as the intermediate calcar. Ovipositor fully a third longer than the hind femora.

Measurements: Length of body, male, 27 mm., female, 26 mm.; of pronotum, male, 5 mm., female, 5.5 mm.; breadth of pronotum, male and female, 7.5 mm.; length of tegmina, male and female, 14.5 mm.; of hind femora, male, 16 mm., female, 16.75 mm.; of ovipositor, 23.5 mm.

This is a species of southern range, specimens in Scudder's collection having come from North Carolina, Georgia, Florida and Texas. He also records one specimen from Brookville, Franklin County, Indiana, collected a number of years ago by Dr. Rufus Haymond. I have seen no specimens from this State, but have one from Agricultural College, Mississippi, collected in December by Mr. H. E. Weed. Nothing distinctive of its habits has been noted. It should be looked for throughout the southern third of the State.

133. Gryllus americanus sp. nov.
Gryllus neglectus, Bl., 12, VII, 1895, 250. (Nec. Scudd.).

A shining black species, the female short-bodied and thick set, the male more slender. Head no broader than the pronotum, the vertex prominent; but sloping rapidly downward. Pronotum a little narrower in front than behind, its length contained in its greatest breadth 1.3 times; the median impressed line more than usually prominent, except upon its posterior fourth; the front margin truncate or a very little concave, the hind margin slightly sinuate and ciliate with black hairs. Tegmina of female covering two-thirds of abdomen, shining black, sometimes with a reddish brown tinge at base and along the humeral angle; their inner margins straight and overlapping or attingent only on their basal halves; the apical halves with the inner margin oblique or "bias" and when at rest therefore widely separated. Tegmina of male usually covering three-fourths of abdomen, rarely reaching its tip, the mediastinal vein with four branches. Wings represented by narrow thin scales. Hind femora short and stout, their lower and inner sides sometimes tinged with reddish brown on the basal third but never with the large reddish brown spot on lower side, so common in *G. abbreviatus* and *G. pennsylvanicus*. Hind tibiæ dark chestnut brown, with five or six rather stout spines on the outer side. Ovipositor short, just equaling, or rarely exceeding by 1 mm. the length of hind femora, dark reddish brown in color, the apex paler.

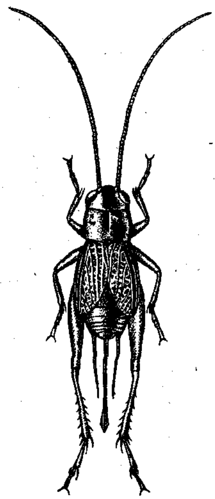


Fig. 109. *Gryllus americanus* sp. nov. Female. One and one-fourth times natural size. (Original.)

Measurements: Length of body, male, 14 mm., female, 16.5 mm.; of pronotum, male, 3.5 mm., female, 4.2 mm.; of tegmina, male, 7.5 mm., female, 8 mm.; of hind femora, male, 10 mm., female, 11 mm.; of ovipositor, 11 mm. Width of pronotum, male, 5 mm., female, 5.6 mm.

This is the species which I formerly thought to be *G. neglectus* Scudder, but that authority states in his latest paper on the genus that *neglectus* is a synonym of *pennsylvanicus*. Moreover, I find that in his original description the average measurements of the ovipositor of *neglectus* are given as .28 of an inch, or 7 mm., whereas in *americanus* they are never less than 10 or more than 12 mm. in length. From *pennsylvanicus*, with which species it has been heretofore confused, *americanus* may be readily separated by its smaller size, narrower pronotum, more uniform shining black color, shorter ovipositor, and the shape, and position when at rest, of the female tegmina. The reticulation of the dorsal field of these tegmina is more noticeable in *americanus* than in *pennsylvanicus*, the main diagonal nerves being closer together and the cross-nervules more elevated and prominent. *Americanus* reaches maturity in the spring about a fortnight the sooner.

Americanus has been taken in Crawford, Posey, Vigo, Putnam, Marion, Marshall, Wells and Lake counties, and probably occurs throughout the State. It is here the first species of Gryllus to become mature in the spring, the note of the male—the first Orthopteran song of the season—having been heard on a number of occasions in the central counties as early as May 5th. The young of this species, as well as of *G. pennsylvanicus*, survive the winter as nymphs. In September and October, after passing the second or third moult, they seek the shelter of loose bark on log or stump, or crawl beneath chunk or rail where they form for themselves small, inverted cone-shaped burrows in the earth, in which they abide until spring. Those which attempt to pass the winter with only a shelter of bark above them almost always succumb to the changing temperatures of that season, but those which choose more wisely a burrowing place beneath some half buried log or chunk for the most part survive. The temperature of their hibernaculum is much more equable, and the insects becoming sluggish in late autumn remain so until called into new activity by the sunshine of spring, unless, meanwhile, they fall a prey to some shrew mouse or other active winter insectivorous mammal. They emerge from their hiding places about April 1st, and after changing their garb two or three times, reach the mating stage in early May, when the males begin to greet the passer-by with their merry chirp.

Neither this species nor *pennsylvanicus* are social crickets. Sometimes two or three of the young have adjacent burrows beneath the same chunk, but more often both they and the adults are solitary. The eggs are laid in June and July, and the newly hatched young are to be found in numbers during July and August.

134. Gryllus arenaceus sp. nov. The Sand-Loving Cricket.

Body very slender, of medium length. Head, black, but little, if any, wider than pronotum, the vertex prominent; the cheeks and palpi reddish brown. Pronotum black; its length contained in its width 1.43 times, the fore and hind margins truncate, very narrowly edged with reddish brown; the median impressed line visible only on anterior half. Tegmina reddish brown, lighter along the humeral angle, covering a little more than half the abdomen in the female, three-fourths or more of abdomen in the male. Wings present but very narrow and shorter than the tegmina; abdomen shining black. All the legs reddish brown throughout, except the hind femora which sometimes have the apical half of outer and inner faces blackish. These femora are short and rather slender. Hind tibiæ with six or seven rather long spines on their outer carina. Ovipositor nearly one and a half times longer than hind femora, the average ratio being 1.43:1, dark reddish brown in color.

Measurements: Length of body, male and female, 15 mm.; of pronotum, male, 3.2 mm., female, 3.5 mm.; of tegmina, male, 9 mm., female, 7 mm.; of hind femora, male, 10 mm., female, 11.5 mm.; of ovipositor, 16.5 mm. Width of pronotum, male, 4.7 mm., female, 5 mm.

This species has been taken only in the sand dune region of Lake County, Indiana, where it is rather plentiful in September and October beneath logs and chunks in bare sandy places. It is more slender bodied than any of our species except the house cricket, *G. domesticus*, which it resembles in form. The reddish brown color of tegmina, legs and cerci, contrasts strongly with the deep black of pronotum and abdomen. It will probably be found in sandy localities in the northern half of the State, especially in those counties bordering Lake Michigan.

135. GRYLLUS ABBREVIATUS Serville. The Common Field Cricket.

Gryllus abbreviatus Serv., **196**, 1839, 336; Scudd., **141**, VII, 1862, 427; Id., **188**, 1900, 89; Id., **194**, IX, 1902, 291; Glov., **62**, 1872, Plate VII, Fig. 17; Sauss., **132**, VI, 1874, 400, 518; Id., **133**, II, 1877, 317; Pack., **104**, 1883, 564; Riley, **122**, II, 1884, 181; Fern., **53**, 1888, 15; McNeill, **88**, VI, 1891, 5; Bl., **5**, 1892, 132 (in part); Id., **12**, VII, 1895, 250; Id., **16**, 1899, 226, Fig. 55; Beut., **3**, VI, 1894, 265; Lugg., **84**, 1898, 264, Fig. 172.

Acheta abbreviata Harr., **72**, 1862, 152, Fig. 69; Rathv., **109**, 1862, 380, Fig. 15.

Gryllus luctuosus Serv., **196**, 1839, 335; Scudd., **141**, VII, 1862, 427; Id., **148**, 1874, 363: Id., **188**, 1900, 89; Thomas, **205**, 1872, 433, Plate I, Figs. 10, 11; Glov., **62**, 1872, Plate IX, Fig. 10; Sauss., **132**, VI, 1874, 396; Id., **133**, II, 1877, 317; Pack, **104**, 1883, 564; Fern., **53**, 1888, 15; Comst., **41**, 1888, 121.

Gryllus angustus Scudd., **141**, VII, 1862, 427.

Body large and especially wide. Head of male shining black, much swollen, and broader than pronotum; of female less prominent. Pronotum black, broad, its length contained in its width nearly 1.5 times, the median impressed line rather faint; the hind margin truncate or very slightly convex. Tegmina usually a very dark reddish brown or black; sometimes dull yellowish brown, covering three-fourths or more of abdomen in female and all of abdomen in male. Wings much shorter than tegmina in the common form *(abbreviatus)* or nearly as long again in the long winged form *(luctuosus)*. Hind femora very stout, black or dark reddish brown, the basal third of the under and inner sides almost always brick red. Ovipositor very long, equaling or exceeding the body in length, and nearly or fully half as long again as the hind femora.

Measurements: Length of body, male, 18-20 mm., female, 18-22 mm.; of pronotum, male and female, 4.75 mm.; of tegmina, male and female, 12 mm.; of hind femora, male, 13 mm., female, 13.5 mm.; of ovipositor, 18-21 mm. Width of tegmina, male and female, 7 mm.

This is, in late summer and early autumn, the most common field cricket occurring in Indiana. In a former paper I stated that the young lived over winter, but more careful observation has proven that the young found in winter are those of *americanus* and *pennsylvanicus*. Professor McNeill, *loc. cit.*, has given an excellent account of the life history of this species as follows: "The eggs of *abbreviatus* hatch in this latitude (northern Illinois) in July, and the first adults appear as early as the second week in August. During every stage of life they are social, feeding together, seeking shelter in company and when egg laying time comes, in October, the females collect by hundreds in some suitable locality, an abandoned or little used roadway suits them well, and each lays several hundred eggs in an irregular mass. After this duty is performed their business on this planet seems to be finished and they succumb to the cold, none surviving the winter. The eggs do not hatch until the following July, or if in rare cases they do they probably perish with cold."

In southern Indiana the eggs hatch in late May or early June and the mature males appear about July 1st, but in the central and northern parts of the State the first males appear about a month later.

Gryllus abbreviatus is, in habits, nocturnal, omnivorous, and a cannibal. Avoiding the light of day, it ventures forth, as soon as darkness has fallen, in search of food, and all appears to be fish which comes to its net. Of fruit, vegetables, grass and carrion, it seems equally fond and does not hesitate to prey upon a weaker brother when opportunity offers. I have often surprised them feasting on the bodies of their companions, and of about 40 imprisoned together in a box, at the end of a week but six were living. The heads, wings and legs of their dead companions were all that remained to show that the weaker had succumbed to the stronger—that the fittest, and in this case the fattest, had survived in the deadly struggle for existence.

The long winged form of *abbreviatus* is seemingly very scarce in this State, but one or two having been taken. There is little doubt but that Scudder is right in referring this form to Serville's *luctuosus* and placing it as a synonym of *abbreviatus*, as Serville states that the ovipositor of *luctuosus* is 9 to 10 lines in length, which is too great for *pennsylvanicus* of which McNeill thought *luctuosus* might be the long winged form. According to strict rules of nomenclature the name *luctuosus* rather than *abbreviatus* should belong to the insect since the former was described first in Serville's work. However, the short winged form seems to be everywhere the more common and better known, hence I follow Scudder in retaining the name *abbreviatus*. The range of the species covers the United States east of the Rocky Mountains.

136. GRYLLUS PENNSYLVANICUS Burmeister. The Pennsylvania Field Cricket.

Gryllus pennsylvanicus Burm , 40, II, 1838, 734; Scudd., 141, VII, 1862, 429; Id., 188, 1900, 90; Id., 193, IX, 1901, 268, 269; Id., 194, IX, 1902, 291; Glov., 62, 1872, Plate I, Figs. 13, 14; Sauss., 132, VI, 1874, 401; McNeill, 88, VI, 1891, 4, 6; Bl., 12, VII, 1895, 250; Beut., 3, VI, 1894, 265, Plate V, Figs. 6, 7; Lugg., 84, 1898, 264, Fig. 173.

Gryllus luctuosus McNeill, 88, VI, 1891, 4; Bl., 5, 1892, 133.

Acheta niger Harr., 72, 1862, 152.

Gryllus neglectus Scudd., 141, VII, 1862, 428; Id., 188, 1900, 89.

A medium sized but rather broad species; the head of male not so swollen as in abbreviatus, a little wider than the pronotum, shining black in color. Pronotum proportionally a little wider and shorter than in *abbreviatus*, the length contained in the breadth nearly 1.6 times; the hind margin a little sinuate, the median impressed line plainly visible on anterior half. The tegmina vary in color from a deep black to a smoky or grayish brown, rarely a dull reddish brown, often with a yellowish brown line along the humeral angle; the inner edges straight and overlapping or attingent their full length; those of female reaching nearly to tip of abdomen in short winged form, or slightly exceeding the tip in the long winged form; those of male reaching the tip of abdomen in both forms. Wings either narrow and shorter than tegmina or extending considerably beyond tegmina in the form of tail-like projections. Pronotum, legs, and under side of body in freshly matured specimens often with a minute grayish pubescence which becomes abraded with age, leaving these parts shining black. Hind femora short and stout, its average length contained in that of ovipositor 1.1 times. Ovipositor always shorter than the body, its average length being 13.5 mm.

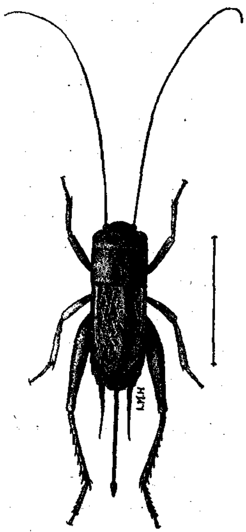


Fig. 110. *Gryllus pennsylvanicus* (Burm.) Short-winged female. (After Lugger.)

Measurements: Length of body, male, 17.5 mm., female, 17.1 mm.; of pronotum, male, 3.9 mm., female, 4.2 mm.; of tegmina, male, 11.5 mm., female, short winged form, 10 mm., long winged form, 12.4 mm.; of hind femora, male, 12.2 mm., female, 12.4 mm.; of ovipositor, 13.5 mm.; width of pronotum, male and female, 6.3 mm.

From *abbreviatus* this species may be distinguished by the shorter body, the less swollen head of male and especially by the short ovipositor, which in Indiana specimens ranges between 13 and 14 mm. in length. The main distinguishing characters between *pennsylvanicus* and *americanus* have been set out under the latter species. Another, very noticeable in the field in the spring, is the dull grayish tinge of *pennsylvanicus*, especially on the legs and pronotum, the whole body of *americanus* being shining black.

The description of *pennsylvanicus* by Burmeister is as follows: "Eine ahnliche Art *(Gr. pennsylvanicus)* findet sich in Nord-amerika; sie ist etwas kleiner, die Flugeldecken kurzer als der Leib, ohne gelbe Basis, aber mit braunlicher Hauptlangsader." This description is so short and vague that it is impossible to ascertain from it just what species he had at hand. Neither Saussure nor Scudder seem to have seen Burmeister's type. If so, they have made no record of the fact. Saussure in his latest paper, followed by McNeill, has asserted his belief that *pennsylvanicus* is a short winged form of *luctuosus.* However, the measurements of body and ovipositor of *luctuosus* as given by Serville agree so closely with those of *abbreviatus* that there can be no doubt of the two being the same. The existence of the long winged forms of both *abbreviatus* and the species I call *pennsylvanicus* has done much to add to the confusion. I have therefore followed Scudder, Beutenmüller and others in applying the name *pennsylvanicus* to the form at hand, though I have no definite means of knowing that it is the same insect as that to which Burmeister gave the name. Certain it is, however, that it is distinct from both *americanus* and *abbreviatus* described above.

In Indiana *pennsylvanicus,* for the most part, survives the winter in the nymph stage, the young, on the approach of cold weather, making for themselves cone-shaped cavities an inch or two across the top and about as deep, in the mold beneath decaying logs and rubbish. Sometimes the margins of these burrows are surrounded by fragments of grass stems and pieces of decaying leaves. In warm, sheltered localities, some individuals evidently reach maturity in late autumn or early winter; a full grown, freshly moulted female having been taken in a greenhouse in Marion County, on December 14th. The males begin to pass their final moult in central Indiana about May 15th, and from then on through June and July the open woods pastures and the angles of old rail fences echo with the music of their song. The young hatch in July and August, and after the second or third moult form their winter abiding places, while the adults perish with the coming of the hoar frost.

Pennsylvanicus occurs throughout the State and is said by Scudder to range across the continent. The long winged form is much less common than the short winged and is seldom met with in the field; but may often be found about electric and other lights during the summer nights. However, on two occasions in June, I have taken a long winged male in company with two short winged females beneath logs.

137. Gryllus domesticus Linnæus. The House Cricket.

Gryllus (Acheta) domesticus L., 81, I, 1758, 428.
Gryllus domesticus Glov., 62, 1872, Plate VI, Fig. 14; Sauss., 132, VI, 1874, 400; Riley, 122, II, 1884, 181; Beut., 3, VI, 1894, 266, Plate V, Fig. 8; Marlatt, 85, 1896, 52, Fig. 20; Lugg., 84, 1898, 266, Fig. 176; Scudd., 188, 1900, 89; Id., 194, IX, 1902, 291, 294.

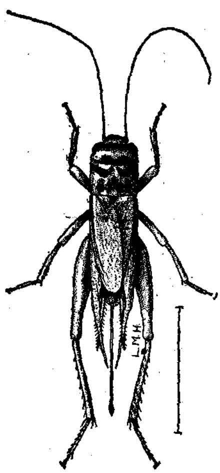


Fig. 111. *Gryllus domesticus* L. Female. (After Lugger.)

Pale yellowish brown or straw color; the head with a dark reddish brown bar on occiput just in front of pronotum; another between the upper portions of eyes; a third between the bases of the antennæ and a fourth across the labrum, the lower two sometimes united. Pronotum with four or five irregular shaped spots of reddish brown on its dorsal surface, and a narrow bar of the same color on each side; the posterior margin a little convex. Tegmina reaching nearly or quite to the end of abdomen; sometimes with a reddish brown spot on their basal third. Inner wings either short and covered by, or extending considerably beyond, the tegmina. Hind femora short and rather slender. Ovipositor one-fifth longer than hind femora, pale brown except the tip, which is darker.

Measurements: Length of body, male, 16.5 mm., female, 15 mm.; of pronotum, male and female, 3.5 mm.; of tegmina, male and female, 11 mm.; of hind femora, male and female, 10 mm.; of ovipositor, 12 mm. Width of pronotum, 4.5 mm.

The "house cricket," or "cricket of the hearth," is scarce in Indiana. Until January 1, 1903, I had in my collection but three specimens, two long winged males and a short winged female, taken by H. McIlroy from beneath rubbish in a gravel pit near West Terre Haute, Vigo County, in October, 1894. On the date mentioned I secured a dozen or more adults and nymphs in a greenhouse belonging to W. J. Hasselman, situated just north of the city of Indianapolis. The proprietor informs me that the males utter their call note throughout the winter, and that the insect is seemingly most abundant at that season. It is an Old World insect which has been introduced into this country, and occurs sparingly in most of the States east of the Rocky Mountains. Scudder states that he has seen no short winged specimens from the United States though they are common in Europe. The insect is probably less abundant in Indiana than it was a half century ago, when log houses and old fashioned brick and stone fireplaces were most in vogue. *Domesticus* has also been noted in Putnam County by J. S. Michaels. It is probable that in many instances the so-called "house crickets" of the present country homes are field crickets, especially *G. abbreviatus*, which have striven to prolong their existence by seeking shelter within the domiciles of man.

Marlatt, *loc. cit.*, has given the following pleasing account of the habits of this house cricket: "In Europe, and in some parts of the United States, no insect inhabitants of dwellings are better known than these domestic or house crickets, not so much from observation of the insects themselves as from familiarity with their vibrant, shrilling song notes. These notes, while thoroughly inharmonious in themselves, are, partly from the difficulty in locating the songster, often given a superstitious significance and taken, according to the mood of the listener, to be either a harbinger of good and indicative of cheerfulness and plenty, or to give rise to melancholy and to betoken misfortune. The former idea prevails, however, and Cowper expresses the common belief that the—

> " 'Sounds inharmonious in themselves and harsh,
> Yet heard in scenes where peace forever reigns,
> And only there, please highly for their sake.'

"The house cricket usually occurs on the ground floor of dwellings and evinces its liking for warmth by often occurring in the vicinity of fireplaces, concealing itself between the bricks of chimneys or behind baseboards, frequently burrowing into the mortar of walls. It is particularly apt to abound in bakehouses. It is rarely very abundant but at times multiplies excessively and becomes a very serious nuisance. During cold weather or in cold rooms in winter, it remains torpid, but under the influence of warmth it becomes active and musical. It is easily kept in captivity as a pet, and will reward the possessor by furnishing an abundance of its peculiar melody, and in Spain it is often kept, it is reported, in cages, as we do singing birds. It is in the main nocturnal in its habits, coming out in the dusk of the evening and roaming about the house for whatever food materials it may discover. It feeds readily on bread crumbs or almost any food product to which it can get access, and is particularly attracted to liquids, in its eagerness to get at which it often meets death by drowning. It is a very pugnacious insect and will bite vigorously if captured, and is often predaceous or carnivorous, like most of its outdoor allies. It is supposed to feed on various other house insects, such as the cockroach and is also probably cannibalistic. A pair of native species kept in a cage by the writer, for a short period manifested the greatest friendliness, but the male shortly afterwards made a very substantial meal of his companion.

"These Crickets, in common with most other Orthoptera, will occasionally in pure wantonness seemingly, cut and injure fabrics, and are particularly apt to cut into wet clothing, evidently from their liking for moisture. Any of the common field grasshoppers or crickets, entering houses, are apt to try their sharp jaws on curtains, garments, etc., and Dr. J. A. Lintner records the case of a suit of clothing just from the tailor which was completely ruined in a night by common black field crickets *(Gryllus luctuosus)*, which had entered an open window in some numbers. There is a popular superstition also to the effect that if a cricket be killed its relatives will promptly cut the garments of the offender.

"The house cricket may be readily destroyed by taking advantage of its liking for liquids, and any vessel containing beer or other liquid placed about will usually result in crickets being collected and drowned in numbers. It may also be destroyed by the distribution of uncooked vegetables, such as ground up carrots or potatoes, strongly poisoned with arsenic. In the use of poisoned baits in dwellings great care, however, should always be exercised."

LVII. MIOGRYLLUS Saussure (1877).

According to Scudder, this genus is distinguished from *Gryllus* by the much smaller size of its representatives, which approximate those of *Nemobius* in length; in the absence or extremely inconspicuous nature of the hearing organ on the inner side of the fore tibiæ; in the unbranched or one-branched mediastinal nerve of the tegmina; in the strictly longitudinal course of the veins on the dorsal field of the female tegmina; in the shortness of the hind tibiæ which are only two-thirds as long as the hind femora and armed on each side with only four or five spines, and in the striped or banded summit of the head.

Five species of the genus are known to occur in the United States. Of these, one has been found in southern Indiana.

138. MIOGRYLLUS SAUSSUREI (Scudder).

Gryllus saussurei Scudd., **160**, XIX, 1877, 35; Id., **161**, VI, 1878, 13; Id., **188**, 1900, 90.

Miogryllus saussurei Scudd., **192**, IX, 1901, 257.

Head rather large, shining black except a yellowish white line on each side of the eyes, extending back to the pronotum; that on the outer side double the width of the other; in most specimens two short whitish lines between these on the occiput. Palpi yellowish, the apical joint sometimes darker. Antennæ dark brown, paler at base. Pronotum broader than long, slightly narrower behind than in front, the anterior border slightly concave, the posterior straight; blackish, faintly mottled with yellowish brown, the front margin sometimes faintly edged with the same; the lower half of the deflected lobes pale yellow edged very narrowly below with black, the upper half of the lobes darker than the upper surface and uniform; front and hind margins with a few curved black bristles. Tegmina of the female but little longer than the pronotum, covering about one-third of the abdomen; those of the male covering two-thirds of the abdomen; reddish brown or blackish in color, the humeral angle black; the longitudinal veins and marginal area often paler. Wings almost wanting. Legs either yellowish brown or blackish. Hearing organ on the fore tibiæ fully one-third the length of the tibiæ on its outer face; wanting on its

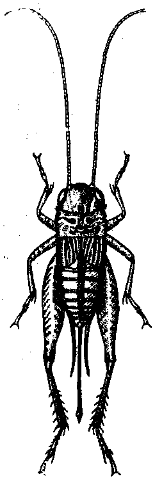


Fig. 112. *Miogryllus saussurei* (Scudd.) Female. One and one-third times natural size. (Original.)

inner face. Abdomen black, with a lighter brown lengthwise band on each side of its dorsal surface. Ovipositor equaling the hind femora in length, yellowish brown in color, the apex darker.

Measurements: Length of body, male, 11.5 mm., female, 14 mm.; of pronotum, male and female, 3 mm.; of tegmina, male, 4.5 mm., female, 3.5 mm.; of hind femora, male and female, 9.5 mm.; of hind tibiæ, male and female, 6 mm.; of ovipositor, 9.5 mm.

This species, resembling in general appearance a large *Nemobius*, has been taken only in Knox, Gibson and Crawford counties, where it occurs on dry wooded hillsides beneath flat stones and logs. It seems to like best places devoid of grass and other vegetation. In southern Indiana it probably reaches maturity about the middle of June, as it seems to be most abundant by the last of that month. Quite a number of specimens were taken in the vicinity of Wyandotte Cave in 1902. It is a southern species which has heretofore been recorded only from Georgia and Florida, and it will therefore probably be found only in the southern third of Indiana.

Sub-family ŒCANTHINÆ.

This sub-family comprises the slender bodied ivory or greenish white tree crickets. Our Indiana species have the pronotum elongated and narrow, its sides deflexed, the posterior margin somewhat broader than the anterior. The wing covers of the male are flattened, semi-transparent, rather firm in texture and much broader than the body. Those of the female are wrapped close about the body, causing such a difference of appearance between the two sexes that collectors often take them for widely different species. The hind femora are weak and slender. The tibiæ, in our most common species, are armed with delicate spines between which are minute teeth, visible only under a lens. The tarsi are four-jointed, elongated and compressed, the second joint being very small and compressed. The ovipositor is straight and shorter than the hind femora; its apex a little enlarged and rather blunt.

All our species are strictly arboreal, living mainly on vines, shrubbery and the taller herbaceous plants. They especially frequent the various species of golden-rod and wild sunflowers, and often three or four can be found on a single one of these plants. For the most part they remain quiescent during the day, but are quite active at night.

Scudder recognizes but one genus, *Œcanthus*, as belonging to our fauna. One species, however, has no spines on the hind tibiæ, and since the presence or absence of these spines is deemed of sufficient importance to be used as one of the principal characters in separating the sub-families, it is surely of generic value. I therefore separate our species into two genera, which may be distinguished as follows:

KEY TO GENERA OF INDIANA ŒCANTHINÆ.

a. Hind tibiæ armed with weak spines, and small teeth between the spines; first joint of antennæ smooth; inner wings but little, if any longer than the tegmina................LVIII. ŒCANTHUS, p. 444

aa. Hind tibiæ unarmed; first joint of the antennæ armed with a stout, blunt tooth in front; inner wings nearly twice as long as the tegmina ....LIX. XABEA, p. 453

LVIII. ŒCANTHUS Serville (1831).

The main characters of this genus have been given under the subfamily heading and in the above key. The tegmina of the female are regularly reticulated, with the oblique longitudinal veins plainly visible. The mediastinal vein of the male tegmina is not strongly bowed, and the humeral angle is distinct. The tarsi are imperfectly four-jointed, the division between the third and fourth joints being visible, but the fourth joint is seldom movable by itself. The name Œcanthus, signifying "I dwell in the flowers," is not always true as the insects are as often found upon the foliage of plants as in the flowers proper. Five species occur in Indiana and may be separated by the following table:

KEY TO INDIANA SPECIES OF ŒCANTHUS.

a. Antennæ without black marks on the under side of the first two joints; tegmina of male more than half as broad as long; front of head and basal joints of antennæ usually pinkish................ 139 *latipennis*, p. 445

aa. Antennæ with one or more black marks or spots on the under side of the first two joints; tegmina of male less than half as broad as long; front of head and basal antennal joints never pinkish.

  b. Antennæ with but one black mark on each of the two basal joints.

    c. Black marks on antennæ in the form of small rounded dots ....140 *niveus*, p. 446

    cc. Mark on first joint of antennæ, long and hooked at base, that on the second joint oblong; wing covers of male narrower and tibial spines weaker than in *niveus*........ 141 *angustipennis*, p. 450

  bb. Antennæ either wholly black or with two black marks on each of the two basal joints.

    d. Head and thorax, either black or trifasciate with black; antennæ usually black; when pale, the marks on first joint generally connected at apex...................... 142 *fasciatus*, p. 450

dd. Wholly pale greenish or yellowish, translucent; marks on antennæ elongate, parallel, distinct.................... 143 *quadripunctatus*, p. 452

139. Œcanthus latipennis Riley. The Broad-winged Tree Cricket.

Œcanthus latipennis Riley, 121, 1881, 61; Id., 122, II, 1884, 182; Brun., 23, 1888, 120, Fig. 39; Id., 32, 1895, 69, 113, Fig. 40; McNeill, 88, VI, 1891, 6; Hart, 73, III, 1892, 33, Fig. 6; Beut., 3, VI, 1894, 272; Lugg., 84, 1898, 273, Fig. 184; Scudd., 188, 1900, 90.

Size, large. Color of male greenish white; of female, pale yellowish green. Antennæ with basal joints destitute of black markings; these joints and top of head usually roseate or pinkish. Tip of ovipositor dark. Tegmina of male, when unfolded, four-fifths as wide as long, much wider than in any other species. Inner wings of male shorter than tegmina; those of female equaling or slightly exceeding the tegmina.

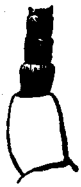


Fig. 113. Four basal joints of antennæ of *Œcanthus latipennis* Riley. (After Lugger).

Measurements: Length of body, male and female, 12.5 mm.; of pronotum, male and female, 3.1 mm.; of tegmina, male, 15 mm., female, 14.5 mm.; of inner wings, male, 12 mm., female, 15 mm.; of hind femora, male and female, 10 mm.; of ovipositor, 6.5 mm. Width of dorsal surface of tegmina of male, 7.5 mm.

This species has been taken only in Vigo and Putnam counties, but probably occurs in all parts of the State, as its range covers the United States east of the Great Plains. It lives mainly on shrubs and vines along the borders of thickets and fence rows, and with us is most abundant from August 10th to October 1st.

The eggs of the broad-winged tree cricket are laid in the pith of the smaller twigs of shrubs and vines, preferably in the slender twigs of the wild and cultivated grapes. Dr. Riley has described the method of oviposition as follows: "The jaws are first used to slightly tear the outer bark. With the antennæ stretched straight forward and the abdomen bent up so as to bring the ovipositor at right angles with the cane, the female then commences drilling, working the abdomen convulsively up and down about twice each second. The eggs are laid lengthwise in the pith, but always in two sets, one on each side of the hole. The number varies according to the size of the cane, and the distance between the holes is also variable. The hole is usually filled up with a white mucous secretion, though there is very little of it about the eggs. This secretion also doubtless serves to facilitate the drilling. The same female will lay over 200 eggs, and will sometimes puncture the same cane at intervals of one-third of an inch for one and a half feet or more."

The day note of the male of *latipennis* is louder than that of any other species. I have heard it when 60 feet distant; have traced it up, and found the musician beneath a leaf or on a post in the angle of a rail fence, industriously sounding his cymbals. The note is kept up for 20 to 30 seconds, and is then succeeded by a pause of about five seconds, when it is begun once more. Dr. Riley has written of it, probably of the night song: "The shrill of *latipennis* is continuous and recalls the trilling of a high-pitched dog-whistle in the distance. The key varies, however, and is sometimes much less high and more musical than at others. The commingled shrill of this species recalls also the distant croaking of frogs in spring. The broad wings are thoroughly elevated during the act, or even bent forward, and the vibration is so rapid that there appears to be no motion."

140. ŒCANTHUS NIVEUS (De Geer). The Snowy Tree Cricket.

Gryllus niveus De G., 57, III, 1773, 522, Plate 43, Fig. 6.

Œcanthus niveus Fitch., 56, XVI, 1856, 404; Harr., 72, 1862, 154, Figs. 71, 72; Scudd., 141, VII, 1862, 431; Id., 148, 1874, 365 (note of set to music); Id., 168, XXIII, 1893, Figs. 65, 66; Id., 188, 1900, 91; Rathv., 109, 1862, 381, Figs. 17, 18; Walsh., 220, I, 1866, 126; Id., 221, II, 1867, 54, 94; Riley, 113, I, 1869, 138, Figs. 77, 78; Id., 114, V, 1873, 120, Fig. 49; Id., 121, VI, 1881, 60; Id., 122, II, 1884, 182, Figs. 256, 257; Glov., 62, 1872, Plate IV, Figs. 1, 2; Id., 63, 1874, 143, Fig. 16; Pack., 104, 1883, 564, Figs. 561, 562; Id., 107, V, 1890, 230, 591, Figs. 75, 76; Fern., 53, 1888, 17, Figs. 7, 8, 9; Comst., 41, I, 1888, 122, Figs. 109, 110; Murtf., 103, II, 1889, 130; McNeill, 88, VI, 1891, 6; Bl., 5, 1892, 141; Id., 16, 1899, 229, Figs. 57, 58; Hart, 73, III, 1892, 33, Fig. 4; Beut., 3, VI, 1894, 269, Plate V, Figs. 12, 13; Brun., 32, 1895, 110, Figs. 37-39; Id., 35, 1899, 133, Figs. 48, 49; Lugg., 84, 1898, 269, Figs. 177, 178.

Both sexes of this species are in color ivory white, more or less tinged with a delicate green, especially in the female. The top of head and basal joint of antennæ are sometimes suffused with ochre yellow, while on the lower face of each of the two basal joints of the antennæ is a small round black spot. The tegmina are almost twice as long as the abdomen and the inner wings equal or slightly exceed them in length. The ovipositor of the female is short, perfectly straight and usually tipped with black. The maxillary palpi are longer in this than in any other species of the genus, and the wing covers of the male are broader in proportion to their length than in any other except *O. latipennis*, when unfolded being two-thirds as wide as long.

Fig. 114. Basal joints of antennæ of *Œcanthus niveus* (DeG.)

Measurements: Male—Length of body, 12 mm.; of wing covers, 12.5 mm.; of hind femora, 8.7 mm.; width of wing covers, 5.5 mm. Female—Length of body, 14.5 mm.; of wing covers, 14 mm.; of hind femora, 10 mm.; of ovipositor, 5.5 mm.

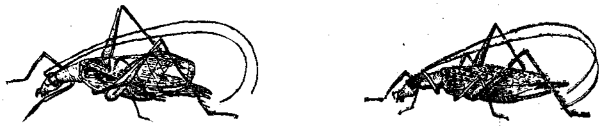


Fig. 115. *Œcanthus niveus* (DeG.) Male and female. (After Beutenmüller).

While the snowy tree cricket occurs in all parts of Indiana, it appears to be less common in the State than either *O. fasciatus* or *O. quadripunctatus*, and much of the published literature relating to it has doubtless been of these two species, especially the latter. Like the other members of its genus *niveus* reaches maturity in southern Indiana about July 1st, and in the central part a fortnight later, and exists in that stage until after heavy frosts. In the writer's experience, the females are more plentiful than the males, the latter being more often heard than seen. During the day they keep themselves hidden among the foliage and flowers of various plants, but as night approaches they come forth and the male begins his incessant, shrill, chirping note, which he continues with little or no intermission till the approach of morning warns him to desist. Professor McNeill, *loc. cit.*, has given an excellent description of the songs of the different species of *Œcanthus*. "That of *niveus*," he says, "is the well-known *t-r-r-r-e-e*, *t-r-r-r-e-e*, repeated without pause or variation about seventy times in a minute. It is heard only at night and occasionally on cloudy days, but in the latter case it is only an isolated song, and never the full chorus of the night song produced by many wings whose vibrations in exact unison produces that characteristic 'rhythmic beat,' as Burroughs has happily phrased it."

Fitch, writing of the note of the same insect in New York, has said: "In the southern part of our State the song of the snowy tree cricket begins to be heard as early as the first of August. Perched among the thick foliage of a grapevine or other shrubbery, some feet up from the ground, and remaining in the same spot day after day, its song begins soon after sunset and before the duskiness of twilight arrives. It is distinctly heard at a distance of several rods, and the songster is always farther off than is supposed. Though dozens of other crickets and katydids are shrilling on every side at the same time, the peculiar note of this cricket is at once distinguished from all the rest, consisting of repetitions of a single syllable, slowly uttered, in a monotonous, melancholy tone, with a slight pause between. The children regard the cricket as no votary of the temperance cause; they understand its song to consist of the words *treat, —treat—treat—treat,* which words, slowly uttered, do so closely resemble its notes that they will at once recall them to the recollection of almost every reader. And the song is thus continued without the slightest variation and without any cessation, I think, the whole night through. I, however, have sometimes heard it at the first commencement of its evening serenade uttering three syllables resembling the words *treat, treat, two; treat, treat, two*—as though the songster was supplicating a libation for his voiceless mate as well as himself—a longer pause following each third note. This prelude is probably performed in limbering or otherwise adjusting his organs, preparatory to performing the regular carol, which is struck into in a few moments."

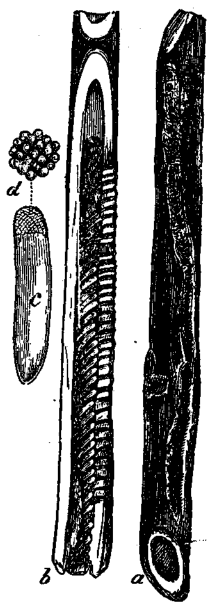


Fig. 116. Eggs of Tree Cricket in raspberry cane.
(a) Cane, showing puncture.
(b) Cane split to show eggs.
(c) Egg enlarged.
(d) Cap of egg enlarged.
(After Riley.)

The females do much harm by ovipositing in the tender canes or shoots of various cultivated fruits, as the raspberry, blackberry, grape, plum, peach, etc.; no less than 321 eggs, by actual count, having been found in a raspberry cane 22 inches in length. So partial is it to the stems of raspberry and blackberry as receptacles for its eggs that in some localities scarcely a cane escapes without being more or less damaged. The eggs are laid in autumn, and at first the injury is shown only by a slight roughness of the bark, but afterwards the cane or branch frequently dies above the puncture, or is so much injured as to be broken off by the first high wind. If the injured and broken canes containing the eggs be collected and burned in early spring the number of insects for that season will be materially lessened.

Professor Bruner, *loc. cit.*, has written of its habits of oviposition in other plants as follows: "In addition to cultivated fruits the snowy tree cricket also deposits its eggs in the stems of a large variety of other plants and trees—the main requirements being a soft fibre and pithy interior to the twigs selected. Among the trees the white willow suffers most. I have seen hedges of this tree so completely utilized that scarcely a twig escaped being deposited into. Other species of willow, cottonwood, elm, maple, box elder, cherry, dog-wood, black locust, sycamore, ash, honey-locust, and in fact almost all kinds of trees, are sometimes attacked. Elder is a great favorite, too. After these come weeds, as the artichoke, sunflower, golden-rod, ambrosia, and many others. All of these latter being annuals, or dying to the ground each year, whether attacked by the cricket or not, the conclusion is plain. All the cricket requires is a receptacle for her eggs. It matters but little whether a dead or a living plant furnishes that condition.

"In the case of the honey locust, the thorns as a rule receive the eggs instead of the twigs, and no apparent damage is done. The mature crickets are also said to be met with abundantly upon oaks, hickories, and elms during the egg-laying season, and evidently use these also occasionally for the deposition of their eggs, although I have never obtained or noticed the eggs in the twigs of these trees.

"While woody plants are known to be very commonly used as receptacles for the eggs of this cricket, it is by far the most numerous upon such weeds as those mentioned above during its entire career; but more particularly so during its latter days when looking after the perpetuation of its kind."

Niveus, however, in part, if not wholly, offsets its injurious habit by its carnivorous propensities, as the young which hatch in May or early June, feed, until they reach maturity, upon the various species of aphids or plant lice which infest the shrubbery they frequent. Mr. B. D. Walsh, *loc. cit.*, was the first entomologist to call attention to this carnivorous habit, but it seems little attention was given to the matter. Recently, however, it has again attracted notice, and in Insect Life for November, 1891, Miss Mary E. Murtfeldt, of St. Louis, Missouri, gave an interesting account of some experiments and observations concerning this habit from which the following extract is taken: "Some leaves of plum infested with a delicate species of yellow aphis were put into a jar with the young of *Œcanthus niveus*, but attracted no immediate attention. As twilight deepened, however, the crickets awakened to greater activity. By holding the jar against the light of the window, or bringing it suddenly into the lamplight, the little nocturnal hunters might be seen hurrying with a furtive, darting movement, over the leaves and stems, the head bent down, the antennæ stretched forward, and every sense apparently on the alert. Then the aphids provided for their food would be caught up one after another with eagerness and devoured with violent action of the mouth parts, the antennæ meanwhile play-ing up and down in evident expression of satisfaction. Unless I had provided very liberally not an aphis would be found in the jar the next morning and the sluggish crickets would have every appearance of plethora."

141. ŒCANTHUS ANGUSTIPENNIS Fitch. The Narrow-winged Tree Cricket.

Œcanthus angustipennis Fitch, 56, XVI, 1856, 404; McNeill, 88, VI, 1891, 8; Bl., 5, 1892, 143 (in part); Hart, 73, III, 1892, 33, Fig. 5; Scudd., 168, XXIII, 1893, 67; Id., 188, 1900, 90; Beut., 3, VI, 1894, 251, 270, Fig. 3; Brun., 32, 1895, 113; Lugg., 84, 1898, 271, Fig., 179.

Pale greenish white, each of the first two basal joints of the antennæ with a black mark, that on the first joint being elongate and hooked inwards at the base; the mark on second joint oblong, slightly curved. Head smaller and pronotum narrower anteriorly than in *niveus*. Tegmina narrower than in any other species except *quadripunctatus*. Inner wings slightly surpassing the tegmina in length.

Fig. 117. Basal joints of antennæ of *Œcanthus angustipennis* Fitch.

Measurements: Length of body, male, 12 mm., female, 11.5 mm.; of pronotum, male and female, 2.75 mm.; of tegmina, male and female, 12 mm.; of inner wings, male and female, 13.5 mm.; of hind femora, male and female, 8.5 mm.; of ovipositor, 5.5 mm.

The narrow winged tree cricket is not a common insect in Indiana, having so far been taken only in Vigo, Putnam and Crawford counties. It frequents the borders of groves and especially ironweeds in open woods pastures and reaches maturity about July 15th. Scudder gives its range as "New York to Kentucky and Nebraska."

The note of *angustipennis* is fainter than that of *niveus* and may be represented by *reeeeeeé*, lasting about five seconds, and terminating abruptly, with an equal interval of rest. It usually sings at night only, but sometimes also late in the afternoon in shady places, and on cloudy days.

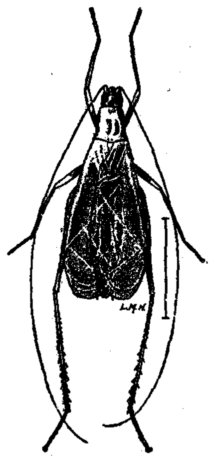
142. ŒCANTHUS FASCIATUS Fitch. The Striped Tree Cricket.

Œcanthus fasciatus Fitch. 56, XVI, 1856, 414; McNeill, 88, VI, 1891, 6; Bl., 5, 1892, 143; Hart, 73, III, 1892, 33, Fig. 1; Scudd., 168, XXIII, 1893, 66; Id. 188, 1900, 90; Brun., 32, 1895, 69, 113; Lugg., 84, 1898, 271, Figs., 180–182.

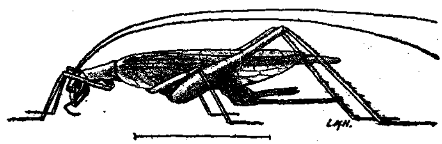
Œcanthus nigricornis Walk., 219, I, 1869, 93; Sauss., 132, VI, 1874, 461; Beut., 3, VI, 1894, 250, 270, Fig. 4; Scudd., 188, 1900, 90.

Greenish yellow; the head and pronotum either wholly black or with three more or less distinct lengthwise black bars. Legs yellowish with a blackish tinge or wholly black. Body black beneath, yellowish green above. Antennæ longer than in other species, often two

Fig. 119. Basal joints of antennæ of *Œcanthus fasciatus* Fitch.



Male.



Female.

Fig. 118. *Œcanthus fasciatus* Fitch. (After Lugger).

and a half times the length of body, either wholly black or with two black marks on each of the two basal joints; the innermost mark on the first joint twice the length of the other, the two often united at the upper ends. Tegmina slightly narrower than those of *niveus*. Inner wings equaling or extending a little beyond the tegmina. Spines at apex of posterior tibiæ stronger and more acute than in allied species. Ovipositor with its apical third slightly but distinctly upcurved.

Measurements: Length of body, male, 12.5 mm., female, 12 mm.; of pronotum, male and female, 3 mm.; of tegmina, male and female, 12 mm.; of inner wings, male and female, 13.2.; of hind femora, male, 10 mm., female, 9.2 mm.; of ovipositor, 5.7 mm. Width of tegmina, male, 5 mm.

The striped tree cricket is the most common member of its kind in Indiana. In August and September, nearly every stalk of goldenrod and wild sunflower along roadsides, in open fields or in fence corners, will have from one to a half dozen of these insects upon its flowers or branches. It is also especially abundant upon the tall weeds and bushes along the borders of lakes and ponds, and in sloughs and damp ravines.

The note of *fasciatus* is a shrill continuous *whi-r-r-r-r* which is kept up for several minutes with the intervals of irregular length.

It is continued for most of the night and on cloudy days. When the sun is shining brightly it usually begins about mid-afternoon and continues with but little pause until the dawn of the next day, unless the caller is, in the meantime, successful in wooing with his music one of the opposite sex within reaching distance.

On September 18, 1898, I was in late afternoon in a wet prairie near Hammond, Indiana, where *O. fasciatus* was more than usually abundant on clumps of wild sunflower. A half dozen or more pairs were seen in copulation. In this act it seems that the female mounts the body of the male, the latter first raising the tegmina until they stand at an angle of about 45 degrees, so as to give the female access to a pair of glands which lie immediately beneath the base of wings. The female worked at these glands with her mandibles, the male meantime moving the inner wings gently sideways, in and out. After working over the glands for ten or fifteen minutes, the female would usually leave the body of the male and crawl onto an adjacent head of the sunflowers. The male meantime kept the tegmina raised, seemingly in waiting for her return, which was always at the end of five or six minutes. During the process, no intromittent organ of the male was noticeable, nor was any union of the parts at the end of the abdomen seen. Is it possible that in the mating of these *Œcanthids* the female removes the semen from the glands whose openings are beneath the tegmina of the male, and then fertilizes her ova?

143. Œcanthus quadripunctatus Beutenmüller. The Four-spotted Tree Cricket.

Œcanthus quadripunctatus Beut., 2, VI, 1994, 250; Id., 3, 271, Fig. 5; Scudd., 188, 1900, 91.

Œcanthus fasciatus Hart., 73, III, 1892, 33 (text in part), Fig. 2; Lugg., 84, 1898, 272, Fig. 183 (text in part).

Males, greenish white, females yellowish green, in color. Antennæ light brown, the basal joints pale green with two black marks on each; those on the second joint oblong, parallel, the inner about double the length of the outer; the inner mark on lower or basal joint, two-thirds the length of the joint, its upper end curved outward, but not united with the outer mark, which is short and almost round. Wing covers a little narrower than in *fasciatus*, the inner wings protruding slightly beyond their tips.

Measurements: Length of body, male and female, 11.5 mm.; of pronotum, 2.6 mm.; of tegmina, male, 12 mm., female, 10.5 mm.; of inner wings, male, 13.5 mm., female, 12.5 mm.; of hind femora, male and female, 8.2 mm.; of ovipositor, 5.5 mm. Width of tegmina, male, 4.7 mm.

This is, next to *fasciatus*, the most common *Œcanthus* in central and southern Indiana. Specimens are before me from Vigo, Putnam, Marion, Floyd, Crawford and Posey counties. It frequents shrubbery and weeds in fence rows and gardens, and along roadsides; and while often found in company with *fasciatus*, has never been seen mating with that species. A female was taken in Crawford County on June 28th, an early date for a mature tree cricket. Scudder gives its range as "New York to Indiana." I have specimens from Agricultural College, Mississippi, and from Sherborn, Massachusetts, and have also found it abundant on the north shore of the Niagara River, opposite Buffalo, New York, where it was the only species present on September 4th.

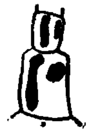


Fig. 120. Basal joints of antennæ of *Œcanthus quadripunctatus* Beut.

LIX. XABEA Walker (1869).

The members of this genus may be known from those of *Œcanthus* by the following characters: The first joint of antennæ is armed on its under side with a stout blunt tooth. The tegmina of female are irregularly reticulated, the oblique longitudinal veins not being conspicuous; male tegmina with the mediastinal vein strongly arcuated; the humeral angle wanting. Inner wings nearly twice as long as the tegmina. Hind tibiæ with neither spines nor serrations, armed with only four apical spurs, two within and two without. First joint of posterior tarsi unarmed, the tarsi clearly but three-jointed, the second joint very short.

But one species of *Xabea* is known from the United States, occurring over most of the region east of the Great Plains.

144. XABEA BIPUNCTATA (De Geer). The Two-Spotted Tree Cricket.

Gryllus bipunctatus De G., **57**, 1773, 523, Plate 43, Fig. 7; Burm., **40**, II, 1838, 732.

Œcanthus bipunctatus Serv., **197**, XXII, 1831, 135; Glov., **62**, 1872, Plate IV, Figs. 5, 6; Sauss., **132**, VI, 1874, 458, 462; McNeill, **88**, VI, 1891, 9; Hart, **73**, III, 1892, 33, Fig. 3; Scudd., **188**, 1900, 90.

Xabea bipunctata Riley, **121**, VI, 1881, 61; Beut., **3**, VI, 1894, 272, Plate V, Fig. 14.

Œcanthus punctulatus Fitch, **56**, XVI, 1856, 415.

Pale pinkish brown, the tegmina of female with two rather large blackish spots, one near the base, the other at the center. Basal joints of antennæ without black marks, but with the scape of the first joint prolonged beneath, forming an acute blackish tooth. Inner wings much produced beyond the tegmina. Legs pale with a pinkish hue.

Measurements: Length of body, male and female, 13 mm.; of pronotum, 3.3 mm.; of tegmina, 11 mm.; of inner wings, 20 mm.; of hind femora, 9 mm.; of ovipositor, 6 mm.

This tree cricket is readily recognized by its unarmed hind tibiæ, pinkish brown color, long inner wings and dark spots on female tegmina. It is scarce in Indiana, having as yet been taken only in Vigo County, though it will doubtless be found to occur throughout the State. So far as known, its habits are the same as those of the more common species of *Œcanthus*.

Sub-family TRIGONIDIINÆ.

The Indiana members of this sub-family are among the smallest of our native Gryllidæ. They are distinguished mainly by the different character of the second tarsal joint, which is depressed and heart-shaped, instead of compressed, as in the preceding sub-families. The tympanum or shrilling organ of the male is more simple than in other species, being divided by a single oblique vein. The hind tibiæ have no serrations between the spines and bear but two apical spurs on the inner side. The ovipositor resembles that of some of the Locustidæ in being short, compressed and saber-like.

Three genera represent the sub-family in the United States. Of these two occur in Indiana.

KEY TO GENERA OF INDIANA TRIGONIDIINÆ.

a. Last joint of maxillary palpus club shaped; basal joint of antennæ sub-depressed, rather large................LX. ANAXIPHA, p. 454

aa. Last joint of maxillary palpus very broad, spoon-like; basal joint of antennæ narrow, minute ....LXI. PHYLLOSCIRTUS, p. 456

LX. ANAXIPHA Saussure (1874).

The members of this genus resemble those of *Nemobius* in form of body, breadth of head, etc., but the females are readily distinguished by the compressed and strongly upcurved ovipositor. The antennæ are very long and setaceous, the first joint being rather large and a little flattened. Ocelli present, but small and arranged in a triangle. Maxillary palpi rather long; the last joint dilated in the form of a funnel. Tegmina of male almost encasing the abdomen, the speculum or round glassy spot on their apical half prominent and undivided by a cross nerve; inner wings absent. Hind tibiæ armed with three pairs of slender spines, of equal length. One species occurs in the United States, ranging from New York to Texas.

145. ANAXIPHA EXIGUA (Say).

Acheta exigua Say, 138, IV, 1825, 309; Id., 139, II, 1859, 238.

Nemobius exiguus Sauss., 132, VI, 1874, 391.

Anaxipha exigua Scudd., 162, XIX, 1877, 82; Id., 168, XXIII, 1893, 67; Id., 188, 1900, 91; Beut., 3, VI, 1894, 268.

Gryllus pulicarius Burm., 40, II, 1838, 732.

Anaxipha pulicaria Sauss., 132, VI, 1874, 371, Plate 7, Fig. 1; Id., 133, II, 1878, 615.

Anaxiphus pulicarius Bl., 5, 1892, 137; Lugg., 84, 1898, 274, Fig. 185.

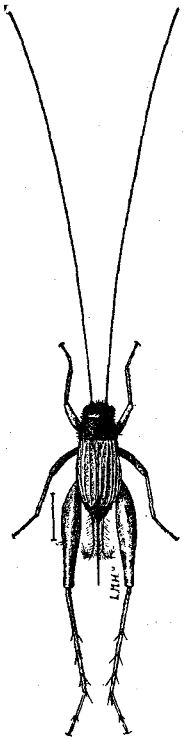


Fig. 121. *Anaxipha exigua* (Say). Female. Much enlarged. (After Lugger).

Head and pronotum dark reddish brown, sparsely covered with long hairs. Tegmina and legs light brown, the former reaching the end of the abdomen in the male, shorter in the female. Abdomen of male blackish; of female pale brown, darker on the sides. Ovipositor dark brown, paler at tip. Cerci very long and slender, clothed with long yellow hairs.

Measurements: Length of body, male, 6 mm., female, 7 mm.; of antennæ, male, 32 mm.; of tegmina, male, 4.5 mm., of female, 3.5 mm.; of hind femora, male and female, 6 mm.; of ovipositor, 3.5 mm.

This handsome little cricket has been taken in Vigo, Putnam, Fulton and Kosciusko counties. At Kewanna and De Long, Fulton County, it occurs in small numbers among the sphagnum mosses growing in dense tamarack swamps. In Vigo County it occurs about the borders of a large pond, and in Kosciusko County in a marsh bordering Tippecanoe Lake. In both these localities it was abundant on the leaves and stems of the arrow alum, cat-tail flags, buttonbush and other semi-aquatic plants. It is very active and difficult to capture, and, on account of its small size, is doubtless overlooked in many localities where it occurs in abundance. In central Indiana it reaches maturity about August 1st, and exists until after heavy frosts. Unlike the *Nemobids*, which it most closely resembles, it is never found on the ground, but clings to the stems of bushes and grasses a few feet above the surface.

LXI. PHYLLOSCIRTUS Guerin (1840).

In this genus the head is noticeably wider than the pronotum, the eyes prominent and protruding; the ocelli indistinct or wanting. The basal joints of antennæ are rather small and narrow, and are proportionally farther apart than in most crickets. The apical joint of the maxillary palpus is dilated and spoon-shaped and much longer than the preceding joint, which is triangular. Pronotum sub-cylindrical, narrower in front. Tegmina as long or longer than the body, rather leather-like in texture. Inner wings nearly as long as the tegmina. Ovipositor short, compressed, curved strongly upward.

The genus is exclusively American. But one species is known in the United States, occurring only east of the Mississippi and south of the latitude of central Indiana.

146. PHYLLOSCIRTUS PULCHELLUS (Uhler). The Handsome Tree Cricket.

Phyllopalpus pulchellus Uhl., 212, II, 1864, 544; Glov., 62, 1872, Plate VI, Fig. 22.

Phylloscirtus pulchellus Sauss., 132, VI, 1874, 368; Id., 133, II, 1878, 637; Riley, 122, II, 1884, 183; Bl., 5, 1892, 137; Beut., 3, VI, 1894, 268, Plate V, Fig. 16; Scudd., 188, 1900, 91.

Head and pronotum bright crimson red, punctured; antennæ twice the length of the body, blackish at base and at tip, the middle portion yellowish; palpi black. Abdomen shining black; tegmina chestnut brown, the sides darker, with paler nervures. Cerci and legs pale yellow. Ovipositor brown, paler at base.

Measurements: Length of body, female, 7.5 mm.; of tegmina, 5 mm.; of hind femora, 5.5 mm.; of ovipositor, 3.5 mm.

But three specimens, all females, of this little bright colored cricket are in my collection from Indiana. One of these was taken on September 6th, from a leaf of the button-bush, *Cephalanthus occidentalis* L., near the border of a large pond in Vigo County. When discovered it was motionless, but was vibrating its large maxillary palpi in a very rapid and curious manner. A second specimen was taken by Mr. Hans Duden from the roadside near Edwardsville, Floyd County, on August 16th. It attempted to bite when picked up. The third was taken from the border of a marsh near Grand Chain, Posey County, on September 17th. It probably occurs in low wet woods throughout the southern half of the State. According to Uhler it is found in Maryland most frequently "amongst the grass and low bushes near ditches where it jumps about with great rapidity."

Sub-family ENEOPTERINÆ.

Medium sized *Gryllidæ*, having the second tarsal joint flattened and bi-lobed, as in the preceding sub-family. The hind tibiæ, however, have serrations between the spines and bear three apical spurs on each side. The tegmina of male in our genera are provided with a sounding organ or tympanum, and the ovipositor is cylindrical and straight or but little curved. Four genera occur in the United States, two of which are represented in Indiana.

KEY TO INDIANA GENERA OF ENEOPTERINÆ.

a. Body short and broad; fore tibiæ with hearing organ on the inner face only; apical segment of the maxillary palpus nearly as long as the two preceding taken together; tegmina in both sexes not reaching the tip of abdomen....................LXII. APITHES, p. 457

aa. Body rather long and slender; fore tibiæ with hearing organ on both faces; apical segment of maxillary palpus but little longer than the one preceding; tegmina extending much beyond the abdomen in both sexes ....LXIII. OROCHARIS, p. 459

LXII. APITHES Uhler (1864).

The main distinguishing characters of this genus have been given in the above key. In addition it may be stated that the head is almost globular and narrower than the pronotum; ocelli present; antennæ about three times the length of the body, their basal joints much thickened and cylindrical. Maxillary palpi with the last segment enlarged at tip; obliquely truncated. Pronotum short, narrower in front than behind, the lateral angles rounded, the anterior and posterior margins truncate. Tegmina with the humeral vein prominent, forming a carina along the humeral angle. Inner wings very short. Hind femora quite broad, though but little thickened. Hind tibiæ armed with two rows of spines which are curved at the tip, eight on the inner and five or six on the outer side.

Two species are known from the eastern United States, one of which occurs in Indiana.

147. APITHES AGITATOR Uhler.

Hapithus agitator Uhl., 2 1 2, II, 1864, 546; Glov., 6 2, 1874, Plate XVI, Fig. 16; Riley, 1 2 2, II, 1884, 183, Fig. 23.

Apithis agitatrix Sauss., 1 3 2, VI, 1874, 490.

Apithes agitator Bl., 5, 1892, 139; Id., 1 6, 1899, 227; Scudd., 1 8 8, 1900, 91.

Hapithus quadratus Scudd., 1 4 4, XII, 1868, 140; Id , 1 6 4, 1879, 4.

Apithis quadrata Sauss., 1 3 2, VI, 1874, 488.

A short, heavy bodied cricket; dull reddish brown in color. Tegmina covering about three-fourths of abdomen, the vein separating the dorsal field from the marginal, a yellowish white. The top of head and pronotum, and the surface of all the femora densely covered with brownish yellow hairs. Ovipositor a little shorter than hind femora, pale brown, the apical third darker, a little upcurved.

Measurements: Length of body, male, 10 mm., female, 11 mm.; of pronotum, male and female, 2.5 mm.; of tegmina, female, 7.5 mm.; of hind femora, male, 8 mm., female, 9 mm.; of ovipositor, 8 mm. Width of pronotum, 3.2 mm.

In Indiana this cricket has as yet been taken only in Vigo County, and during the month of September. The first ones discovered were on the slender twigs of some prickly-ash shrubs which grew in a damp upland woods. The place was visited a number of times and the crickets were always found, perfectly motionless, and immediately above or below one of the thorns or prickles jutting forth from the twigs. The tips of the hind femora were raised so as to project above the body, thus causing them to resemble the thorns; and the color of the insect, corresponding closely to that of the bark, made them very difficult to discover even when in especial search of them. On every clump of prickly-ash in the woods mentioned a number of specimens were secured, but they could be found nowhere else thereabouts. A second locality was about the roots of a scarlet oak, *Quercus coccinea* Wang, which grew on a sandy hillside. Here they were plentiful, and resting motionless in the depressions of the bark or beneath the leaves in the cavities formed by the roots of the tree. A pair were also noted in another place on the flowers of golden-rod.

Of all the males taken, over thirty in number, there was not one with perfect wing covers, and, in almost every instance, the wing covers as well as the rudimentary wings were wholly absent; while every female had both pairs unarmed. I at first ascribed this wing mutilation to the males fighting among themselves, but finally discovered a female in the act of devouring the wings of a male. Why this curious habit on the part of one sex? Possibly the females require a wing diet to requite them for their bestowed affections, or, perchance, they are a jealous set, and, having once gained the affections of a male, devour his wing covers to keep him from calling other females about him. *Quien sabe?*

It is more than probable, however, that the mating of the sexes takes place in a similar manner to that of the striped tree cricket *Œcanthus fasciatus* Fitch, described above; the females gnawing away the tegmina of the males in order to more readily reach some seminal glands which lie beneath. The openings of these glands, located on the dorsum of the mesothorax, are visible in dried specimens at hand.

Agitator is said to be common in the middle and southeastern States, where it inhabits grapevines and dense shrubbery. The eggs of the female are there deposited in twigs of the white elm, *Ulmus americana* L., and the insects are very active at night, running and jumping about on the trunks of various trees.

LXIII. OROCHARIS Uhler (1864).

The members of this genus have the body flattened and rather slender; the head short, slightly narrower than the pronotum, the front depressed and prolonged between the eyes in the form of a short beak; ocelli present, arranged in a triangle on the short frontal beak; the maxillary palpi with the third segment longest, cylindrical; the apical one a little longer than the one preceding, enlarged gradually from the base, obliquely truncate. Pronotum wider than long, though narrower than the tegmina, the front and hind margins truncate and ciliate. Tegmina longer than the abdomen, their texture more membranous than in the preceding genus; strongly reticulated and tapering posteriorly; inner wings a little longer than the tegmina. Hind femora rather short and slender.

Three nominal species occur in the United States; of these one has been taken in Indiana.

148. OROCHARIS SALTATOR Uhler. The Jumping Tree Cricket.

Orocharis saltator Uhl., 212, II, 1864, 545; Riley, 113, I, 1869, 138; Id., 114, V, 1873, 119, Figs. 47, 48; Id., 121, VI, 1881, 62; Id., 122, II, 1884, 182, Fig. 258; Glov., 62, 1872, Plate III, Figs. 11, 12; Bl., 5, 1892, 138; Lugg., 84, 1898, 275, Fig. 186; Scudd., 188, 1900, 92.

Orocharis saltatrix Sauss., 132, VI, 1874, 494; Scudd., 174, XCIII, 1896, 694.

Apithes mcneilli Bl., 5ª, XXIV, 1892, 27.

Pale brownish yellow. A dark brown stripe reaches from the eye along the side of head and pronotum, and sometimes an irregular fuscous line on middle of pronotum. The tegmina each with a dark brown or fuscous spot at base, sometimes covering most of the wing; those of the female with many cross-veinlets which are darker than those running lengthwise, giving the dorsal field a checkered appearance; those of the male with the vein separating the dorsal field from the marginal, yellow. Inner wings extending 2 to 3 mm. beyond the tegmina. All the femora rather thickly marked with small, dark spots; those on the posterior pair being arranged in regular rows. Ovipositor a third longer than the hind femora, nearly straight.

Measurements: Length of body, male, 14 mm., female, 16 mm.; of pronotum, male and female, 2.5 mm.; of tegmina, male, 12.5 mm., female, 14 mm.; of hind femora, male, 8 mm., female, 10 mm.; of ovipositor, 12 mm.

This is a southern species, which in Indiana has so far been taken in small numbers only in Vigo, Putnam and Marion counties; though it doubtless occurs throughout the southern half of the State. In Vigo County it was found in October on the leaves of a golden-rod, *Solidago latifolia* L., and on those of prickly-ash, *Xanthoxylum americanum* Mill., both in dense upland woods. In Marion County, Philip Baker brought me several specimens which he found on August 22d, beneath an old coat hanging on a grape arbor, in the back yard of his father's residence near the center of the city of Indianapolis. When disturbed it often seeks safety in flight, and when it alights flattens out its body close against its resting place. Professor Riley has given an interesting account of the egg-laying and song habits of the jumping tree cricket, from which I quote at length as follows:

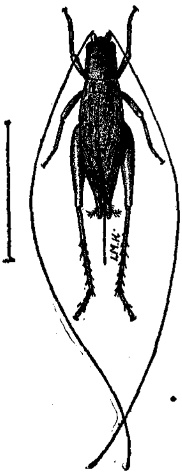


Fig. 122.
Orocharis saltator Uhler. Female. (After Lugger).

"In December, 1877, I watched a female of *O. saltator* ovipositing in the end of a dead and rather soft twig of the soft maple at Kirkwood, Missouri. The twig had been pruned and the bark was somewhat gnawed by the cricket and the eggs thrust in irregularly from the end and from the sides. Both wood and pith were crammed with eggs, but all longitudinally inserted. The favorite nidus of the species is, however, the soft and somewhat corky, rough bark of the trunk and older branches of the American elm, the eggs being thrust in singly or in small batches, either longitudinally with, or very slightly obliquing from, the axis of trunk or branch. The female is very intent in the act, working her abdomen deliberately from side to side during the perforation.

"The stridulation of this cricket is a rather soft and musical piping of not quite half a second's duration, with from four to six trills, but so rapid that they are lost in the distance. The key is very high, but varies in different individuals and according to moisture and temperature. It most resembles the vibrating touch of the finger on the rim of an ordinary tumbler when three-fourths filled with water —repeated at intervals of from two to four per second, and it may be very well likened to the piping of a young chick and of some tree frogs. As the species is very common in the southwest its chirp is everywhere heard and is so distinctive that when once studied it is never lost amid the louder racket of the katydids and other night choristers. It is frequently heard during the day time in cloudy or damp weather, and I have heard it at St. Louis the first days of November after a slight frost.

"The courting of the sexes is amusing. They face each other and play with their antennæ for the best part of an hour or more than an hour. The female is, otherwise, pretty quiet, but the male continually mouths the twig or the bark upon which the courting is being done, and plays his palpi at a great rate, very stealthily approaching nearer to his mate meanwhile. At last the antennal fencing ceases and those of the female bend back and then the male approaches until their heads touch. He then deliberately turns round, elevates the elytra and slips his abdomen under the female, who virtually mounts and assists him, his elytra overshadowing her head."

THE LIFE ZONES OF INDIANA, AS ILLUSTRATED BY THE DISTRIBUTION OF ORTHOPTERA WITHIN THE STATE.

The detailed study of the distribution of the Orthoptera of Indiana, made necessary in preparing the foregoing descriptive catalogue, has developed certain facts regarding the life zones of the State which are of especial interest. Dr. C. H. Merriam, in his "Life Zones and Crop Zones of the United States,"* has made the "Upper Austral" life zone cover the entire State, with the exception of a very small area of "Lower Austral" in the extreme southwestern corner. The facts brought out regarding the distribution of Orthoptera in Indiana, which are supplemented by numerous field notes on other groups of insect and animal life, and on the flowering plants, prove conclusively that the "Transition Zone," represented by the Alleghanian fauna and flora, overlaps the northern fourth of the State, while the "Lower Austral Zone," represented by the Austroriparian fauna and flora, covers the greater part of the southern third. The Carolinian fauna and flora of the Upper Austral embraces, of course, the prevailing forms of life in the State, 93 of the 148 species of the preceding catalogue belonging to it. The majority of these range over the entire State mingling with the representatives of the Alleghanian fauna in the north and with those of the Austroriparian fauna in the southern third. To the Carolinian fauna belongs also the great majority of the other forms of animal life in the State.

* Bulletin No. 10, Division Biological Survey, U. S. Department of Agriculture, 1898 pp. 1-79, map.

THE TRANSITION ZONE.—The three northern tiers of counties in Indiana embrace several hundred fresh water lakes within their bounds. These lakes range in size from an area of half an acre up to five and a half square miles. About their margins are often extensive areas of low, boggy land, covered with numerous forms of plant life whose main distribution is far to the north, and which have here their southern limit. Among the more characteristic plants of the Alleghanian flora, which are found only in the northern fourth of Indiana, are the following: Larch or tamarack, *Larix laricina* (Du Roi); arbor vitæ or white cedar, *Thuja occidentalis* L.; false lily of the valley, *Unifolium canadense* (Desf.); moccasin flower, *Cypripedium acaule* Ait.; showy lady's slipper, *Cypripedium reginæ* Walt.; bog orchis, *Arethusa bulbosa* L.; fen orchis, *Leptorchis lœselii* (L.); sweet fern, *Comptonia peregrina* (L.); paper or canoe birch, *Betula papyrifera* Marsh; speckled or hoary alder, *Alnus incana* (L.); gold-thread, *Coptis trifolia* (L.); round-leaved sundew, *Drosera rotundifolia* L.; black chokeberry, *Aronia nigra* (Willd.); round-leaved wintergreen, *Pyrola rotundifolia* L.; shin-leaf, *Pyrola elliptica* Nutt.; trailing arbutus, *Epigœa repens* L.; creeping wintergreen, *Gaultheria procumbens* L.; large cranberry, *Oxycoccus macrocarpus* (Air.); chick-weed wintergreen, *Trientalis americana* Pursh.; purple bladderwort, *Utricularia purpurea* Walt., and the twin-flower, *Linnœe borealis* L.

Among mammals and reptiles, the following representatives of the Alleghanian fauna occur in the northern fourth of the State: Canada porcupine, *Erethizon dorsatus* (L.); red squirrel or chickaree, *Sciurus hudsonicus* Erxleben; star-nosed mole, *Condylura cristata* (L.); hoary bat, *Atalapha cinerea* (Beauvais); American badger, *Taxidea americana* (Boddært); speckled tortoise, *Clemmys guttata* (Schneider), and Blanding's tortoise, *Emys meleagris* Shaw.

Of the Orthoptera described in the foregoing catalogue, 23 species, or 15.5 per cent. of the total, may be classed as belonging to the Alleghanian fauna, and as occupying the southern limits of the Transition Zone, which lies between the Boreal and Upper Austral zones. These truly northern members of our Orthopteran fauna are as follows:

INDIANA ORTHOPTERA BELONGING TO THE ALLEGHANIAN FAUNA.

1. *Orphulella pelidna* (Burm.).
2. *Orphulella speciosa* (Scudd.).
3. *Stenobothrus curtipennis* Harris.
4. *Mecostethus lineatus* (Scudd.).
5. *Camnula pellucida* (Scudd.).
6. *Hippiscus haldemanni* (Scudd.).
7. *Spharagemon wyomingianum* (Thom.).
8. *Trimerotropis maritima* (Harris).
9. *Schistocerca rubiginosa* (Harris).

10. *Hesperotettix pratensis* Scudd.
11. *Melanoplus fasciatus* (Walker).
12. *Melanoplus extremus* (Walker).
13. *Melanoplus angustipennis* (Dodge).
14. *Phœtaliotes nebrascensis* (Thom.)
15. *Paroxya scudderi* Bl.
16. *Scudderia pistillata* Brunn.
17. *Conocephalus robustus* Scudd.
18. *Orchelimum indianense* Bl.
19. *Orchelimum delicatum* Brun.
20. *Orchelimum gladiator* Brun.
21. *Nemobius palustris* Bl.
22. *Nemobius confusus* Bl.
23. *Gryllus arenaceus* Bl.

THE LOWER AUSTRAL ZONE.—The extreme northern boundary of the "Lower Austral" life zone passes in a northwest southeast direction through the following counties of Indiana: Vigo, Clay, Owen, Monroe, Jackson, Jennings, Jefferson and Switzerland. In the territory south of this line the Austroriparian fauna of that sub-zone overlaps and merges with the Carolinian fauna of the Upper Austral zone. The extension northward on the western line of the State is, without doubt, due to the presence of the broad and sheltering valley of the Wabash River, within the confines of which certain southern forms have found a climate mild and suitable to their habits. Within this valley the following members of the Austroriparian flora grow indigenously, a number of them as far north as Terre Haute: Bald cypress, *Taxodium distichum* (L.); upright burhead, *Echinodorus cordifolius* (L.); showy amaryllis, *Hymenocallis occidentalis* (Le Conte); pecan, *Hicoria pecan* (Marsh.); swamp or downy poplar, *Populus heterophylla* L.; chinquapin, *Castanea pumila* (L.); Texan red oak, *Quercus texana* Buckley; pipe vine, *Aristolochia tomentosa* Sims; American lotus, *Nelumbo lutea* (Willd.); Carolina moonseed, *Cebatha carolina* (L.); great burnet, *Sanguisorba canadensis* L.; water or swamp locust, *Gleditsia aquatica* Marsh; water ash, *Fraxinus caroliniana* Mill, and crossvine, *Bignonia crucigera* L.

Among other characteristic southern plant forms occurring in Indiana south of the northern boundary of the Lower Austral zone are: The yellow pine, *Pinus echinata* Mill.; mud plantain, *Heteranthera reniformis* R. & P.; false aloe, *Agave virginica* L.; Spanish oak, *Quercus digitata* (Marsh); southern hackberry, *Celtis mississippiensis* Bosc.; American mistletoe, *Phoradendron flavescens* (Pursh.); cucumber tree, *Magnolia acuminata* L.; pencil flower, *Stylosanthes biflora* (L.); Carolina buckthorn, *Rhamnus caroliniana* Walt.; yellow passion flower, *Passiflora lutea* L.; Hercules club, *Aralia spinosa* L.; persimmon, *Diospyros virginiana* L.; unicorn plant, *Martynia louisiana* Mill.; catalpa, *Catalpa catalpa* (L.), and the rough button-weed, *Diodia teres* Walt.

The southern mockingbird, *Mimus polyglottos* (L.), nests in numbers as far north as Terre Haute; while among the batrachians and reptiles the hellbender, *Cryptobranchus alleghaniensis* (Daud.); the southern cricket frog, *Acris gryllus* Le Conte; the corn snake, *Ophibolus doliatus* (L.); Say's chain snake, *Ophibolus calligaster* (Say); the bead snake, *Elaps fulvius* (L.); the ground lizard, *Oligosoma laterale* (Say); the alligator snapper, *Macrochelys lacertina* (Schweigger), and the yellow-bellied terrapin, *Pseudemys troosti* (Holbrook), all forms whose main distribution is far to the south, find in southern Indiana a congenial abiding place.

It is not strange, therefore, that we find, living with these plants and animals, a number of Orthoptera whose range has heretofore been thought to be confined to the region mapped by Merriam as the "Lower Austral." Thirty-two of the species listed in the preceding catalogue, or 21.6 per cent. of the total, may be classed as southern forms. They are as follows:

INDIANA ORTHOPTERA BELONGING TO THE AUSTRORIPARIAN FAUNA.

1. *Temnopteryx deropeltiformis* Brunn.
2. *Ischnoptera inæqualis* Sauss.-Zehnt.
3. *Ischnoptera major* (Sauss.-Zehnt.)
4. *Stagmomantis carolina* (L.).
5. *Gonatista grisea* (Fab.).
6. *Anisomorpha ferruginea* (Pal. de Beauv.).
7. *Tettix arenosus* Burm.
8. *Neotettix hancocki* Bl.
9. *Tettigidea spicata* Morse.
10. *Tettigidea lateralis* (Say).
11. *Syrbula admirabilis* (Uhl.).
12. *Hippiscus phœnicopterus* (Germar).
13. *Mestobregma cinctum* (Thom.).
14. *Trimerotropis citrina* Scudd.
15. *Leptysma marginicollis* (Serv.).
16. *Schistocerca damnifica* (Sauss.).
17. *Melanoplus morsei* Bl.
18. *Melanoplus impudicus* Scudd.
19. *Amblycorypha uhleri* (Brunn.).
20. *Conocephalus bruneri* Bl.
21. *Atlanticus dorsalis* (Burm.).
22. *Camptonotus carolinensis* (Gers.).
23. *Ceuthophilus stygius* (Scudd.).
24. *Ceuthophilus uhleri* Scudd.
25. *Myrmecophila pergandei* Brun.
26. *Nemobius canus* Scudd.
27. *Nemobius cubensis* Sauss.
28. *Gryllus firmus* Scudd.
29. *Miogryllus saussurei* (Scudd.).
30. *Phylloscirtus pulchellus* (Uhl.).
31. *Apithes agitator* Uhl.
32. *Orocharis saltator* Uhl.

Of the species listed, *Stagmomantis carolina* (L.), *Camptonotus carolinensis* (Gers.), *Syrbula admirabilis* (Uhl.) and *Orocharis saltator* Uhl. have been taken in small numbers as far north as Marion County; all the others only south of the line mentioned as forming the northern border of the Lower Austral. It will be noted that this line corresponds approximately with the southern border of the glacial invasion of Indiana, and it is more than probable that the ancestors of many of these southern forms existed in southern Indiana in preglacial times, when the climate was much warmer than now. As Webster has recently pointed out*, it is also probable that some of these Orthoptera, as well as a number of those species inhabiting the entire State, advanced into the State from the south as fast as it was uncovered by the receding ice.

* "The Diffusion of Insects in North America," Psyche, X, 1903, pp. 47-58.

The members of the Alleghanian fauna entered the State, for the most part, from the north or northeast. A number of those which I have not classed as Alleghanian or Austroriparian, and which, therefore, are to be considered Carolinian, evidently came in from the west. Chief among these are *Ageneotettix scudderi* (Brun.), *Melanoplus blatchleyi* Scudd., *Conocephalus palustris* Bl., *Xiphidium saltans* Scudd., *Xiphidium strictum* Scudd., and *Orchelimum volantum* McN., all of which appear to be confined to the western half of the State.

GLOSSARY OF TERMS USED IN TEXT.

Abbreviated.—Shortened—not reaching the tip of abdomen when applied to tegmina and wings.

Abdomen.—Posterior part of body.

Aborted.—Imperfectly developed.

Acuminate.—Becoming gradually narrower; tapering to a point.

Acutely.—Sharp; sharply pointed.

Adult.—The imago or winged stage of an insect.

Anal.—Situated at or near the anus.

Annulus, annulation, annulate. — Ringed; furnished with ring-like bands.

Antennæ.—The jointed organs of touch and smell, attached to the upper part of the face.

Anterior, anteriorly.—Near the head; situated more to the front.

Anus.—The posterior opening of the alimentary canal.

Apex.—The terminal portion of any organ or part of the body.

Apical, apically.—That part of any organ farthest from the body.

Appressed.—Pressed closely against; fitting closely to.

Approximate.—Near to; near together.

Apterous.—Wingless.

Arboreal.—Living on or among trees.

Arcuate.—Arched; bowed.

Area, areola, areolate. — Wing cells; cellules; the membranaceous spaces between the nervules.

Articulated.—Divided into distinct joints.
Auditory organ.—Ear; hearing organ.
Attingent.—Touching; coming in contact with.

Basal.—Next to the body.
Bifid.—Cleft; cloven in two.

Calcaria.—The spines or spurs at the apex of the tibia.
Carina, carinæ (pl.).—A keel or ridge.
Castaneous.—Chestnut brown; bright reddish brown.
Cerci.—The appendages issuing from the sides of the last abdominal segment.
Chitine.—The corneous substance of the skin of an insect.
Cimeter-shaped.—Like a short, curved oriental sword.
Cinereous.—Ash-colored; gray tinged with blackish.
Clavate.—Having a thickened, club-like extremity.
Clypeus.—A part of the head.
Concave.—When the surface gradually declines toward the center, which thus becomes the deepest.
Convex.—When the surface gradually rises toward the center, which thus becomes the highest.
Cordiform, cordate.—Heart-shaped.
Coriaceous.—Leather-like, tough and somewhat rigid.
Corneous.—A horny substance, resembling horn.
Costa.—Median carina of the face.
Costal.—The front margin of tegmina or wing.
Coxa.—The globular or oblong basal piece of the leg.
Crest.—A sharp ridge.
Cristate.—With a prominent longitudinal carina on its upper surface.

Declivent.—Sloping downward.
Decurved.—Bent downward.
Depressed.—Pressed downward; more or less flattened vertically.
Dentate.—Furnished with a tooth or teeth.
Denticulations.—With fine tooth-like notches.
Dilated.—Broadened; expanded.
Dimorphic.—Existing in two forms.
Disk.—The middle of a surface; the surface within the margins.
Distal.—Farthest distant, opposite of proximal.
Diurnal.—Active during the day.
Dorsal.—Pertaining to the upper surface.
Dorsum.—The upper surface or back of thorax, abdomen, etc.

Elongate.—More lengthened than usual.

Elytra.—The wing covers; the tegmina.

Emarginate, emargination.—Edged; notched; terminating in an acute notch at tip.

Ensiform.—Sword-shaped; sharp on both edges and tapering to a point.

Exserted.—Protruding so as to be visible.

Falcate.—Sickle-shaped; curved like a sickle.

Fastigium.—The extreme point of the front or vertex of the head.

Fauna.—The animals of a locality.

Femur, femora (pl.).—The thigh or thighs.

Ferruginous.—Rusty brown; brownish red with some yellow.

Filiform.—Slender, thread-like.

Fossorial.—Fit or used for digging or burrowing.

Foveola.—A cavity or small depression.

Front, frons—The upper forward part of the head.

Frontal.—Relating to the front or face.

Fuliginous.—Sooty; dark brown.

Fulvous.—Tawny or light yellowish brown.

Furcula.—The processes of the last abdominal segment of the male.

Fuscous.—Dark brown.

Fusiform.—Spindle-shaped.

Gena.—Cheek.

Gibbous.—Protuberant; swollen.

Glabrous.—Smooth or polished, not hairy.

Glaucous.—Whitish-blue, inclining to gray.

Globose.—Like a ball.

Granulated.—Furnished with minute prominences like grains of sand.

Griseous.—Light gray (white and black).

Gula.—Throat, concave portion below the head.

Habitat.—The place or region which an insect inhabits.

Hemisphercial.—Shaped like half a ball.

Hexagonal.—Six sided.

Hibernate.—To pass the winter in seclusion or sleep.

Host.—The individual furnishing food to a parasite.

Humeral.—Situated on or near a humerus or front corner of the thorax or wing cover.

Hyaline.—Transparent, with a greenish tinge.

Imago.—An adult or winged insect.
Immaculate.—Not marked; unspotted.
Integument.—Outer covering, skin.
Intercalary vein.— See p. 136.
Interspace.—Space between.
Interrupted.—Suddenly stopped or broken.

Labial palpus.—See p. 131.
Labium.—Lower lip.
Labrum.—Upper lip.
Lanceolate.—Lance-shaped.
Larva.—The second or worm-lie stage of an insect.
Lateral lobes of the pronotum.—The deflexed portions that cover the sides of thorax.
Linear.—Very slender.
Longitudinal.—Lengthwise.
Luteous.—Unmixed yellow; color of clay.

Maculate.—Spotted, marked with spots.
Mandibles.—Hard and horny jaws.
Marginal.—Situated on or near the margin.
Median.—Occupying the middle.
Membrane, membraneous.—A thin tissue; consisting of a thin tissue.
Mesonotum.—The upper or dorsal surface of the mesothorax.
Mesosternum.—The under surface of the mesothorax.
Mesothorax.—The middle part of the thorax, to which the wing covers and middle pair of legs are attached.
Metamorphosis.—Changes an insect undergoes before reaching maturity.
Metanotum.—The upper or dorsal surface of the metathorax.
Metathorax.—The posterior part of the thorax to which the wings and hind pair of legs are attached.
Metazona.—The posterior part of the pronotum.
Millimeter (mm.).—The thousandth part of a meter, equal to 0.03937 inch, or nearly 1-25th inch.

Nebulous.—Clouded; with uneven, cloudy markings.
Nerves.—The large ribs or veins of wing and wing-covers, extending from the base toward the apex.
Nervules. — The smaller connecting veins of the wings and wing covers.
Nocturnal.—Active at night.
Nymph.—An immature insect, active and feeding in the larval and pupal stages.

Obconic.—Conical, with the vertex pointing downward.

Oblique.—Slanting; when applied to the face, denotes that it slopes under and backward toward the breast.

Oblong.—With the transverse diameter much shorter than the longitudinal.

Obsolete.—Wanting or nearly so; indistinct.

Obtuse.—Blunt.

Ocellus, ocelli.—The three simple eyes.

Occiput.—The back part of the head.

Omnivorous.—Eating everything eatable.

Oötheca.—A case enclosing eggs.

Opaque.—Without any lustre; impenetrable by light rays.

Ovipositor.—The organ for depositing eggs.

Oviposition.—The act of laying eggs.

Pallid.—Pale or whitish yellow..

Palpus, palpi. — Articulated and movable organs attached to the maxillæ and mandibles.

Parasite.—An animal which grows and lives upon another.

Pellucid.—Transparent; translucent, but not necessarily colorless

Pentagonal.—Five-sided.

Percurrent.—Running through the entire length.

Piceous.—Pitchy, the color of pitch.

Pilose.—Having long, sparse hairs.

Plantula.—A cushion-like pad between the tarsal hooks or ungues; same as *pulvillus.*

Plumbeous.—Pale, blue gray, like lead.

Pronotum.—The shield which covers the front part of the thorax.

Prosternum.—The under surface of the thorax.

Prosternal spine.—A spine projecting from the under side of the prothorax.

Prothorax.—The anterior division of the thorax to which the head is joined.

Proximal.—Nearest; opposite of distal.

Prozona.—The front dorsal part of the pronotum.

Pubescent.—Covered with soft, short and not crowded hair, wool or down.

Punctate, punctured.—Containing numerous small, point-like depressions or punctures.

Pupa, pupal.—The third stage of an insect; the stage before the imago.

Pulvillus, pulvilli.—The little pads between the claws of the tarsi.

Pyriform.—Pear-shaped.

Reticulate.—With net-like veins or markings.

Rudimentary.—Not sufficiently developed to be of use.

Rugose.—Rough, wrinkled; furnished with numerous small elevations.

Rufous.—Dark reddish brown.

Saltatorial.—Fitted for leaping.

Scabrous.—Covered with small, slight elevations; rough like a file.

Scrobes.—Pits or depressions in which are placed the bases of the antennæ.

Segment.—Ring-like division or joint, as of the antennæ.

Serrate.—Saw-toothed.

Serrations.—Teeth like a saw.

Serrulate.—Finely serrate; having minute serrations.

Setaceous.—Bristle-shaped.

Sinuate.—Winding in and out; twice or more curved.

Sinus.—An excavation as if scooped out.

Smooth.—Without elevations or wrinkles.

Solitary.—Single.

Spatulate.—Paddle or spoon-shaped; flattened and broader at the apex than at the base.

Spinose.—Armed with spines.

Spinulose.—Furnished with *spinules* or diminutive spines.

Spiracle.—An external opening of the respiratory system.

Spurs.—The strong spines at the apex of the tibiæ.

Sternite.—The ventral part of each abdominal segment.

Sternum.—The ventral part of a body segment.

Stridulate.—To make a shrill sound; to grate, scrape or creak with the stridulating organs.

Styliform.—Shaped like a style.

Sub.—A prefix meaning nearly; almost; somewhat; under, etc.

Sub-costal vein. See p. 135.

Sub-median vein. See p. 136.

Sulcate.—Grooved, furrowed.

Sulcus, sulci (pl.).—A linear groove or channel; a groove-like excavation.

Suture.—A seam or impressed line; generally used in reference to the junction of two pieces or plates.

Tarsus, tarsi (tarsal).—The jointed foot.

Tectiform.—Ridged in the middle and sloping down on each side.

Tegmina.—The fore wings, upper wings or wing covers.

Terete.—Sub-cylindrical; straight, without enlargements.
Tergite (tergum).—The dorsal part of a body segment.
Testaceous.—Dull yellowish brown; tile or brick colored.
Thorax.—The part of the body of an insect to which are fastened wings and legs.
Translucent.—Transmitting very little light.
Transparent.—Transmitting light.
Transverse.—Crosswise; signifies that the part or area is broader than it is long.
Tri-carinate.—Having three keels or carinæ.
Trochanter.—The second joint of the leg.
Truncate.—Cut off squarely at the tip.
Tubercle.—A little solid pimple or excrescence.
Tuberculate.—Covered with tubercles.
Tympanum.—The membrane closing the ear.

Unarmed.—Without a spine.
Ungues.—The curved hooks terminating the tarsus.
Ulnar vein. See p. 136.

Valves.—Four horny appendages forming the ovipositor.
Veins—Nerves; ribs of a wing.
Veinlets.—Nervules; very small cross-veins of the wings.
Venation.—Method of distribution of veins.
Ventral.—Pertaining to the under surface of the abdomen.
Vertex.—The front portion of the upper surface of the head between and in front of the eyes.

Wing-covers.—Front wings; tegmina.
Wing-pads.—Undeveloped wings, as in the pupa or nymph.

REPORT OF STATE SUPERVISOR OF OIL INSPECTION.

INDIANAPOLIS, IND., December 31, 1902.

Prof. W. S. Blatchley, State Geologist of Indiana:

Dear Sir—I have the honor to submit to you my Fourth Annual Report, the same being for the calendar year, 1902.

The total number of barrels of coal oil inspected were 343,482, of this number 920 were rejected for illuminating purposes. Of miners' oil, 1984 barrels were inspected, 45 of which were rejected for use in the mines.

With this report our official relationship is ended. I beg to assure you, however, my sincere appreciation of your many kind acts, and loyal support during the many years we have been together.

I am, dear sir, your obedient servant,

W. C. ZARING.

DEPUTY SUPERVISORS OF OIL INSPECTION.

Andress, E. H. .... Lafayette.
Bell, T. E. .... Hammond.
Blatchley, F. H. .... Bainbridge.
Boltz, J. H. .... Winchester.
Bowman, M. J. .... Madison.
Cooper, W. V. .... Evansville.
Crabbs, O. W. .... Muncie.
Davenport, J. B. .... Elkhart.
Derr, Walter .... South Bend.
Dorsey, C. B. .... New Albany.
Dorsey, W. C. .... Terre Haute.
Johnston, J. M. .... Logansport.
Lane, C. R. .... Ft. Wayne.
Lockwood, W. W. .... Peru.
Markley, G. W. .... Crawfordsville.
Schutt, M. A. .... Michigan City.
Weems, R. F. .... Vincennes.
Zehrung, P. H. .... Cambridge City.

TABLE SHOWING THE TOTAL NUMBER OF BARRELS OF PETROLEUM OIL INSPECTED AT EACH STATION FOR THE YEAR 1902.

	Bbls.
Anderson	2,869
Angola	2,733
Argos	340
Attica	1,697
Auburn	2,275
Aurora	2,844
Batesville	842
Bedford	4,000
Bloomfield	2,229
Bloomington	1,448
Bluffton	2,425
Boonville	1,066
Bourbon	1,077
Brazil	3,176
Bremen	524
Brook	528
Brookville	1,447
Brownstown	872
Butler	597
Cherubusco	744
Cincinnati, O	3,726
Clay City	571
Cleveland, O	17,991
Clinton	1,479
Columbia City	1,345
Columbus	3,023
Connersville	2,197
Corydon	580
Crawfordsville	3,378
Crown Point	1,127
Danville, Ill.	405
Danville	1,518
Decatur	1,614
Delphi	815
Elkhart	3,917
Elwood	1,699
Evansville	19,230
Ft. Wayne	9,582
Fowler	1,861
Frankfort	2,815
Franklin	1,771
Garrett	197
Goshen	1,841
Greencastle	1,341
Greenfield	891

	Bbls.
Greensburg	1,245
Hammond	3,993
Hartford City	1,389
Hobart	619
Huntingburg	1,159
Huntington	3,620
Indianapolis	49,204
Jeffersonville	2,387
Jasper	158
Kendallville	2,358
Knox	484
Kokomo	2,796
Lafayette	10,522
Lagrange	1,088
Laporte	1,853
Lebanon	2,529
Liberty	861
Ligonier	1,636
Lima, Ohio	2,056
Lima	606
Logansport	3,210
Loogootee	686
Louisville, Ky	2,445
Madison	3,298
Mansfield, O	3,877
Marion	2,950
Martinsville	1,011
Medaryville	706
Michigan City	2,315
Middlebury	5
Mishawaka	460
Monroeville	386
Monticello	886
Mt. Vernon	875
Muncie	3,606
Nappanee	1,177
New Albany	4,291
New Haven	53
New Castle	2,092
Newport	620
North Manchester	1,376
North Vernon	1,528
Oakland City	740
Osgood	1,188
Paoli	1,133
Peru	2,924
Petersburg	556
Pierceton	585
Plainfield	1,275

	Bbls.
Plymouth	1,544
Porter	731
Portland	2,326
Poseyville	813
Princeton	1,755
Remington	905
Rensselaer	795
Richmond	5,428
Roachdale	346
Rochester	1,406
Rockport	906
Rockville	1,451
Rushville	1,730
Salem	1,207
Scottsburg	979
Seymour	1,873
Shelbyville	2,786
South Bend	8,083
Spencer	1,071
St. Joe	560
Sullivan	1,800
Tell City	1,019
Terre Haute	13,049
Tipton	1,228
Toledo, O	2,076
Topeka	240
Union City	3,059
Valparaiso	1,622
Veedersburg	1,675
Vevay	59
Vincennes	6,931
Wabash	2,421
Walkerton	1,157
Warsaw	1,564
Washington	2,049
Westfield	1,629
Whiting	8,475
Winamac	1,270
Total	343,482

TABLE SHOWING THE NUMBER OF BARRELS OF MINERS' OIL INSPECTED.

	Bbls.
Evansville	340
Terre Haute	1,424
Vincennes	212
Indianapolis	8
Total	1,984

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

OFFICE OF STATE NATURAL GAS SUPERVISOR,
KOKOMO, IND., January 12, 1903.

Prof. W. S. Blatchley, State Geologist:

Sir—In obedience to Section 7504 of the Revised Statutes of the State of Indiana, I submit to you herewith my Eighth Annual Report and the eleventh annual report from this department.

In closing this, my eighth year of service in this office, I desire to acknowledge the very cordial support that I have at all times received from you. It has been my constant endeavor to perform the duties of the office in accordance with the law and in so doing I have been very materially aided by your instructions, helpful suggestions and encouragement.

I respectfully submit this report and remain,

Yours sincerely,

J. C. LEACH,
State Natural Gas Supervisor.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

The law creating the office of State Natural Gas Supervisor makes it the duty of that officer to make a report to the State Geologist annually, which is incorporated in the annual reports of the Geologist and published. In these annual reports is to be given certain statistical information regarding the geological formation of the gas field, the rock pressure and production of gas wells, pipe lines used for the transportation of natural gas and such other data regarding the gas rock and the production of natural gas as will tend to make the reader familiar with the conditions in the gas territory. In other words, it is one of the lawful duties of the Natural Gas Supervisor to make public annually the true conditions in the gas field. The purpose of this provision of the law is plain. The law-makers thought it wise that not only the resources of the field be advertised to the world, but that the limitations surrounding the same be made known. It is hardly possible for the average consumer to know much of the progress and conditions in the field from actual observation, and it is certainly due him, and especially the large consumer, the manufacturer whose business prosperity depends largely on the life of this fuel, that the actual conditions in the field be made known at least once each year, if not oftener.

From the beginning the annual reports from this office have said, in substance, that the natural gas in this field, as in all other known fields, is a stored product, that has accumulated in rocks of a suitable structure to serve as a reservoir; or, in other words, we are drawing upon a fixed stock of this fuel from which a given number of millions of cubic feet can be used for a certain number of years, and when this stock is exhausted there is no more possibility of its renewal in the reservoir than there is of the growth of coal in the mines that have been worked. This statement is not the result of mere guesswork nor has it been deduced from false data. There are some facts regarding a natural gas reservoir, the generation and storage of natural gas that can be accurately ascertained by any one who will give the subject attention. The exact location of the gas rock, as well as the composition and texture of the same can be known. The composition of the gas contained in the gas rock is equally well known. At this time no one doubts the prevailing theory advanced regarding the origin of natural gas. In none of the deep wells that have been drilled in the various sections of the field has any material been found, aside from petroleum, from which natural gas could be generated. Then, considering the history of other gas fields, and the positively known conditions surrounding this gas territory, it has not required much of the prophetic instinct to foretell the future, except that no one knows when the gas reservoir will cease to honor the draught. How long will gas last? is a question often asked, and it is but natural that it should be, especially by those who have not given the subject much thought. There have always been a few "knowing ones" throughout the field who have given the public the benefit of their superior knowledge of the subject, but unfortunately they have had to revise their guesses every few months. I have always been frank to confess my ignorance. I do not know how long it will last. The life of this field, as of all other fields, must be determined by the extent of the reservoir (supply of gas) and the consumption. Regarding the former, its capacity has not been determined, nor can it be; nor is the latter known. The two principal factors in the case being unknown, the third must remain a matter of speculation until the last. And again I desire to say, and emphasize it, that year after year for the past eight years, I have said on all occasions, and especially in my annual reports, that the stock of natural gas was fixed, and that the near future could not bring anything but absolute exhaustion of the gas reservoir. In making this statement I have not claimed any superior knowledge of the subject, for this is the only rational conclusion to which any one can arrive who knows the conditions and considers them unprejudiced. During the early history of the field the statements that I made regarding the diminution of the supply of gas and the final exhaustion of the reservoir were very freely criticised by land agents, professional "boomers," a few citizens and newspapers who were more interested in booming the gas field regardless of consequences than they were in the real conditions of the field; but evidence in proof of my statements has increased with the years, and at present there is but little discussion or disagreement. I think that I know and fully appreciate the value of natural gas as a domestic and manufacturing fuel, and I understand what the loss of it means to the citizens of the gas belt and the State; yet, for any one or class of citizens to say that natural gas will last forever, that the geologists of the country know nothing about the subject, and that the reports of the Natural Gas Supervisor are false, has not changed the history of the field.

The Indiana natural gas field has been the most productive ever known. With thousands of others, I regret that its product was not from the beginning used as it should have been. If it had been sold as other fuels are, by measurement, and none permitted to be wasted, the end, in my opinion, would not be near. Pity it is that it has not been within the power of the State under existing laws to regulate the consumption of this fuel; for, through crude appliances and unscientific methods of use, a large per cent. of the gas consumed has been wasted. To an observer it seems that everything has conspired from the beginning to impress the consumer of natural gas that the supply is abundant for all time, regardless of how it is used. Under such conditions it has been difficult indeed to enforce the law regarding willful waste.

Let it be understood that what has been said regarding the annual reports from this office and the relation that the statements contained therein regarding the condition of the gas field bears to the present condition of the field has not been written in a spirit of "I told you so," but somewhat in self-defense. I would be glad if those who have been so willing to enlighten the public regarding the condition of the field and discredit the reports from this office would spend a little time in the field now. By a careful examination they might find some little evidence of a decline in the natural gas supply.

THE PAST AND THE PRESENT.

That period in the history of the Indiana natural gas field has arrived when the compilation of a report giving the true condition of the field is a difficult task. This has not always been so. During the early history of the field, and, in fact, until the last three or four years, very similar conditions were found throughout the entire gas area. Of course, there were some localities in which salt water appeared early, influencing both the rock pressure and the flow of wells, but these were confined to a narrow outer zone, and on account of the large area of productive territory, received but little consideration. At that time the rock pressure tended to equalize during periods of light draught, and was comparatively uniform throughout the field. But few failures were recorded, and the difference in the volume of flow was not marked. Exceptions to this general statement might be found in wells located in widely separated sections of the field, in which the texture of the gas rock varied. During the time under consideration it was but necessary to test a few wells in different localities to ascertain the field pressure. The progress of the field seemed to be regular and uniform. As I have said, this condition continued for a number of years. But now, how different! What at one time seemed to be one immense gas-holder or reservoir is apparently a number of small pools or reservoirs of gas of very limited production. A little investigation and consideration will convince the most skeptical that this is the real condition of the gas rock at present.

What is known as gas rock in this field is that part of the Trenton limestone that serves as a reservoir for the natural gas. This limestone is not always a gas rock; neither is it the only rock in which natural gas is found, for it is found more frequently in sandstone. In Indiana the gas rock is located in the upper part of the Trenton limestone. It is not equally porous throughout, and not of uniform thickness, as every driller in the field can testify. This gas rock seldom if ever comes to the surface of the Trenton limestone, from one to fifteen feet of the uppermost portions usually being hard and nonporous. It must be known, also, that not only the lower but the upper surface of the gas reservoir is very uneven, as the records of numerous wells throughout the territory will testify. A relief map of the upper surface of the gas rock would show many ridges, valleys, elevations and depressions. Then, it must be plain that as the supply of gas diminishes, the salt water will advance and finally meet the lower portions of the overlying strata of hard limestone first, completely occupying the gas rock at the lowest points. Thus, various localities in the field which differ only in the elevation of the gas rock become hermetically sealed, one from the other. And, instead of there being one gas reservoir, there are numerous small reservoirs, each completely sealed in by the salt water. At points near the border of these small gas-holders both gas and salt water seem to be present, waging an unequal warfare for possession of the rock.

THE CONDITIONS IN THIS FIELD.

The conditions described above are the conditions in this field at present. When the drill strikes a valley in the gas rock where the salt water completely occupies it, the result is evident. It is but reasonable that as the total supply of gas diminishes and the salt water advances that what seems to be small reservoirs at present will be divided and subdivided and the per cent. of absolute failures will become greater each year. And also, in the light of the above facts, the reason for the great difference in the life, rock pressure and volume of wells located in the same section of the field is plain.

And it is from the condition of these wells that the field must be judged. The average consumer who seldom sees a gas well, much less tests one, is indeed very poorly equipped to pass judgment on the condition of the gas field.

The history of this field during the past year is in many respects very much unlike that of former years. Every one at all acquainted with the early history of the field understands something of the manner of development from year to year. It followed natural and practical lines. For a considerable time after the field was discovered, systematic drilling was unknown. In locating wells, convenience to the distributing plant or consumer was given first consideration. Cities were supplied from wells within their limits, or the immediate vicinity, and factories seldom went beyond their own yard for fuel. This condition did not continue long. The transportation of natural gas long distances was practical, and cities outside of the gas belt coveted the new fuel. The fifth year after gas was discovered had not passed until pipe lines from six to twelve inches in diameter were conveying gas to cities and towns in every direction. These lines tapped the field at the nearest point, and thus an outer zone around the entire gas field was the first to be systematically drilled, and consequently the first to show signs of exhaustion. Pipe line companies very early saw the necessity for planning their field of operation; of leasing territory for future drilling. When the larger companies began to plan for future operations and to lease available territory, cities in the gas belt and manufacturers were compelled to do the same. Some of the larger gas companies have for years been paying rentals on a very large acreage, probably much larger than they will be able to drill. The result is that there is but little land in the gas territory that is not now or has been at some time under lease for gas or oil, or both.

As the territory near the edge of the gas area began to show signs of exhaustion, the pipe lines were extended toward what was thought to be the center of the field. As the pipe lines were extended year after year, new wells were drilled, sometimes one-fourth of a mile apart, but usually not nearer than one-half mile. At the beginning of this year it seemed to all who were at all acquainted with the field that it was completely developed, that is, that enough wells were drilled to drain the reservoir. Pipe lines from the west crossed and recrossed and headed near lines from the east, and so with lines from other directions. An occasional small area of gas territory could be found not drilled, but it was usually so located that it was under the influence of one or more pipe lines or had been tested and found unproductive.

With these conditions, and others that have been noted, the future of the gas industry at the beginning of 1902 was anything but bright, notwithstanding the fact that a few "expert" gas men, who probably had never seen a gas well, were telling the consumers throughout the field that there was plenty of gas; that the reports to the contrary were false.

Most gas companies have made an effort to obtain an adequate supply for the present cold season. How well they have succeeded to the present time is well known. But few main line extensions were necessary the past year, service and lateral lines being sufficient. Many of the wells drilled in 1902 were in territory once drilled, and where this was not the case the wells were drilled unusually close together. The per cent. of failures has been large, and the per cent. of really good wells very small. The average well has been small, and the gas found has been compelled to wage an unequal warfare with the salt water from the beginning. The wells drilled now are very short-lived, as must be expected from the condition of the gas rock. Most gas companies are keeping the drill busy during the cold weather in order to supply their consumers as long as possible. At this time many consumers in the gas belt that used gas last winter are using coal or wood.

ROCK PRESSURE IN THE FIELD.

As has been said in another part of this report, the rock pressure of the field varies greatly at this time, and while it is never an index of the capacity of a given well, the relation that it bears to the volume of flow becomes less as the supply diminishes. In what has been known as the main gas field, that is, the territory that is supplying the gas that is consumed by the principal factories and transported by the principal pipe lines, the average rock pressure is not above 40 pounds, and many new wells show even a lower pressure.

RE-DRILLING ABANDONED TERRITORY.

The scarcity of gas has caused a number of wells to be drilled in territory that has been entirely unproductive for a number of years. The results have been anything but encouraging to those who understand anything of the production, piping and consumption of natural gas. In one city in the gas belt, nine wells have been drilled the past year within the city limits in territory overrun with salt water and abandoned ten years ago. Five were absolute failures, and of the remaining five, the largest does not produce to exceed 150,000 cubic feet daily. From present indications all will meet an early salt water death. Notwithstanding failures in old territory, it is altogether probable that much of the field will be redrilled. After using this fuel for 15 years the people in the gas belt dislike very much to give it up, and will risk considerable in an effort to prolong the life of the supply. In many of the wells drilled in old abandoned territory the rock pressure is high, regardless of the small flow of gas, for, as I have said many times, the rock pressure is not an index of the volume of flow. A majority of the people, however, estimate a well by the rock pressure, and therein is found the reason for so many wells being drilled in territory that does not contain enough gas to pay for the fuel used in drilling the wells.

NEW TERRITORY.

Considerable drilling has been done the past year around the edge of the field, with the hope of finding some projection of the gas rock that had been missed in the early location and development of the field. As a result, on the northern boundary of the field in Wabash, Grant and Huntington counties, a number of productive wells have been drilled. Much of the gas used in Wabash, Converse, Huntington and Marion, this winter, is from this territory. The gas rock is not uniform in texture, and a number of "dusters" have been found, but the rock pressure is comparatively high, and enough gas has been found to warrant further development of the territory. It must be remembered, also, that the price of natural gas has advanced during the past two or three years, and that wells once unprofitable can be operated with profit now.

NATURAL GAS AS A MANUFACTURING FUEL.

In former reports I have said that natural gas would be used as a domestic fuel in the gas belt long after it is abandoned as a manufacturing fuel and by pipe line cities. At this time the truthfulness of the above statement is admitted by all. But few factories in the most favored localities are depending entirely upon gas now, and those that do are compelled to shut down occasionally. Some factories run at night time only, and thus take advantage of the light draught on the gas supply. It is probably not necessary for me to say here that the conditions of the gas field are such at this time that natural gas can no longer be depended upon as a universal fuel for any purpose.

Of course, residents of the gas belt are anxious now, as they have always been, regarding the manufacturing industries that located in this section of the State on account of the natural gas. I feel warranted in saying with increased emphasis, as I have said many times before, that when the supply of gas is exhausted that a large majority of the factories will successfully adopt other fuels and remain here. This is especially true of those factories that have proven to be successful business enterprises. Some of the largest factories in this part of the State have been erected the past year. These are equipped with the most modern appliances to use coal, and are in successful operation at this time. Older factories are either supplementing their gas supply with coal or are equipping their factories for coal with the purpose of abandoning natural gas as fuel.

OIL IN NATURAL GAS TERRITORY.

Natural gas and oil are usually spoken of as associated products of the earth's crust, and the Indiana natural gas field and the Indiana oil field are accordingly thought of as one and the same territory by those not engaged in either business. Unquestionably, these products have the same origin and were generated under similar conditions, and it is also true that natural gas and oil are frequently found in the same rock, but, nevertheless, that oil always follows gas, as is heard so frequently in the Indiana field, is not true. In Indiana there is an area that is distinctly oil territory. It never has been gas territory, although in some cases enough gas has been found to operate the oil wells. There is an area that is distinctively gas territory, showing no signs of oil. There is also considerable territory that produces both gas and oil. What is known as the Indiana oil field is located on the northeastern border of the gas field, and occupies a portion of six counties, viz.: Jay, Adams, Huntington, Wells, Blackford and Grant. This is distinctively oil territory, though that part of it lying in Blackford and Grant counties and part of that portion in Jay County was formerly gas territory. Van Buren Township, in Grant County, and Washington and Harrison townships, in Blackford County, are wholly in this territory. The territory to the south and west of this is gas territory, though the oil industry is rapidly invading it.

In June, 1899, a "wildcat" well was drilled on the B. F. Van Vactor farm, about three miles southeast of Marion, Grant County. It showed both gas and oil in large quantities, and was promptly closed by the State to prevent the waste of gas, which discouraged and stopped the progress of the oil industry for the time. Early in 1900, the gas pressure had so decreased in that section of the field that oil wells could be operated in localities near large pipe lines or where the gas could be consumed near the wells. Since that time the oil industry has had a steady growth in that part of the original gas field. The per cent. of failures is small, and though the operator is compelled to pump much salt water, some of the leases have been quite profitable. Much of the developing for oil in this locality is done by manufacturers or oil companies prepared to care for the gas. From the hundreds of wells drilled for oil, much of the gas consumed in the factories in Marion comes. Operations in this particular locality have to date been confined to Center, Franklin, Mill, Monroe and Washington townships. This part of the gas field has exhausted very rapidly the past year, and at present there is but little gas, as is evidenced by the fact that many drillers are compelled to use coal. From this small field the oil operators are pushing toward the northeast, and it will only be a short time, from present indications, until this territory can be classed as a part of the Indiana oil field.

Oil has been found in a number of wells in the vicinity of Fairmount, Grant County, and the indications are decidedly favorable for a productive field as soon as the gas pressure has decreased to a point where the oil can be produced without wasting the gas.

In former reports considerable space has been given to the oil industry in the vicinity of Alexandria, Madison County. From the beginning this has been very productive gas territory and the determined effort made in former years to develop the oil industry has very seriously interfered with the gas production. A number of very productive oil wells were drilled in this locality in 1898. There was considerable delay in closing them and an enormous amount of gas was wasted. They were finally closed by the State. After this nothing was done toward developing this section of the field for oil until 1901, when a second effort was made, mostly by manufacturers this time, to develop the oil industry. About seventy-five wells were drilled for oil during the year mentioned. Large pipe lines were laid to the wells and most of the gas was consumed by factories in Alexandria. While but few absolute failures were reported and some of the wells were large producers when drilled, the history of the field is disappointing to the oil industry. With the exception of two or three leases the production has decreased rapidly from the beginning. At present a very small per cent. of the wells once productive are being operated and that part of the field can hardly be classed as oil territory.

During the latter part of the year 1900, what seemed to be a very productive "oil pool" was found near Hartford City, and in fact I might say in Hartford City, for many wells were drilled within the city limits. It was not possible to ascertain the normal production of the wells at first on account of the gas pressure. It was not long, however, until pipe lines from the city gas plants and factories were prepared to care for the surplus gas. Most of the wells drilled in this pool have been abandoned, but the drill is pushing north and west and from present indications this part of Blackford County will soon be a part of the main oil field.

Delaware County has comparatively few oil wells. In the eastern part of the county a few profitable wells have been drilled this year. There is but little surplus gas and there is no incentive whatever to waste it, as it can be disposed of at a profit near by.

Washington, the northwest township of the county, has produced a little oil since 1898, but the high gas pressure has discouraged the oil operator who was not prepared to care for the gas.

A few productive oil wells have been drilled the past year in the vicinity of Parker, Randolph County. But little gas is found with the oil, scarcely enough to operate the wells.

THE WASTE OF NATURAL GAS.

This is certainly not a new subject. Of all subjects kindred to the natural gas industry, it has probably been most discussed. Especially has it been a fertile field for the local correspondents of newspapers. As with most subjects in which the public are interested, some things have been said that were true and much that was not. To persons acquainted with the real conditions in the gas field and the production and consumption of natural gas it seems that most of the articles published in two or three of the local papers and the "specials" sent out from the gas field have been written without any knowledge of the conditions in the gas field or else with no regard for the facts. Probably many of the misrepresentations regarding the conditions in the gas field that are circulated can be charged to a lack of knowledge of the real conditions on the part of those who pretend to know. A man spends one day in the gas field and poses as an "expert." And again, those who have criticised this office most severely for failing, as they aver, to stop the waste of gas, utterly fail to distinguish between waste that is prohibited by law and that that is not, and to consider the area of the gas field, the many avenues of waste and the help at my command to enforce the law.

I have referred to the different classes of waste in former reports and will refer to them very briefly here, that the reader may distinguish between that waste that is prohibited by law and that that is not. Fully one-half of the questions coming to this office pertain to this subject.

That natural gas has been wasted and is being wasted no one will deny who is at all acquainted with the field; and more, it will be wasted as long as there is any to waste. That is to say, the time will not come when all consumers of natural gas will use such appliances as will burn all the gas and put the heat where it belongs. It is generally understood even by those interested in the natural gas industry that the laws of the State prohibit the waste of natural gas. This is true in part only. Some of the greatest avenues of waste do not come under the inhibitions of the law.

HOW NATURAL GAS HAS BEEN WASTED.

In the consumption of natural gas both by domestic and manufacturing consumers it is wasted. A majority of the domestic consumers use it in such a manner as to waste fully 50 per cent. of its heating power. In how many residences in the gas belt and pipe line cities, too, is the gas all burned and the heat applied where it belongs? Incomplete combustion is the rule rather than the exception, and that always means waste. What has been said about wasteful methods of consumption by domestic consumers will apply with equal force to manufacturers. In the days of plenty, when a shortage of gas was not known, the very crudest of appliances imaginable were used in a majority of factories. Consumers have not been ignorant of these conditions and the certain result. Year after year in my annual reports attention has been called to the wasteful methods of using it practiced by all classes of consumers. What the result would have been if the same degree of economy had have been practiced in the use of natural gas from the beginning by all classes of consumers as is practiced in the use of other fuels I can not say. One thing is certain, we would not be at the end yet. *The class of waste just referred to is not prohibited by law.*

GAS USED TO PUMP WATER.

Gas is used to pump water throughout the entire gas field by farmers and drillers. In some cases these pumps are allowed to run day and night. The amount of gas used is governed entirely by the condition of the pump and the pressure of the gas. These pumps are a great convenience to farmers who have a large amount of stock to water as they are to drillers who have to pump water a long distance. The best that can be said is that it is a very extravagant use of gas and in some cases it is positively wasteful. There is no statute that directly prohibits the use of gas in pumps or engines. In a few cases where the engine was out of repair and was wasting the gas in large quantities I have, following the advice of the Attorney-General, tried to apply the general law prohibiting the waste of gas, but have failed to make a case in every instance. If it could be proven that the purpose of using the gas in the pump or engine was to get rid of the gas or waste it, as is sometimes asserted, the law would doubtless apply. That would be difficult to prove in any case.

NATURAL GAS FLAMBEAUX.

A State law prohibits the use of natural gas for illuminating purposes in flambeau lights (Acts 1891, page 55). The early history of the field on this subject is familiar to every one. Flambeaux were the universal out-door light for farmers, drillers, oil operators, and but few manufacturers used any other light. For many years after the enactment of the law, public opinion was bitterly opposed to its enforcement. Even manufacturers, who of all others should have been interested in every effort to protect the natural gas supply, most bitterly opposed the enforcement of the law. During my term of office I have given my best efforts to the enforcement of this law, though it has been a difficult and usually a thankless task. It has not been an unusual thing for those parties who have made the most noise about the waste of gas in general to be the first to cry out against the injustice of the law. I do not say that no flambeaux are used. The gas and oil fields cover a large territory and it is impossible for me to see all parts of the field at once. It should be understood, also, that many times flambeaux reported by people traveling in the night time through the gas or oil fields are not flambeaux, though the light seen appears to be such. An open boiler door, a cluster of jumbo tips, an open fire for heating purposes, or even a single jumbo tip, seen at a distance can not be distinguished from a flambeau. The flambeau law is well observed througnout the gas field.

THE WASTE OF GAS FROM OIL AND GAS WELLS.

A State law makes it unlawful for "any person, firm or corporation having possession or control of any natural gas or oil well, whether as contractor, owner, lessee, agent or manager, to allow or permit the flow of gas or oil from any such well to escape into the open air, without being confined within such well or proper pipes, or other safe receptacle for a longer period than two (2) days next after gas or oil shall have been struck in such well." The law further provides as follows: "and thereafter all such gas or oil shall be safely and securely confined in such well, pipes or other safe and proper receptacles." To enforce the letter of this law would mean the absolute annihilation of the oil industry in this State. There have been but few oil wells drilled in this State that did not show a little gas soon after the Trenton limestone was struck. Though the amount of gas is probably not enough for a common flambeau, yet under a literal interpretation of the law it is a violation. To complete an oil well within two days next after gas is struck is in most cases impossible. Then, must a well such as the class referred to above be closed when the two days have expired regardless of whether it has been finished or not, in order that a very small amount of gas without value where it is, may be shut in the ground; or can the well be completed and the gas utilized to operate it? It is hardly necessary for me to say here that there are a very few manufacturers in the gas belt that have openly proclaimed their opposition to the oil industry. During the past two years they have in some cases fought it with relentless energy, but with little avail. They were unreasonable in their demands and sought to persecute those interested in one of the most valuable industries in the State rather than prosecute those who violated the law. They were not content with the way this office enforced the law. They sought to take matters into their own hands for a while, but failed. It is but fair to say that most of these parties are now in the oil business.

In December, 1901, I addressed a letter through Prof. W. S. Blatchley, the State Geologist, to Hon. W. L. Taylor, Attorney-General of Indiana, asking a construction of the law. December 17th I received an opinion from that officer covering the subject quite fully. In concluding his opinion, Mr. Taylor says: "That the well must be closed and the gas confined within two days after the first *forcible* flow of gas has been struck." And then again to the question, When shall the supervisor begin to count the two days? the Attorney-General answers, "At the time the first *profitable* flow of gas appears from the well." This is certainly a reasonable construction of the law and I am endeavoring with the limited amount of help at my command to enforce a strict observance of the same.

While during the past year sixty-four affidavits were filed against oil operators and manufacturers for violating the law, in but two cases did I find what seemed to be a manifest disposition to violate the law. In many cases the person responsible for the violation of the law had been but a short time in the field and had not acquainted himself with the provisions of the law. In but one instance has it been necessary to file the second affidavit.

WASTE OF GAS FROM PIPE LINES.

Natural gas escaping from the many pipe lines that line nearly every road in the gas belt attracts the attention of the public more than any other class of waste. A very small amount of gas whistling from a pipe line near the highway usually attracts more notice than 100,000 cubic feet of gas escaping from a gas or oil well. I do not underestimate the amount of gas wasted from pipe lines and am giving much of my time to the enforcement of the law relating to the same. There is much misunderstanding regarding the provisions of the statute relating to pipe line waste. Previous to 1899, there was no law prohibiting pipe line waste, and the General Assembly that met that year enacted a law making it the duty of the Natural Gas Supervisor upon the discovery of any leak in any pipe line to notify the owner or superintendent of the same to repair the line, and in case he does not do so within two days after receiving the said notice it then becomes the duty of the supervisor to make such repairs as may be necessary to stop the leak and collect all costs of the same from the owner of the line. I am frequently requested to have persons arrested for permitting gas to escape from a pipe line. To those who read the law the reason that I do not is certainly plain. Giving the two days' notice as is provided by law has been sufficient to date.

THE PLUGGING OF ABANDONED GAS AND OIL WELLS.

Though this subject has been referred to in former reports, I desire to call attention to it again. It is well known by all interested in the subject that the law is defective. It stipulates the manner of plugging wells and provides a penalty for its violation which is entirely inadequate. This is not the worst. The law provides no way by which the supervisor can ascertain when a well is to be plugged, and if plugged, it is next to impossible to prove that it has not been plugged properly. Complaint is made to me that a well has been abandoned and not properly plugged. The person making the complaint was not present when the tubing and casing were taken from the well and, in all probability, can not cite any person that was. The only evidence that the well is not properly plugged is the condition of the oil and gas rock in the vicinity of the well. A large number of wells have been abandoned the past year, and the annual number will increase. There is little doubt but that many of these have been left practically open, thus allowing the water to rush in and occupy the surrounding rock. I have brought two suits under the law during the past year. In each case the party was fined a small amount and the well remains open. The damage was done long before the suit was brought.

A bill was submitted to the last Legislature that sought to remedy the defects in the present law. It was indorsed by the principal gas companies and oil operators of the State. It was passed by both branches of the Legislature without a dissenting voice. The Governor vetoed it.

REPORT OF STATE INSPECTOR OF MINES.

OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, IND., February 10, 1903.

Prof. W. S. Blatchley, State Geologist:

Dear Sir—I have the honor to submit to you herewith my fourth annual report as Inspector of Mines, covering the calendar year of 1902, and being the twenty-third annual report of this department and the twelfth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and will be found worthy of the consideration of the public.

JAMES EPPERSON,
Inspector of Mines.

CONTENTS.

INTRODUCTION.

It is almost impossible and certainly undesirable to make extensive changes in either the form, or the substance of each annual report. When a good form of report has been arrived at, covering the subjects and including the information of general interest, it would be unwise to depart largely therefrom. It would depreciate the value of the report to pad it with useless and uncalled for matter, for the sole only purpose of enlarging the report. For this reason the report is, in general, along the same lines as my last report. We have, we think, however, in this report given some interesting and important additional information.

The production of coal has been treated in a manner similar to our former report, but it has been subdivided much more. The machine mined block coal has been separated from the machined bituminous coal, and the hand mined block and bituminous have been treated in the same way. The production of pick and machine mined coal are likewise separated. The number of mules used, the number of miners employed, the average production per miner, the general distribution, and other matters usually included.

Of course, the totals are given in each case, in fact, more totals are given than ever before. A general summary of totals will be found at the end of the report, thus facilitating the finding of these statistics, and making an addition to the report.

The table of machine mined coal is a new feature of the report. It gives this production by mines and by counties, and subdivides the same, giving the number of machines, the kind of machines, the production and the average tons produced per miner.

An estimate is given in the general review and in a note under the table of machine mines of the number of pick or hand miners displaced by the introduction of mining machines. The computation is made upon last year's production, and varying conditions may cause this estimate to lack absolute accuracy, but it is believed that the same is practically correct.

A table has been added to the report, showing the purchase of coal land during the year, giving the name of the owner, the number of acres of surface and of coal, the geological number of coal seams, the thickness thereof, the average thickness of the same, the location of the land and the facilities for transporting the coal.

It is hoped that the effort will be rewarded by its usefulness and the interest taken therein by the public.

CONDITION OF COAL TRADE FOR 1902.

A review of the coal trade and mining conditions for the year just ended discloses a gratifying state of affairs in all their various branches. Never in the history of the State have more satisfactory conditions existed. There was a strong healthy market during the spring and summer months at good prices for all grades of coal and a demand during the fall and winter greater by far than the supply, comparatively steady employment for labor at higher wages, with one exception, than ever paid in previous years, almost a total absence of strikes and a reasonably good car supply at the mines. Considering the unusual increased demand for coal, transportation, with the exception of one or two short periods of time during a heavy snow fall or excessively cold weather was all that could be expected. In this respect, the Southern Indiana railroad management deserves great credit notwithstanding the fact that the road has been built only a little over two years and traverses one of the most extensive coal fields in the State, and that more new mines have been opened on this road within this period of time than on any other road in the State, yet the mines have lost comparatively little time on account of either the car supply or transportation. And it may be said that the greater part of the time lost was due to the inability of other roads to handle the coal delivered to them by the Southern Indiana.

Whenever the other roads became congested with business, they laid an embargo on the Southern Indiana coal, and refused to accept the business and thus made it impossible for this road to transport its coal with dispatch.

COAL FAMINE.

During the time of making this report the insufficiency of the coal supply amounted to almost a coal famine, in Indianapolis and throughout the greater part of the gas belt the result being much suffering among the domestic consumers, and loss and inconvenience to manufacturers who, in many instances, were closed down for want of fuel. The mine operators and railroads were both subject to severe criticism by the general public for this state of affairs; and, in justice to them, it may be said that neither of these parties were to blame.

The real cause of the shortage in the coal supply is attributable to the following conditions: The prolonged strike in Pennsylvania, causing thousands of tons of soft coal to be shipped to supply the anthracite market, the almost complete failure of gas throughout the greater part of the gas belt of Indiana, thus causing an increased demand for Indiana coal, and the unprecedented activity in manufacturing of every kind, and thereby causing a larger consumption of coal. Another factor in the inability of consumer to get coal was the lack of foresight on the part of the people in not ordering coal until the supply had been entirely exhausted. This caused an excessive demand for a short time.

So great was the demand for coal, that, in ordinary weather, the coal-carrying roads were worked nearly to their limit. The above conditions coupled with the fact that in excessive cold weather, or during a heavy snow fall, the carrying capacity of a railroad is reduced considerably, explains clearly the coal shortage.

NEW AND ABANDONED MINES.

Twenty new mines were opened during the year, one in the block field and nineteen in the bituminous; while four block mines, and seven bituminous mines were abandoned.

Nearly all of the new mines, especially those in the bituminous field, are equipped with up-to-date mining machinery, such as machines, self-dumping cages, shakers, screens and other modern appliances for handling and preparing a large output of coal, which will increase the producing capacity of Indiana mines to a very considerable extent.

COAL PRODUCTION.

There was mined in Indiana during the year 1902, 8,763,197 tons of coal, which shows a net gain over 1901, of 1,743,994 tons, being an increase of nearly 25 per cent. (See comparative tables.)

For the coal mined in 1902, there was paid $7,078,913.12, showing a total increase over 1901 of $1,398,373.26, being an increase of nearly 20 per cent. (See comparative table.) The increase in the production of coal for the past year is due, to a large extent, to improved machinery and appliances, especially to mining machines. Their use is increasing rapidly, more particularly in the newly developed coal fields, and this has resulted in the displacement of a large number of hand or pick miners.

It is shown in the summary and note at the end of the table, relative to the production of coal in machine mines, that 923 pick miners have been displaced by mining machines, that is to say, 923 more men would have been required to mine the amount of coal produced last year, if no mining machines had been in use.

There was a decrease in the production of block coal during the year of 72,242 tons. This was due almost entirely to the fact that a greater number of the good producing mines were worked out and abandoned than new ones opened.

There were 13,139 mine workers employed during the year, making the greatest number ever employed in any one year, as will be seen by comparing the years 1895 to 1901. Of the coal mined in 1902, 4,581,964 tons were consumed in Indiana, and 4,181,233 tons were shipped out of the State, Chicago being the principal foreign market.

NEW INVESTMENTS.

Never in the history of the State was capital so eager for investment in coal lands as at the present time. Greene and Sullivan counties being comparatively new fields and having a large amount of undeveloped coal property, received most attention from purchasers and large sums of money have been invested in these counties. An effort was made by this department to find out the number of tracts purchased and the average amount in each tract; but while we have been fairly successful, yet we were unable to gather full data in each case. We give in another part of the report a table showing the names of companies, the number of acres purchased by each, and total area of coal underlying the surface of each tract. As shown by this table, there has been purchased 34,066 acres of land. In most instances the purchase includes only the mineral, with proper surface rights to mine the coal. By referring to the table, it will be noticed that a considerable portion of the land is underlaid with two or three seams, a compilation of which shows a total area of 56,224 acres of coal, averaging 5 feet 4 inches thick; or calculating each cubic yard of coal to weigh a ton and allowing 20 per cent. for coal lost by being left in the mines for pillars and on account of falls, bad top and other causes, the field of coal purchased in 1902 will last for over 50 years, basing the estimate on the output and sales of 1901.

TERRE HAUTE AGREEMENT.

April 1, 1902, to April 1, 1903.

Pursuant to an agreement made between the coal operators and United Mine Workers of America of Illinois, Indiana, Ohio, and Pennsylvania, made at Indianapolis, Indiana, February 8, 1902, the price of mining for bituminous coal in the State of Indiana shall be 80 cents per ton of 2,000 pounds for screened lump coal, made over a standard screen, and 49 cents per ton of 2,000 pounds for run-of-mine. That further details in scale of prices for pick and machine mining in the State of Indiana for one year, beginning April 1, 1902, shall be as follows:

The standard height of coal in Indiana shall be 3 ft. 6 in., excepting in mines already opened, where the standard height shall be 3 ft. 3 in. All coal less than 3 ft. 3 in. in thickness and over 2 ft. 9 in., the price shall be 88 cents per ton for mine-run coal. All coal less than 2 ft. 9 in. and down to 2 ft. 6 in., the price shall be 96 cents per ton for screened lump coal and 59 cents per ton for mine-run coal.

Narrow entries 7 to 9 ft. wide, $1.66 per yard.

Wide entries 12 ft. wide, $1.03½ per yard.

Wide entries shall not be more than 13 ft. nor less than 11 ft. In the event of a 10 or 11 ft. entry being demanded by the operator, narrow entry prices shall be paid; if 14, 15, 16 or 17 ft. entries are demanded the wide price shall be paid.

The right of the operators to drive an 18 ft. room when necessary shall not be questioned.

Break Throughs.

Break throughs between entries shall be paid for at entry prices. Break throughs between rooms, when sheared or blocked, shall be paid for at entry prices, but no break throughs shall be driven without consent of the operators. Nothing herein shall interfere with the law governing break throughs.

Room Turning.

Room turning, $4.00.

Room necks to be driven 12 ft. in and widened at an angle of 45 degrees when so desired by the operator. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 ft. When room necks are driven 12 ft. wide, the price shall be five-eighths of regular price, or $2.50.

Machine Mining.

In entries 7 to 9 ft. wide, $1.19.

In entries 12 ft. wide five-eighths of price for narrow entries, or 74 cents.

Narrow work after punching machines shall be sheared when demanded by the operator. Narrow work after the chain machine must be done in a workmanlike manner.

BREAK THROUGHS.

Break throughs between entries, same as entry prices. Break throughs between rooms shall be paid for at same price when similarly driven.

ROOM TURNING.

Room necks to be driven 12 ft. in and widened at an angle of 45 degrees when so desired by operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 ft. When room necks are driven 12 ft. wide, price shall be five-eighths of regular price, or $1.87.

DAY WORK FOR PUNCHING MACHINES.

Machine work, when paid for by the day, shall be for machine runner, $2.82.

Helper, $2.25.

DAY WORK, CHAIN OR CUTTER BAR MACHINE.

When paid for by the day shall be for machine runner, $2.67½.

Helper, $2.67½.

Day work by machines shall apply only to opening new mines and defective work, such as horse backs, etc.

PRICE PER TON FOR MACHINE MINING.

FOR PUNCHING MACHINE.

Vandalia Track and north thereof:

Screened Lump.—Runner, 10c; Helper, 9c; Loading, Shooting and Timbering, 43c. Total, 62c.

Run of Mine.—Runner, 6½c; Helper, 6c; Loading, Shooting and Timbering, 26½c. Total, 39c.

SOUTH OF VANDALIA TRACK.

Screened Lump.—Runner, 9c; Helper, 8c; Loading, Shooting and Timbering, 45c. Total, 62c.

Run of Mine.—Runner, 5¾c; Helper, 5¼c; Loading, Shooting and Timbering, 28c. Total, 39c.

FOR CHAIN MACHINE.

Screened Lump.—Runner, 5¼c; Helper, 5¼c; Loading, Shooting and Timbering, 48c. Total, 58½c.

Run of Mine.—Runner, 3¼c; Helper, 3¼c; Loading, Shooting and Timbering, 30c. Total, 36½c.

Machine shovels shall be furnished by the operators, but when replaced the old shovels must be returned, and in case of careless breaking or destruction, the helper shall pay for the shovel so destroyed.

Blacksmithing.

Price of blacksmithing shall be 1¼c on the dollar. Sharpening shall be done in a workmanlike manner and men shall not have to wait for their tools.

Day Labor.

Inside day labor shall not be less than $2.25 per day of eight hours, when men are employed, and track men and timber men shall receive $2.30 per day of eight hours.

And for outside day labor on and north of the B. & O. S. W., the minimum price shall be $1.80 per day. South of the B. & O. S. W., the price shall be 18c. per hour.

All outside day laborers working at the mines, excepting weighmasters, flat trimmer and dumper, who shall be regarded strictly as company men, shall be recognized as members of the United Mine Workers of America, and present conditions and hours of labor shall prevail during the existence of this contract: And provided further, That in emergencies or in the absence of any regular employe the right of the operator to employ men not members of the United Mine Workers of America for outside day labor shall not be questioned. Any and all flat trimmers shall dock for dirty coal.

Dead Work.

1. It is agreed that the companies shall have the working places as dry as local conditions will permit, and said working places shall be in working condition at time of starting work in the morning. If any company shall fail to have said working places dry or reasonably so one hour after starting time two successive days, the company shall, if said failure is traceable to neglect or carelessness of the company's agent, give miner or miners so affected other work or pay him or them for time so lost.

2. The question of slate in or over the coal shall be and is regarded a local question to be taken up and adjusted by the methods provided in the annual Terre Haute agreement for the settlement of disputes: Provided, however, That established usages and prevailing conditions shall not be changed except in new mines where they have not been considered and adjusted.

3. Where bottom coal is excessively hard to take up the operator shall have the option. If he demands that it be taken up he shall pay extra therefor: Provided, That where coal so left shall exceed four inches in thickness it shall be taken up by the loaders and paid for by the machine men, but this shall not apply when caused by sulphur, boulders, rock, or any unusual condition.

General.

1. When the coal is paid for mine run, it shall be mined in as good condition as when paid for on the miner's car. It shall, as nearly as possi-

ble, be free from slate, bone coal, or other impurities, and, if it can be shown that any miner persistently violates the letter or spirit of this clause, he shall be discharged. Persistently, as used in this clause, means three cars the first week and two cars in any succeeding week. Nor shall he load an undue proportion of fine coal in any one car, but shall see that the fine coal is mixed with the large coal in such a way as to make a fair quality of mine run coal. This provision for cleaning coal and penalty for failure also applies to screened lump coal.

2. The semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme Courts of Indiana and of the United States.

3. The time of beginning work in the morning and the length of intermission at noon shall be considered a local question.

4. That the above scale is based upon an eight-hour work day; that it is definitely understood that this shall mean eight hours' work at the face, exclusive of the noon time, six days in the week or 48 hours in the week, and that no local ruling shall in any way deviate from this agreement, or impose conditions affecting the same, but any class of day labor may be paid at the option of the operator for the number of hours and fraction thereof actually worked at the hour rate, based on one-eighth of the scale rate per day; provided, that, when men go into the mine in the morning, they shall be entitled to two hours' pay whether the mine works or not; excepting in event of a mine being closed down by action of any member or members of the United Mine Workers of America, the two hours' pay shall be forfeited.

Regarding Drivers.

They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the change at which they receive empty cars, but in no case shall a driver's time be docked while he is waiting for such cars at the point named.

5. Inside day work may be done upon idle days, and in case of emergency on overtime.

6. It is agreed that if any difference arises between the operators and miners at any time, a settlement shall be arrived at without stopping work. If the parties immediately affected can not reach an agreement themselves the question shall be referred without delay to a board of arbitration consisting of two operators, selected by the operator interested, and two miners, selected by the local union of the United Mine Workers of America involved. In the event of these four being unable to reach a decision, they shall select a fifth man, and the decision of the board so constituted shall be final, but no miner or operator directly interested in the differences shall be a member of such board.

7. The duties of the Mine Committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines, except as hereinafter set forth in Article No. 16. In case they fail to agree, they shall proceed to adjust the trouble by the selection

of an arbitration board as provided in Article 6 of this agreement. The Mine Committee shall have no other control, nor in any way interfere with the operation of the mine, and, for violation of this agreement, the committee or any member thereof or mine boss or superintendent shall be discharged.

8. That under no circumstances will the operators recognize or treat with a Mine Committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

9. The operator shall have the privilege of working a night shift for cutting coal with machines. All men so employed shall be paid 25 cents extra for each eight hours' work at night, in addition to the scale price per ton.

10. Work on driving entries and drawing pillars may be by double shift at the option of the operator.

11. This contract shall in no case be set aside because of any rules of any local union of the United Mine Workers of America. Nor shall there be any rules made controlling or affecting the operations of the mines, nor shall any change be made in accepted rules without the operators and miners first consulting and agreeing thereto.

12. Coal may be dumped as slowly as the operator may find necessary to thoroughly screen it, even if the car is brought to a stop, but it shall not be dumped in such a way as to throw the coal over the car door or unnecessarily break it.

13. Any miner knowing his place to be unsafe, shall protect same without delay and shall go into the mine for that purpose outside of regular hours and on idle days.

14. No restrictions shall be placed on the amount of coal which machines may mine, nor on the number of cars that any miner may load in any specified time.

Men shall work double in wide entries at option of operator in developing the mine or for running entries for purpose of increasing production.

Enough extra loaders shall be employed in each mine so that the full complement of loaders agreed upon to follow each machine shall be at work every day that the mine hoists coal.

Where three places are now given to two loaders the custom shall continue.

No more than three places for two men nor two places for one man rooms 30 feet wide or over equipped with two tracks shall be considered double places; and two loaders may be limited to two such places.

In Sullivan County, where men work double in two rooms 25 to 30 ft. wide with track up the center, the custom shall continue.

Whenever a new mine is opened it shall be governed by the same rules existing in other contiguous mines in the same vein of coal.

15. The price of powder per keg shall be $1.75. The miners agree to purchase the powder from their operator, provided, it is furnished of standard grade and quality, that to be determined by the operators and expert miners jointly where there is a difference.

16. Engineers shall be paid the present rate of wages. Eight hours shall constitute a day's work. But the engineers shall, outside of regular hours, hoist and lower the men, and in addition shall perform all the

duties which necessarily and usually pertain and belong to an engineer's position, and shall not receive any extra pay therefor.

It is agreed further that no hoisting engineer shall be subjected to the interference or dictates of the Mine Committee nor the local unions, but all the differences between the engineer and his employer shall be adjusted by the officers of the United Mine Workers of America and employer interested.

17. The prices now paid firemen and blacksmiths, together with present condition of employment and hours of labor, shall continue during the existence of this contract.

18. It is further agreed that the operators shall offer no objection to the check-off for the check-weighmen and for dues for the United Mine Workers of America, provided that no check-off shall be made against any person until he shall have first given his consent in writing to his employer.

This applies to all day work as well as miners.

INDIANA BITUMINOUS COAL OPERATORS' ASSOCIATION.
By J. SMITH TALLEY,
President.
P. H. PENNA,
Secretary.

UNITED MINE WORKERS OF AMERICA, DISTRICT No. 11.
By W. D. VAN HORN,
President.
J. H. KENNEDY,
Secretary-Treasurer.

BRAZIL AGREEMENT.—CONTRACT.

Pick Mining Scale for 1902.

Contract between the Operators, Miners and Day Laborers of the Brazil Block Coal District from April 1, 1902, to April 1, 1903.

1. Entered into this first day of April, 1902, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and United Mine Workers of America, of Indiana, Illinois, Ohio and Pennsylvania, made at Indianapolis, Ind., February 8, 1902.

3. The price for mining screened block coal in the Block Coal District of Indiana shall be 90 cents per ton of 2,000 lbs., it being understood also that the price for digging unscreened coal shall be an equivalent of the price paid for screened coal.

4. That further details in scale of prices for pick mining in the Block Coal District shall be as follows:

5. The payment for low coal shall be upon the following scale:

6. For all coal two feet ten inches and under three feet one inch, ninety-five (95) cents.

7. For all coal under two feet ten inches, one dollar ($1.00).

8. The price of yardage shall be as follows:

Single yardage in coal 3 ft. 1 in. or over	$0 90
Double yardage in coal 3 ft. 1 in. or over	1 80
Gob entries in coal 3 ft. 1 in. or over	1 35
Gob entries in coal 3 ft. 1 in. or over, without brushing	45
Single yardage in coal 2 ft. 10 in. and under 3 ft. 1 in.	95
Double yardage in coal 2 ft. 10 in. and under 3 ft. 1 in.	1 90
Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in.	1 42½
Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in., without brushing	47½
Single yardage in coal below 2 ft. 10 in.	1 00
Double yardage in coal below 2 ft. 10 in.	2 00
Gob entries in coal below 2 ft. 10 in.	1 50
Gob entries in coal below 2 ft. 10 in., without brushing	50

All entries to be driven when required by the operator, 5½ feet in the clear in height, and the miners agree to gob the dirt, when he is not required to take it more than the distance of six rooms back from the last break-through, and when the dirt is hauled by a mule, then the miners agree to unload the same at a distance of not more than eight rooms back from the last break-through from the face of the entry. This agreement shall apply to all the block coal mines in the Block Coal District, with the exception of the present No. 1 and No. 2 Superior mines of the Zeller & McClellan Company, and in these two mines the same conditions shall continue as were in force during the year just ended, viz.: The miners shall continue to gob the break-throughs. Twenty-five cents per yard shall be paid extra for all double yardage when the same is worked double shift, and 12½ cents per yard for all single yardage when same is worked double shift. Work on driving entries and drawing pillars may be by double shift at the option of the operator.

It is further agreed that in the McIntosh & Company Mine, and the Eureka Block Coal Company Mine No. 4, the respective companies will submit to an investigation relative to the time that the companies commenced gobbing the dirt, and that said companies will abide by the decision of the joint board relative to the operators' right to have the dirt gobbed at these mines.

9. Inside day scale:

Track Layers	$2 30
Track Layers' Helpers	2 25
Trappers	1 00
Bottom Cagers	2 25
Drivers	2 25
Trip Riders	2 25
Water Haulers	2 25
Timber Men, where such are employed	2 30
Pipe Men for compressed air plants	2 25
All other inside day labor	2 25
Blacksmiths	2 50

10. Where a miner is working a deficient place, and is being paid by the day, his pay shall be $2.25 per day, and if he uses his own tools during such time, he shall be paid 10 cents per day for the use of same. The operator shall have the option of furnishing tools for any such work.

11. The price for blacksmithing shall be 1½ cents on the dollar.

12. Semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme Court of Indiana, and of the United States.

13. The miner shall not be compelled to load his coal more than six feet from the face at beginning time.

14. Inside day work may be done upon idle days, and in case of emergency on overtime; but 48 hours shall constitute a week's work.

15. The hour to begin work in the morning shall be seven (7) a. m., with thirty minutes stop for dinner, and begin shooting at 3:30 o'clock p. m., from April 1, 1902, to October 1, 1902, and from October 1, 1902, to April 1, 1903, the mines shall start at 7:30 a. m., with thirty minutes stop for dinner, and begin shooting at 4:00 p. m., and that no shooting shall be done at the mine except by mutual consent between the bank boss and the Bank Committee, and in the event that the mine is to work a half day it shall be the duty of the mine boss to notify the Bank Committee of the fact.

16. That eight hours a day means eight hours' work in the mine at the usual working places for all classes of inside workmen. This shall be exclusive of the time required in reaching said working places in the morning and departing from the same at night.

17. The miners hereby agree to do all the propping in their rooms, except setting props required to break the bottom in shooting the same, and if any props are loosened or displaced, thereby endangering the safety of the workmen, the miners agree to reset the same.

18. It is also agreed on the part of the operators not to require the miners to put down their own road, and bottom shooters may lay the road in the rooms when required.

19. Also to give each miner as near as possible an equal turn of cars and not to allow any day hands to load coal on idle days.

20. No miner shall be discharged or discriminated against because of his refusal to do work by the day when called upon by the pit boss.

21. It is also agreed not to require miners to load or clean falls unless they are caused by some fault of the miner not properly timbering his working place, or his having shot or otherwise caused his timbers to become insecure, in which case it will be the duty of the miner to put his place in good order again.

22. It is further agreed that if any differences arise between the operator and miner at any pit, settlement shall be arrived at without stopping of work. If the parties immediately affected can not reach an adjustment between themselves, the question shall be referred to the Executive Board of the United Mine Workers of America, representing District No. 8, and an equal number of operators, whose action shall be final, but no miner or operator interested in the differences shall be a member of said committee.

23. The duties of the Mine Committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines.

24. Regarding Drivers: They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor. Their work beginning when they reach the parting at which they receive empty cars, and in no case shall the driver's time be docked while he is waiting for said cars at the point named, but when the men go into the mine in the morning, they shall be entitled to two hours' pay, whether or not the mine works the full two hours, but after the first two hours, the men shall be paid for every hour thereafter by the hour, or for each hour's work, or fractional part thereof. If for any reason the regular routine of work can not be furnished inside labor for a portion of the first two hours, the operators may furnish other than the regular labor for the unexpired time.

25. That under no circumstances will the operators recognize or treat with a Mine Committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

25. The Block Coal District of Indiana may continue the use of the Diamond Bar Screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

27. It is hereby agreed that track layers may begin work on top before the usual time of hoisting coal in getting track material ready to send down on the cage, and that the time required in doing so shall be a part of the eight hours work.

28. The Crawford Coal Company, in their mines at Center Point, may continue to do the brushing in the entries where the coal is 3 ft. 1 in. and under in thickness.

29. This contract is entered into in good faith by both parties, and there is to be no deviation from it by the operators, miners, laborers or any local union.

Committee on behalf of the Operators for the Block Coal District:

JAS. H. McCLELLAND,
W. W. RISHER,
WM. M. ZELLER,
W. E. EPPERT,
M. H. JOHNSON.

Executive Committee District No. 8, United Mine Workers of America, for Block Coal Miners:

JAMES CANTWELL,
WM. HOUSTON,
WM. TREAGER,
JOHN GARDNER,
JOHN HART.

CONTRACT.

Machine Mining Scale for 1902.

Contract between the Machine Operators of the Block Coal District and the Executive Board District No. 8 United Mine Workers of America, governing prices and conditions of mining in Machine Mines Block Coal District:

1. Entered into this 1st day of April, 1902, between the operators Machine Mines of the Block Coal District, and the Executive Board of the United Mine Workers of America representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, Indiana, February 8, 1902.

3. The price for loading, shooting, timbering, taking care of all draw slate that is four (4) inches and under in thickness, in rooms and entries, shall be 46 cents per ton.

Price for entry driving, 6 to 9 ft. wide, 46 cents per yard.

Price for entry driving, 9 to 12 ft. wide, 29 cents per yard.

The loader agrees to keep the bug dust and draw slate back 14 ft. from the working face.

All entries more than 12 ft. in width shall be paid same as rooms.

Machine Runners and Helpers to be paid 22½ cents per ton, and when working by the day, machine runner to be paid $2.70 per day. Helpers, $2.40 per day.

Entry driving, 6 to 9 ft. wide, Machine Runner to be paid 14 cents per yard.

It is further agreed that where there is not sufficient room to gob the bug dust and draw slate, the loader will load it in the bank cars and the company will unload it.

It is understood that there shall be nothing paid for room turning or low coal, and there shall be nothing charged for blacksmithing.

There shall be no discrimination against any employes.

That the system of loading coal in machine mines be on the following basis, to wit:

1. That one man shall have the right to two places where he can take care of same.

2. That two men shall have the right to three places where they can take care of same.

3. All others one place.

When a man is off work more than one day, the mine boss shall have the right to put a man in his place if it is necessary, providing the man leaves the places in the same condition as near as possible as he found them.

The Block Coal District of Indiana may continue the use of the Diamond Bar Screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

This agreement to become a part of the agreement entered into on the 1st day of April, 1902, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

On behalf of the Machine Operators of the Block Coal District:

BRAZIL BLOCK COAL COMPANY,
JAS. H. McCLELLAND, President.
DIAMOND BLOCK COAL COMPANY,
JAS. H. McCLELLAND, President.

On behalf of the Executive Board District No. 8, United Mine Workers of America:

JAMES CANTWELL,
WM. HOUSTON,
WM. TREAGER,
JOHN GARDNER,
JOHN HART.

CONTRACT.

Between the National Brotherhood of Coal Hoisting Engineers and Operators of District No. 8, Signed April 18, 1902.

Contract between the National Brotherhood of Coal Hoisting Engineers and Operators of District No. 8, signed April 18, 1902.

1. On and after April 1, 1902, until April 1, 1903, the scale for hoisting engineers throughout the Block Coal District, or District No. 8, shall be as follows:

Where one engineer is employed the compensation shall be $75 per month; the second, $65 per month, and when they change week about, $70 per month.

2. It is agreed on the part of the engineers to be at their work in time to lower the men and mules, and remain a sufficient time after the regular working hour to hoist the men and mules from the mine. Also to keep up all repairs on the machinery, including pumps in the mine.

3. It is also mutually agreed that a licensed engineer shall be employed at all times when steam is required at the throttle: Provided, however, That in all cases where the mine is not hoisting coal, or the machines are not operated, then, and in all such cases, the engineers are

required to do their own firing, it being understood that this provision does not apply in any case where the work of the mine may be stopped in the midst of any one shift. Nor does it cover any case where the fireman is required to assist in the washing or cleaning out of the boilers on Sunday.

4. It is also fully understood and agreed upon the part of the Brotherhood of Hoisting Engineers that they will not under any circumstances allow affiliation with any other labor organization to interfere with or prevent their being on duty at any and all times required by the operators, and that they will not suspend work in sympathy with any other organization; and further that they will, during the continuance of this contract, at all times fully protect all the company's property under their care, and that they will operate fans and pumps, and lower and hoist such men or supplies as may be required to protect the company's property, and any and all coal that may be required to keep up the steam at the company's plant. But it is understood that the operators will not ask them during this period to hoist any coal produced by non-union labor for sale on the market.

5. It is also agreed that only members of the National Brotherhood of Coal Hoisting Engineers shall be employed in the capacity of hoisting engineers during the continuance of this agreement, when such members, competent to fill the position, can be obtained.

6. No engineer shall lay off or exchange shifts without the consent of the operators.

7. It is also agreed that in case of sickness or unexpected absence of the engineer any other engineer or engineers shall perform his duty, and if desired by them his wages for time so absent shall revert to the engineer performing such duty.

8. It is also agreed that in case of any dispute or trouble arising between any engineer and the operator by whom he is employed, work shall not be suspended, but the grievance shall be taken up by the proper officials.

9. It is also agreed upon the part of the operators that they will enforce a rule forbidding the entering of the engine room by loafers and disinterested parties and that they will have cards printed and placed in conspicuous places to this effect.

Signed and agreed to by Operators' Committee:

W. W. RISHER,
JAS. H. McCLELLAND,
M. H. JOHNSON,
W. E. EPPERT,
WM. M. ZELLER.

Engineers' Committee:

DAVID COLLIER,
ROBERT BIGGINS,
THOS. ALDERSON,
AARON MARTIN,
MACK TAYLOR,
T. E. JENKINS.

TABLE

Showing by Counties the Name of Mine, Number of Tons Screened, Slack and Nut and Mine Run Coal, Total Tons of All Grades of Coal Produced, and the Distribution Thereof; the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand Mined Coal.

BLOCK COAL MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 1	33,417	6,430	......	39,847	4,212	829	......	5,041	10,759	34,129	$29,092 09	$22,606 20	$8,470 13	$60,168 42
Brazil Block No. 8	34,743	6,565	......	41,308	15,264	3,005	......	18,269	2,937	56,640	40,073 69	26,403 64	8,357 58	74,834 91
Brazil Block No. 11	26,194	5,712	......	31,906	8,931	1,775	......	10,706	3,629	38,983	26,534 39	16,223 59	5,939 61	48,697 59
Briar Hill	13,718	1,515	......	15,233	......	......	......	......	9,466	5,767	12,518 03	5,773 57	3,126 16	21,417 76
Diamond No. 3	563	124	......	687	224	46	......	270	......	957	675 17	605 50	462 79	1,743 46
Diamond No. 5	44,992	8,641	21	53,654	7,809	1,489	2	9,300	2,464	60,490	42,610 02	19,683 83	8,652 06	70,945 91
Gart No. 10	12,678	2,489	......	15,167	20,043	3,980	......	24,023	3,569	35,621	28,441 70	11,329 29	5,732 31	45,503 30
Totals	166,305	31,476	21	197,802	56,483	11,124	2	67,609	32,824	232,587	$179,945 09	$102,625 62	$40,740 64	$323,311 35
PARKE COUNTY.														
Brazil Block No. 12	57,380	11,470	......	68,850	9,665	1,900	......	11,565	6,168	74,247	$49,761 47	$33,449 14	$10,465 10	$93,675 71
Totals in Block Coal Machine Mines	223,685	42,946	21	266,652	66,148	13,024	2	79,174	38,992	306,834	$229,706 56	$136,074 76	$51,205 74	$416,987 06

BLOCK COAL—HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Distribution.		Wages Paid.			
					Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Columbia No. 5	2,982	600	739	4,321	2,724	1,597	$3,224 96	$685 00	$133 40	$4,343 36
Cornwell	26,981	6,763	....	33,744	31,776	1,968	27,039 03	11,002 99	3,784 79	41,826 81
Crawford No. 2	41,431	13,180	1,904	56,515	19,134	37,381	40,387 64	6,893 75	5,256 60	52,537 99
Crawford No. 3	31,893	7,777	....	39,670	23,869	15,801	29,803 56	5,689 88	4,626 90	40,120 34
Crawford No. 5	28,526	9,003	2,491	40,020	16,296	23,724	31,305 76	6,448 93	4,630 65	42,385 34
Crawford No. 6	1,909	840	....	2,749	650	2,099	1,614 84	3,284 60	1,317 06	6,216 50
Crawford No. 7	28,817	7,947	....	36,764	19,757	17,007	30,906 31	8,171 75	5,509 88	44,587 94
Dewey	3,273	620	....	3,893	3,893	....	3,507 04	613 60	447 19	4,567 83
Rob Roy	15,682	3,512	....	19,194	5,759	13,435	16,267 12	4,885 23	2,579 55	23,731 90
Eureka No. 2	21,367	3,779	97	25,243	5,443	19,800	20,517 85	8,366 35	3,783 45	32,667 65
Eureka No. 3	19,094	3,913	731	23,738	6,854	16,884	20,227 95	6,405 50	2,906 30	29,539 75
Eureka No. 4	7,479	1,855	112	9,446	2,495	6,951	7,267 35	2,033 65	1,288 30	10,589 30
Gart No. 5	36,172	7,185	....	43,357	27,943	15,414	35,592 34	6,734 31	5,632 78	47,959 43
Gart No. 7	....	....	809	809	....	809	573 78	67 82	138 75	780 35
Gladstone	....	....	3,425	3,425	....	3,425	2,589 27	991 09	906 55	4,486 91
Lawrence No. 6	63,009	15,150	....	78,158	54,518	23,641	61,967 24	9,216 49	6,479 11	77,662 84
Lawrence No. 7	20,952	4,900	1,244	27,096	17,477	9,619	25,340 08	7,611 86	4,645 17	37,597 11
Monarch	....	....	8,850	8,850	8,850	....	....	12,866 62	1,027 84	13,894 46
Pratt	19,509	2,085	577	22,171	20,527	1,644	18,535 00	6,547 00	4,266 00	29,348 00
Totals	369,076	89,109	20,979	479,164	267,965	211,199	$376,667 12	$108,516 42	$59,660 27	$544,843 81

BLOCK COAL—HAND OR PICK MINES.—Continued.

PARKE COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Distribution. Indiana.	Distribution. Other States.	Wages Paid. To Miners.	Wages Paid. To Inside Day Men.	Wages Paid. To Outside Day Men.	Wages Paid. Total Wages.
Brazil Block No. 9	11,246	2,230	....	13,476	5,184	8,292	$12,695 83	$7,592 65	$4,776 93	$25,065 41
Mary	42,660	9,910	....	52,570	938	51,632	46,986 67	8,906 58	5,949 55	61,842 80
McIntosh No. 3	29,895	6,610	6,703	43,208	1,381	41,827	33,807 41	8,894 61	4,039 59	46,741 61
Pan American	30,294	4,988	311	35,593	10,342	25,251	32,329 25	8,682 75	4,892 05	45,904 05
Standard	3,663	690	30	4,383	4,383	....	3,267 00	802 00	573 00	4,642 00
Superior No. 1	81,597	19,730	1,201	102,528	35,986	66,542	79,166 02	16,537 80	11,025 26	106,729 08
Superior No. 2	60,846	14,550	1,587	76,983	27,648	49,335	59,036 47	17,654 00	12,366 27	89,056 74
Superior No. 3	7,283	1,750	....	9,033	4,183	4,850	9,938 45	2,535 80	1,811 64	14,285 89
Totals	267,484	60,458	9,832	337,774	90,045	247,729	$277,227 10	$71,606 19	$45,434 29	$394,267 58

TOTALS IN BLOCK COAL HAND MINES.

Clay County	369,076	89,109	20,979	479,164	267,965	211,199	$376,667 12	$108,516 42	$59,660 27	$544,843 81
Parke County	267,484	60,458	9,832	337,774	90,045	247,729	277,227 10	71,606 19	45,434 29	394,267 58
Totals	636,560	149,567	30,811	816,938	358,010	458,928	$653,894 22	$180,122 61	$105,094 56	$939,111 39

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	MACHINE MINED.				PICK MINED.				DISTRIBUTION.		WAGES PAID.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Gifford No. 1	43,416	14,520	....	57,936	23,648	7,201	....	30,849	8,747	80,028	$41,201 21	$21,849 64	$12,150 66	$75,201 51
Gifford No. 2	17,408	5,028	....	22,436	21,043	5,975	....	27,018	....	49,454	29,898 71	7,364 77	3,087 66	40,351 14
Totals	60,824	19,548	....	80,372	44,691	13,176	....	57,867	8,747	129,482	$71,099 92	$29,214 41	$15,238 32	$115,552 65

GREENE COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Black Creek	47,973	25,368	32,525	105,866	32,648	19,046	24,390	76,084	121,006	60,944	$86,875 41	$30,950 38	$11,166 73	$128,992 52
Gilmour	....	....	120,727	120,727	....	....	....	....	106,953	13,774	59,455 65	19,331 42	10,191 37	88,978 44
Island No. 1	....	....	87,661	87,661	....	....	27,120	27,120	57,390	57,391	51,758 52	17,893 08	7,707 47	77,359 07
Island No. 2	55,788	26,204	25,770	107,762	19,071	8,375	10,231	37,677	72,719	72,720	68,881 87	21,907 53	13,146 50	103,935 90
Atlas	....	....	5,194	5,194	....	....	....	....	33	5,161	3,908 94	1,400 08	1,069 36	6,378 38
Midland	40,267	17,449	12,745	70,461	4,757	1,312	1,454	7,523	56,526	21,458	34,925 69	14,014 16	7,890 77	56,830 62
Vulcan No. 1	2,508	1,554	1,126	5,188	2,862	1,249	1,465	5,576	3,379	7,385	5,917 50	1,295 69	2,217 99	9,431 18
Summit No. 2	29,257	7,514	95,926	132,697	1,423	572	766	2,761	24,475	110,983	55,536 91	19,684 76	11,140 05	86,361 72
Glenburn	51,351	32,668	45,254	129,273	25,005	16,414	26,440	67,859	172,832	24,300	101,316 31	27,977 64	9,356 86	138,650 81
Tower Hill	7,371	2,678	252	10,301	797	271	50	1,118	11,419	....	6,044 06	4,738 62	2,418 40	13,201 08
Green Valley	1,958	1,093	8,811	11,862	....	....	....	....	7,711	4,151	7,226 75	5,354 95	2,577 38	15,159 08
Antioch	....	....	3,907	3,907	....	....	....	....	3,907	....	3,009 10	1,000 00	11,337 63	15,346 73
Lattas Creek No. 1	....	....	6,956	6,956	....	....	....	....	6,926	30	13,562 25	1,581 61	1,509 51	16,652 77
Totals	236,473	114,528	446,854	797,855	86,563	47,239	91,916	225,718	645,276	378,297	$498,418 96	$167,129 32	$91,730 02	$757,278 30

BITUMINOUS MACHINE MINES—Continued.

PARKE COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Parke No. 8	31,042	27,479	11,660	70,181	20,700	3,615	6,584	30,899	81,574	19,506	$47,438 37	$17,191 09	$7,086 15	$71,715 61
Totals	31,042	27,479	11,660	70,181	20,700	3,615	6,584	30,899	81,574	19,506	$47,438 37	$17,191 09	$7,086 15	$71,715 61

SULLIVAN COUNTY.

NAME OF MINE.	Machine Mined: Tons of Screened Coal.	Machine Mined: Tons of Slack and Nut Coal.	Machine Mined: Tons of Mine Run Coal.	Machine Mined: Total Tons of Coal Produced.	Pick Mined: Tons of Screened Coal.	Pick Mined: Tons of Slack and Nut Coal.	Pick Mined: Tons of Mine Run Coal.	Pick Mined: Total Tons of Coal Produced.	Distribution: Indiana.	Distribution: Other States.	Wages Paid: To Miners.	Wages Paid: To Inside Day Men.	Wages Paid: To Outside Day Men.	Wages Paid: Total Wages.
Bunker Hill	39,297	13,764	6,121	59,182	6,797	3,051	1,308	11,156	....	70,338	$33,332 30	$16,326 99	$6,738 26	$56,397 55
Dugger	79,412	34,912	5,186	119,510	90	29	....	119	104,171	15,458	52,429 31	24,656 65	9,797 12	86,883 08
Green Hill	35,146	16,843	827	52,816	....	....	....	....	7,533	45,283	21,975 76	12,204 29	4,744 03	38,924 08
Hymera	35,699	55,768	52,178	143.645	....	....	....	....	65,211	78,434	54,887 91	25,511 78	11,504 94	91,904 63
Hymera No. 2	....	....	4,931	4,931	....	....	....	....	....	4,931	2,262 37	1,480 99	757 63	4,500 99
West Linton	161	61	749	971	2,789	1,000	4,933	8,722	6,685	3,008	4,600 41	3,918 99	2,597 75	11,117 15
Jackson Hill No. 2 ...	109,374	84,397	38,558	232,329	....	....	....	....	70,661	161,668	92,178 03	34,103 41	10,635 17	136,916 61
Jackson Hill No. 3 ...	....	....	9,459	9,459	2,463	1,651	1,954	6,068	15,527	....	2,858 47	1,349 26	8,419 81	12,627 54
Phœnix No. 3	....	....	165,495	165,495	....	....	....	....	82,750	82,745	72,769 35	23,244 40	21,503 43	117,517 18
Shelburn	6,769	3,582	744	11,095	11,915	8,445	217	20,577	17,920	13,752	9,199 50	8,684 47	4,132 05	22,016 02
Star City	110,599	56,618	5,316	172,533	....	....	32	32	17,931	154,634	67,059 51	32,511 21	14,853 75	114,424 47
Sunflower	44,119	13,393	....	57,512	....	....	....	....	15,067	42,445	25,754 04	3,531 97	5,203 57	34,489 58
Willfred	925	385	5,600	6,910	....	....	....	....	265	6,645	3,446 37	1,474 28	2,728 23	7,648 88
Totals	461,501	279,723	295,164	1,036,388	24,054	14,176	8,444	46,674	403,721	679,341	$442,753 33	$188,998 69	$103,615 74	$735,367 76

VIGO COUNTY.

Glen Oak	....	....	133,224	133,224	....	....	523	523	....	133,747	$52,873 03	$22,167 02	$12,830 15	$87,870 20
Parke No. 10	26,784	22,759	104,703	154,246	....	....	....	....	110,496	43,750	65,188 04	24,760 81	10,413 97	100,362 82
Ray	320	87	396	803	25,171	15,462	53,239	93,872	37,092	57,583	47,811 66	11,706 73	5,888 96	65,407 35
Lawton	28,335	15,040	....	43,375	28,749	15,984	....	44,733	88,108	....	47,762 00	13,730 00	6,432 00	67,924 00
Totals	55,439	37,886	238,323	331,648	53,920	31,446	53,762	139,128	235,696	235,080	$213,634 73	$72,364 56	$35,565 08	$321,564 37

WARRICK COUNTY.

Big Four	....	....	21,455	21,455	2,186	1,457	51,321	54,964	57,165	19,254	$35,135 52	$5,789 82	$4,768 07	$45,693 41
Big Vein No. 2	....	....	52,095	52,095	....	....	18,602	18,602	70,697	....	27,949 00	7,308 40	8,698 95	43,956 35
Totals	....	....	73,550	73,550	2,186	1,457	69,923	73,566	127,862	19,254	$63,084 52	$13,098 22	$13,467 02	$89,649 76

BITUMINOUS HAND MINES.

CLAY COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Cloverland	75,854	26,140	25,734	127,728	89,397	38,331	$78,457 23	$15,812 23	$9,542 65	$103,812 11
Fortner	15,752	7,384	....	23,136	17,413	5,723	16,173 32	3,881 65	2,342 77	22,397 74
Klondyke	34,318	21,040	27,664	83,022	61,269	21,753	42,232 13	10,023 95	4,242 92	56,499 00
Glen	40,450	12,900	....	53,350	9,018	44,332	39,423 00	5,628 00	3,600 00	48,651 00
Pearl	55,002	37,137	5,922	98,061	66,035	32,026	52,034 42	9,789 92	5,461 92	67,286 26
Silverwood No. 3	45,870	26,887	....	72,757	41,917	30,840	35,588 84	9,919 46	5,773 25	51,281 55
Totals	267,246	131,488	59,320	458,054	285,049	173,005	$263,908 94	$55,055 21	$30,963 51	$349,927 66

DAVIESS COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Cabel No. 4	11,856	3,954	....	15,810	15,810	....	$11,073 03	$3,663 07	$2,076 96	$16,813 06
Cabel No. 9	3,918	2,223	4,973	11,114	7,999	3,115	5,165 79	2,619 30	1,174 80	8,959 89
Hoosier No. 4	2,450	1,005	150	3,605	3,605	....	1,520 00	486 00	248 00	2,254 00
Montgomery No. 2	44,238	7,934	8,033	60,205	47,244	12,961	34,409 95	13,385 70	4,554 50	52,350 15
Logan Grove	....	....	3,880	3,880	3,880	....	1,981 24	410 65	263 10	2,654 99
Montgomery No. 3	62,023	9,647	8,742	80,412	62,912	17,500	52,215 75	18,132 93	6,356 20	76,884 88
Mutual	16,390	1,950	14,030	32,370	16,950	15,420	22,862 80	4,195 00	2,425 50	29,483 30
Totals	140,875	26,713	39,808	207,396	158,400	48,996	$129,228 56	$42,892 65	$17,279 06	$189,400 27

FOUNTAIN COUNTY.

Silverwood No. 4	9,591	4,153	....	13,744	10,096	3,648	$8,488 40	$5,424 88	$1,876 55	$15,789 83
Totals	9,591	4,153	....	13,744	10,096	3,648	$8,488 40	$5,424 88	$1,876 55	$15,789 83

GIBSON COUNTY.

Oswald	28,695	24,054	29,245	81,994	77,255	4,739	$45,315 16	$14,356 86	$10,243 21	$69,915 23
Totals	28,695	24,054	29,245	81,994	77,255	4,739	$45,315 16	$14,356 86	$10,243 21	$69,915 23

GREENE COUNTY.

Hoosier	1,127	641	616	2,384	2,384	....	$892 04	$783 84	$391 91	$2,067 79
Island No. 3	8,652	5,555	49,293	63,500	58,165	5,335	35,290 07	13,068 09	5,634 22	53,992 38
Island Valley No. 1	5,581	2,998	13,785	22,364	13,685	8,679	12,145 54	4,640 62	3,861 39	20,647 55
Island Valley No. 2	29,220	19,016	....	48,236	30,008	18,228	26,023 23	6,156 14	3,885 39	36,064 76
Island Valley No. 3	56,092	28,847	69,262	154,201	93,549	60,652	84,652 17	18,639 64	6,985 14	110,276 95
South Linton	48,562	28,427	54,553	131,542	87,317	44,225	73,629 43	21,799 88	8,071 76	103,501 07
Templeton	13,465	7,030	100,859	121,354	120,598	756	63,589 00	14,820 00	7,751 00	86,160 00
Fry	....	....	2,205	2,205	2,205	....	....	1,756 00	1,199 17	2,955 17
Victoria	13,822	5,789	42,012	61,623	26,819	34,804	36,364 71	5,605 96	4,388 64	46,359 81
Totals	176,521	98,303	332,585	607,409	434,730	172,679	$332,586 19	$87,270 17	$42,168 62	$462,024 98

KNOX COUNTY.

Bicknell	9,667	8,147	17,152	34,966	29,236	5,730	$17,027 53	$3,868 30	$3,055 20	$23,951 03
Edwardsport	533	532	10,836	11,901	11,776	125	7,692 90	2,334 71	2,296 54	12,324 15
Knox	10,582	8,592	13,571	32,745	32,745	....	15,117 91	6,396 67	3,737 97	25,252 55
Lynn	....	....	6,252	6,252	6,002	250	4,036 58	609 43	938 18	5,584 19
Prospect Hill	5,216	3,712	3,481	12,409	12,409	....	8,254 66	3,839 84	2,282 07	14,376 57
Totals	25,998	20,983	51,292	98,273	92,168	6,105	$52,129 58	$17,048 95	$12,309 96	$81,488 49

BITUMINOUS HAND MINES—Continued.

PARKE COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Cox No. 3	....	....	119,628	119,628	77,602	42,026	$63,625 39	$23,803 87	$10,205 03	$97,634 29
Lucia	24,438	10,430	45,094	79,962	48,862	31,100	47,440 98	12,078 48	8,313 96	67,833 42
Lyford No. 1	....	....	37,174	37,174	....	37,174	18,692 05	7,427 34	3,896 90	30,016 29
Lyford No. 2	....	....	12,256	12,256	....	12,256	4,111 15	1,725 58	988 63	6,825 36
Mecca No. 1	21,061	8,319	5,727	35,107	16,727	18,380	21,568 04	9,960 88	4,718 57	36,247 49
New Century	5,400	2,471	382	8,253	....	8,253	5,552 31	1,814 88	1,157 39	8,524 58
Minshall No. 1	32,180	7,800	8,899	48,879	48,879	....	37,239 85	7,466 36	5,181 92	49,888 13
Totals	83,079	29,020	229,160	341,259	192,070	149,189	$198,229 77	$64,277 39	$34,462 40	$296,969 56

PERRY COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Troy	....	....	11,791	11,791	11,791	....	$7,270 59	$1,903 29	$1,501 41	$10,675 29
Totals	....	....	11,791	11,791	11,791	....	$7,270 59	$1,903 29	$1,501 41	$10,675 29

PIKE COUNTY.

Aberdeen	1,550	1,450	15,975	18,975	7,316	11,659	$9,996 86	$3,009 71	$2,226 85	$15,233 42
Ayrshire No. 3	47,046	24,758	8,389	80,193	46,451	33,742	39,459 73	15,434 98	11,331 57	66,226 28
Ayrshire No. 4	4,017	1,954	38,957	44,928	34,060	10,868	24,737 51	5,821 41	4,554 02	35,112 94
Ayrshire No. 5	....	....	3,394	3,394	1,244	2,150	2,123 65	535 93	667 02	3,326 60
Ayrshire No. 6	....	....	3,259	3,259	2,269	990	2,190 09	172 86	270 81	2,633 76
Blackburn	14,827	16,301	10,339	41,467	17,048	24,419	22,713 03	5,598 12	4,409 40	32,720 55
Hartwell	285	150	37,898	38,333	25,986	12,347	22,250 09	6,708 11	5,190 75	34,148 95
Littles	34,075	41,167	18,032	93,274	83,793	9,481	49,343 26	16,450 50	5,699 28	71,493 04
Petersburg	....	....	44,072	44,072	44,072	....	20,281 65	6,772 49	6,079 45	33,133 59
Rogers	....	....	29,092	29,092	29,092	....	15,282 73	4,597 52	3,097 35	22,977 60
Carbon	736	736	1,367	2,839	672	2,167	1,618 84	1,202 83	380 50	3,202 17
Massey	2,629	1,204	12,560	16,393	12,200	4,193	9,291 41	1,845 00	1,655 00	12,791 41
Totals	105,165	87,720	223,334	416,219	304,203	112,016	$219,288 85	$68,149 46	$45,562 00	$333,000 31

SULLIVAN COUNTY.

Caledonia	37,122	12,699	13,040	62,861	5,448	57,413	$34,994 78	$14,741 45	$7,157 83	$56,894 06
Freeman	5,771	2,649	....	8,420	....	8,420	5,087 23	1,547 59	1,253 10	7,887 92
Glendora	....	....	5,610	5,610	4,470	1,140	....	9,859 20	5,208 44	15,067 64
White Ash	4,450	1,900	15,595	21,945	13,829	8,116	10,811 31	4,939 73	3,231 80	18,982 84
Totals	47,343	17,248	34,245	98,836	23,747	75,089	$50,893 32	$31,087 97	$16,851 17	$98,832 46

VANDERBURGH COUNTY.

Diamond	12,895	7,762	8,725	29,382	29,382	....	$17,849 69	$3,310 55	$3,215 48	$24,375 72
Sunnyside	20,916	6,251	33,706	60,873	7,839	53,034	33,906 76	10,310 98	9,093 54	53,311 28
Union	8,078	4,075	8,138	20,291	20,291	....	15,514 85	3,084 95	3,722 30	22,322 10
Unity	10,656	....	54,059	64,715	63,874	841	39,677 60	5,838 95	3,606 35	49,122 90
Totals	52,545	18,088	104,628	175,261	121,386	53,875	$106,948 90	$22,545 43	$19,637 67	$149,132 00

BITUMINOUS HAND MINES—Continued.

VERMILLION COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Bruillett's No. 3	6,950	4,870	15,112	26,932	7,825	19,107	$12,789 80	$4,698 35	$1,810 55	$19,298 70
Bruillett's No. 4	1,532	905	106,024	108,461	19,797	88,664	53,216 92	12,548 85	4,780 00	70,545 77
Bruillett's No. 5	53,874	33,981	45,974	133,829	14,082	119,747	72,335 19	11,529 05	6,349 10	90,213 34
Buckeye	20,225	9,811	16,277	46,313	....	46,313	26,618 35	11,069 18	6,741 36	44,428 89
Cayuga	....	....	13,982	13,982	13,982	....	8,480 28	2,464 76	1,622 47	12,567 51
Crown Hill	17,811	8,711	22,466	48,988	17,052	31,936	29,281 90	4,967 85	3,242 98	37,492 73
Oak Hill	48,250	29,910	84,467	162,627	14,829	147,798	88,898 44	15,305 23	9,866 59	114,070 26
Prince	....	....	149,775	149,775	....	149,775	86,163 77	22,754 57	8,469 05	117,387 39
Torrey	....	....	18,853	18,853	18,853	....	9,237 72	3,352 04	2,421 71	15,011 47
Willow Grove	24,040	14,827	44,302	83,169	15,850	67,319	44,938 82	7,338 05	4,783 65	57,060 52
Keeler	2,129	1,318	222	3,669	119	3,550	3,188 19	1,633 37	1,938 75	6,760 31
Totals	174,811	104,333	517,454	796,598	122,389	674,209	$435,149 38	$97,661 30	$52,026 21	$584,836 89

VIGO COUNTY.

Brick Works	....	....	14,720	14,720	14,720	....	$8,474 37	$2,742 62	$1,449 08	$12,666 07
Chicago No. 6	10,644	5,742	43,129	59,515	....	59,515	31,712 23	11,628 53	4,430 75	47,771 51
Diamond	61,600	29,435	36,824	127,859	127,859	....	76,337 00	26,902 00	8,319 00	111,558 00
Ehrlich	23,168	17,471	....	40,639	31,806	8,833	19,099 28	7,645 13	2,912 82	29,657 33
Grant No. 2	16,887	19,680	107,757	144,324	57,487	86,837	86,840 06	18,159 53	10,624 57	115,624 16
Hector	36,870	17,795	29,029	83,694	72,663	11,031	42,531 37	9,753 50	6,770 44	59,055 31
Klondyke	19,333	15,360	48,646	83,339	27,764	55,575	39,457 35	12,363 50	4,641 80	56,462 65
Miami	71,347	35,052	....	106,399	....	106,399	62,517 19	10,740 08	6,365 80	79,623 07
Nickelplate	23,460	11,547	40,696	75,703	....	75,703	41,209 67	18,152 19	7,755 21	67,117 07
Peerless	17,976	9,105	17,247	44,328	2,387	41,941	27,364 00	8,738 00	4,996 00	41,098 00
Red Bird	5,214	5,350	13,481	24,045	24,045	....	10,892 49	1,871 60	1,279 91	14,044 00
Rosebud	61,279	37,917	23,228	122,424	104,510	17,914	62,167 32	12,775 63	6,454 22	81,397 17
Royal	12,741	8,378	58,947	80,066	80,066	....	36,378 52	7,580 02	4,966 61	48,925 15
Larimer	....	....	19,640	19,640	19,640	....	11,543 94	1,569 98	3,015 20	16,129 12
Union	89,541	44,870	4,307	138,718	138,718	....	78,051 00	21,087 00	9,616 00	108,754 00
Eagle	....	....	46,692	46,692	35,549	11,143	13,601 99	12,863 18	2,872 33	19,337 50
Totals	450,060	257,702	504,343	1,212,105	737,214	474,891	$648,177 88	$174,572 49	$86,469 74	$909,220 11

WARRICK COUNTY.

Air Line	4,040	1,990	2,230	8,260	7,120	1,140	$4,725 40	$622 35	$570 45	$5,898 20
Caledonia	....	....	26,590	26,590	26,590	....	14,145 82	3,858 96	1,740 79	19,745 57
Chandler	4,940	2,268	13,373	20,581	15,661	4,920	11,433 45	1,945 35	1,259 80	14,638 60
DeForrest	5,004	3,200	5,954	14,158	14,158	....	6,279 31	1,204 25	809 92	8,293 48
Star No. 1	....	....	44,206	44,206	44,206	....	20,777 00	5,124 04	3,373 48	29,274 52
Star No. 2	....	....	3,853	3,853	3,853	....	1,735 69	372 18	514 90	2,622 77
Totals	13,984	7,458	96,206	117,648	111,588	6,060	$59,096 67	$13,107 13	$8,269 34	$80,473 14

RECAPITULATION.

Showing Total Production and Wages at Indiana Mines for 1902.

	Machine Mined.				Pick Mined.				Distribution.		Wages.			
	Screened.	Slack and Nut.	Mine Run.	Total.	Screened.	Slack and Nut.	Mine Run.	Total.	Indiana.	Other States.	Miners.	Inside Day and Monthly Men.	Outside Day and Monthly Men.	Total.
Total Block Machine Mines	223,685	42,946	21	266,652	66,148	13,024	2	79,174	38,992	306,834	$229,706 56	$136,074 76	$51,205 74	$416,987 06
Total Block Pick Mines	....	....	....	....	636,560	149,567	30,811	816,938	358,010	458,928	653,894 22	180,122 61	105,094 56	939,111 39
Total Block...	223,685	42,946	21	266,652	702,708	162,591	30,813	896,112	397,002	765,762	$883,600 78	$316,197 37	$156,300 30	$1,356,098 45
Total Bituminous Machine Mines .	845,279	479,164	1,065,551	2,389,994	232,114	111,109	230,629	573,852	1,502,876	1,460,970	$1,336,429 83	$487,996 29	$266,702 33	$2,091,128 45
Total Bituminous Pick Mines	....	....	....	....	1,575,913	827,263	2,233,411	4,636,587	2,682,086	1,954,501	2,556,712 19	695,353 18	379,620 85	3,631,686 22
Total Bituminous	845,279	479,164	1,065,551	2,389,994	1,808,027	938,372	2,464,040	5,210,439	4,184,962	3,415,471	$3,893,142 02	$1,183,349 47	$646,323 18	$5,722,814 67
Total Machine Mined..........	1,068,964	522,110	1,065,572	2,656,646	....	....	....	....	....	....	....	....	....	....
Total Pick Mined.	2,510,735	1,100,963	2,494,853	6,106,551	....	....	....	....	....	....	....	....	....	....
Grand total...	3,579,699	1,623,073	3,560,425	8,763,197	....	....	....	....	....	....	$4,776,742 80	$1,499,546 84	$802,623 48	$7,078,913 12

NOTE.—Miners', Machine Runners' and Helpers', and Loaders' wages are reported together under "Miners."

TABLE

Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1902 at Mines Employing More Than Ten Men.

MONTHS.	CLAY COUNTY.		DAVIESS COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	143,564	$138,728 72	24,084	$21,135 43
February	129,142	128,731 11	20,343	17,646 65
March	127,759	113,067 80	18,971	16,503 85
April	63,713	57,669 77	13,105	12,338 23
May	70,771	74,690 31	10,913	10,491 17
June	87,094	89,602 06	10,470	10,374 97
July	107,617	110,346 03	16,605	15,646 85
August	84,442	98,081 04	7,800	8,866 52
September	126,811	127,177 77	18,285	16,586 80
October	142,973	142,002 12	21,100	20,701 80
November	126,911	122,003 15	22,979	18,316 40
December	130,071	131,535 59	22,741	20,791 60
Totals	1,340,868	$1,333,635 47	207,396	$189,400 27

	FOUNTAIN COUNTY.		GREENE COUNTY.	
January	2,919	$2,892 44	157,153	$115,645 03
February	2,255	2,395 14	130,889	90,424 85
March	2,408	2,562 45	133,133	98,486 48
April	1,964	2,265 35	78,673	60,240 53
May	1,978	2,219 40	103,340	73,783 35
June	1,311	1,970 60	123,965	87,631 98
July	909	1,484 45	145,521	103,120 30
August	....	....	103,479	85,262 80
September	....	....	136,640	105,136 03
October	....	....	178,808	136,208 76
November	....	....	164,603	130,165 35
December	....	....	174,778	133,197 82
Totals	13,744	$15,789 83	1,630,982	$1,219,303 28

	GIBSON COUNTY.		KNOX COUNTY.	
January	12,050	$8,923 20	9,764	$8,022 96
February	10,774	8,107 72	8,949	7,444 77
March	9,630	7,340 40	8,024	6,423 72
April	3,040	3,156 74	5,868	5,245 56
May	2,751	2,940 57	4,594	3,925 62
June	5,255	4,630 16	5,973	4,693 42
July	6,950	5,716 92	6,947	5,403 03
August	1,955	3,043 08	6,022	5,345 88
September	7,280	5,852 59	7,242	5,868 05
October	9,450	7,761 97	12,350	10,035 93
November	6,914	6,747 19	10,727	9,127 68
December	5,945	5,694 69	11,813	9,951 87
Totals	81,994	$69,915 23	98,273	$81,488 49

MONTHS.	PARKE COUNTY.		PIKE COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	87,896	$80,501 43	46,341	$34,731 28
February	72,631	69,852 68	43,828	33,717 08
March	71,570	66,915 44	35,237	27,243 48
April	41,366	38,600 58	22,253	18,939 53
May	69,938	52,002 21	32,880	19,663 47
June	57,098	58,151 39	31,897	26,016 50
July	70,656	70,720 49	28,056	23,141 36
August	64,635	65,760 29	31,425	18,710 75
September	60,683	82,152 72	32,436	24,749 54
October	99,598	100,181 57	43,197	36,068 40
November	80,879	84,760 22	41,982	33,642 80
December	83,578	87,029 44	44,687	36,376 12
Totals	860,528	$856,628 46	416,219	$333,000 31

	SULLIVAN COUNTY.		VANDERB'GH COUNTY.	
January	123,789	$83,613 42	16,930	$14,025 57
February	93,544	66,643 96	17,938	14,738 59
March	108,745	71,126 76	13,477	10,664 61
April	89,924	59,918 32	9,339	8,495 68
May	84,559	56,032 44	7,711	7,256 92
June	82,958	56,706 43	10,497	8,946 15
July	87,998	56,840 59	10,509	9,159 56
August	76,793	57,678 46	9,519	9,053 59
September	93,320	66,030 65	17,951	15,739 72
October	112,442	80,584 65	21,778	19,217 49
November	107,297	85,708 14	18,421	14,538 74
December	120,529	95,316 40	21,191	17,295 38
Totals	1,181,898	$834,200 22	175,261	$149,132 00

	VERMILLION COUNTY.		VIGO COUNTY.	
January	87,579	$62,273 94	149,751	$113,605 08
February	71,203	53,555 43	146,533	106,160 97
March	56,737	43,071 73	150,682	110,665 88
April	41,464	32,234 34	97,241	81,926 79
May	53,003	38,905 78	120,122	88,505 52
June	59,892	43,355 88	154,696	107,815 31
July	61,302	44,891 72	140,809	101,898 21
August	38,966	30,802 60	112,119	84,583 18
September	67,494	46,899 20	133,790	97,347 13
October	82,474	57,293 96	158,576	110,505 86
November	84,324	62,790 35	163,880	110,963 61
December	92,160	68,761 96	154,682	116,806 94
Totals	796,598	$584,836 89	1,682,881	$1,230,784 48

	WARRICK COUNTY.	
January	22,190	$14,313 34
February	21,754	14,117 00
March	17,252	12,804 41
April	17,680	12,198 66
May	19,383	11,620 84
June	18,919	13,077 03
July	21,178	13,787 21
August	16,904	10,937 89
September	19,104	12,219 02
October	29,911	18,284 22
November	28,311	17,119 69
December	32,178	19,643 59
Totals	264,764	$170,122 90

TABLE OF MACHINE MINES.

Showing Name of Mine, Number and Kind of Machines, Tons of Coal Mined, Number of Miners Employed, and Average Tons Per Miner.

BLOCK COAL MINES.

CLAY COUNTY.

MINE.	Number of Machines.	KINDS.				Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.
		Electric Chain.	Compressed Air Chain.	Compressed Air Cutter Bar.	Compressed Air Puncher.			
Brazil Block No. 1	11	11	......	......	......	39,847	44	905
Brazil Block No. 8	10	10	......	......	......	41,308	37	1,116
Brazil Block No. 10	5	5	......	......	......	15,167	12	1,264
Brazil Block No. 11	7	7	......	......	......	31,906	29	1,100
Diamond No. 5 and No. 3	10	10	......	......	......	54,341	56	958
Briar Hill	6	......	......	......	6	15,233	28	544
Average and totals	49	43	......	......	6	197,802	206	960

PARKE COUNTY.

Brazil Block No. 12	8	......	......	......	......	68,850	71	850
Total block mines	57	43	......	......	6	266,652	277	962

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

Gifford No. 1	6	6	......	......	......	57,936	56	1,035
Gifford No. 2	3	3	......	......	......	22,436	24	934
Average and totals	9	9	......	......	......	80,372	80	105

GREENE COUNTY.

Black Creek	5	5	......	......	......	105,866	65	1,628
Island No. 1	10	......	......	......	10	87,661	61	1,437
Island No. 2	15	......	......	......	15	107,762	96	1,122
Tower Hill	2	2	......	......	......	10,301	21	491
Lattes Creek	2	2	......	......	......	6,956	30	232
Antioch	2	2	......	......	......	3,907	18	217
Gilmour	8	8	......	......	......	120,727	73	1,653
Midland	6	6	......	......	......	70,461	61	1,155
Summit No. 2	8	8	......	......	......	132,697	104	1,275
Glenburn	8	8	......	......	......	129,273	85	1,521
Green Valley	2	2	......	......	......	11,862	41	296
Atlas	2	2	......	......	......	5,194	22	236
Vulcan	1	......	......	......	......	5,188	16	324
Average and totals	71	45	......	......	25	797,855	693	1,151

BITUMINOUS MACHINE MINES—Continued.

PARKE COUNTY.

MINE.	Number of Machines.	Kinds. Electric Chain.	Compressed Air Chain.	Compressed Air Cutter Bar.	Compressed Air Puncher.	Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.
Parke No. 8	14				14	70,181	52	1,349

SULLIVAN COUNTY.

MINE.	Number of Machines.	Electric Chain.	Compressed Air Chain.	Compressed Air Cutter Bar.	Compressed Air Puncher.	Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.
Bunker Hill	4	4				59,182	55	1,021
Green Hill	5	5				52,816	42	1,257
Ingleside	1	1				971	30	32
Phœnix 1-3-5	16				16	165,495	121	1,367
Star City	8	8				172,533	110	1,568
Wilfred	2	2				6,910	79	87
Dugger	5	5				119,510	85	1,406
Hymera No. 1	8	8				143,645	117	1,228
Hymera No. 2	2	2				4,930	24	205
Jackson Hill No. 2 and No. 3	10	10				241,788	138	1,804
Shelburn	2		1	1		11,095	15	740
Sun Flower	5	5				57,512	38	1,513
Average and totals	68	50	1	1	16	1,036,387	854	1,226

VIGO COUNTY.

MINE.	Number of Machines.	Electric Chain.	Compressed Air Chain.	Compressed Air Cutter Bar.	Compressed Air Puncher.	Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.
Glen Oak	6	6				133,224	75	1,776
Ray	1				1	803	5	161
Parke No. 10	18				18	154,246	99	1,558
Lawton	8	8				43,375	48	903
Average and totals	33	14			19	331,648	227	1,461

WARRICK COUNTY.

MINE.	Number of Machines.	Electric Chain.	Compressed Air Chain.	Compressed Air Cutter Bar.	Compressed Air Puncher.	Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.
Big Four	4				4	21,455	46	466
Big Vein	5				5	52,095	40	1,302
Average and totals	9				9	73,550	86	1,768
Total Bituminous Mines	204	118	1	1	83	2,389,993	1,992	1,199
Grand totals	261	161	1	1	89	2,656,646	2,269	1,171

	Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.
Total machine mined block	266,652	297	962
Total machine mined bituminous	2,389,994	1,992	1,199
Total hand mined block	816,938	1,395	585
Total hand mined bituminous	4,636,587	5,942	780
Grand total	8,763,197	9,606	912
Total hand mined coal	6,106,551	7,337	832
Total machine mined coal	2,656,646	2,269	1,177
Grand total	8,763,197	9,606	912

NOTE.—If the average production by hand mining is 832 tons per miner, then it would have required 3,192 hand miners to produce the 2,656,646 tons of coal mined with machines. As it only required 2,269 miners, together with mining machines, to produce 2,656,646 tons of coal, it is obvious that about 923 miners have been displaced in this State by mining machines.

TABLE

Showing Per Cent. in Gross Tons Produced, Gross Wages Paid, and Total Number of Persons Employed at Indiana Mines for Year 1902 Over 1901.

	1901.	1902.	Tons Gained.	Per Cent. Gained
Total tonnage produced	7,019,203	8,763,197	1,743,994	24
Total wages paid	$5,680,539 86	$7,078,913 12	$1,398,373 26	24
Total employes	12,096	13,139	1,043	8

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, and Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used, and Totals by Counties.

COUNTY AND NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Accidents.
CLAY.									
Brazil Block No. 1	15	12	32	30	11	100	260	8	4
Brazil Block No. 8	31	12	25	34	10	112	264	10	4
Brazil Block No. 11	11	8	21	18	7	65	259	8	8
Briar Hill	8	10	18	9	8	53	194	6	.....
Cloverland	132	.....	.....	25	11	168	241	11	11
Columbia No. 5	31	.....	.....	4	2	27	18	2	.....
Cornwall	70	.....	.....	9	7	86	197	5	3
Crawford No. 2	83	.....	.....	14	6	103	227	5	2
Crawford No. 3	74	.....	.....	11	6	91	216	5	1
Crawford No. 5	63	.....	.....	11	6	80	216	5	2
Dewey	35	.....	.....	4	2	41	23	2	.....
Diamond No. 5	18	12	44	30	10	114	240	11	5
Eureka No. 2	41	.....	.....	13	6	60	213	6	2
Eureka No. 3	50	.....	.....	10	6	66	193	6	1
Eureka No. 4	29	.....	.....	7	4	40	70	3	1
Fortner	30	.....	.....	6	4	40	210	3	.....
Gart No. 5	65	.....	.....	11	7	83	240	6	.....
Gart No. 7	Idle greater part of the year.						No report.		
Gart No. 10	22	4	8	10	6	50	254	5	3
Gifford No. 1	45	12	44	23	12	136	233	10	3
Gladstone	73	.....	.....	22	12	107	55	5	.....
Klondyke	95	.....	.....	16	8	119	212	11	2
Glen	73	.....	.....	8	6	87	193	4	4
Lawrence No. 6	106	.....	.....	9	7	122	243	6	2
Monarch	15	.....	.....	3	2	20	295	2	1
Pearl	91	.....	.....	15	7	113	240	7	.....
Pratt	45	.....	.....	12	6	63	205	7	1
Rob Roy	37	.....	.....	7	7	51	244	3	.....
Silverwood No. 3	60	.....	.....	13	9	82	256	7	2
Crawford No. 7	71	.....	.....	10	6	87	235	3	4
Lawrence No. 7	71	.....	.....	18	9	98	142	5	.....
Gifford No. 2	51	6	18	11	7	93	169	8	.....
Crawford No. 6 (See note No. 1)	18	.....	.....	6	4	28	84	2	.....
Totals	1,659	76	210	429	221	2,595	6,341	187	66

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

COUNTY AND NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Accidents.
DAVIESS.									
Hoosier No. 4	13	......	......	4	2	29	91	18	......
Montgomery No. 2	62	......	......	20	9	91	218	8	1
Montgomery No. 3	100	......	......	34	12	146	216	14	......
Mutual	50	......	......	8	6	64	266	7	......
Cabel No. 4	24	......	......	7	6	37	187	5	......
Cabel No. 9	41	......	......	12	6	59	101	6	......
Logan Grove	13	......	......	2	3	18	100	1	......
Totals	303	......	......	83	44	430	1,179	59	1
FOUNTAIN.									
Silverwood No. 4	40	......	......	10	5	55	153	5	1
Totals	40	......	......	10	5	55	153	5	1
GIBSON.									
Oswald	76	......	......	27	19	122	190	12	3
Totals	76	......	......	27	19	122	190	12	3
PARKE.									
Brazil Block No. 12	18	22	59	11	15	125	202	13	4
Cox No. 3	93	......	......	25	17	135	269	12	6
Lucia	66	......	......	17	5	88	187	10	......
Lyford No. 1	35	......	......	9	6	50	204	3	8
Lyford No. 2	65	......	......	25	10	100	37	18	1
Mary	90	......	......	12	8	110	231	5	3
Mecca No. 1	35	......	......	15	5	55	250	9	......
McIntosh No. 3	67	......	......	12	5	84	255	5	1
New Century	30	......	......	5	6	41	83	13	......
Parke No. 3	34	26	26	34	11	131	221	12	......
Standard	18	......	......	1	3	22	65	4	......
Superior No. 1	110	......	......	17	10	137	247	10	4
Superior No. 2	122	......	......	24	9	155	256	11	3
Minshall No. 1	77	......	......	12	6	95	174	5	3
Pan American	60	......	......	7	5	72	216	3	1
Superior No. 3	34	......	......	5	4	43	147	2	1
Brazil Block No. 9	35	......	......	18	11	64	147	11	......
Totals	989	48	85	249	136	1,507	3,191	146	35
PERRY.									
Troy	18	......	......	3	2	23	216	2	1
Total	18	......	......	3	2	23	216	2	1

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

COUNTY AND NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Accidents.
PIKE.									
Massey	20	......	......	3	3	26	230	2	2
Aberdeen	35	......	......	7	6	48	190	4	......
Ayrshire No. 3	98	......	......	18	15	131	230	30	2
Ayrshire No. 4	41	......	......	9	8	58	168	5	......
Ayrshire No. 5 (see Note No. 2)	9	......	......	3	3	15	87	1	......
Blackburn	44	......	......	9	8	61	191	6	4
Hartwell	55	......	......	11	11	77	220	7	1
Littles	97	......	......	27	11	135	216	14	......
Petersburg	41	......	......	13	7	61	245	6	2
Rogers	28	......	......	7	5	40	234	4	......
Ayrshire No. 6	Mine	redu	ced t	o less	than	ten me	n.		
Carbon	15	......	......	6	3	24	65	3	......
Totals	483	......	......	113	80	676	2,076	82	11
SULLIVAN.									
Bunker Hill	13	8	47	24	8	100	170	11	2
Caledonia	68	......	......	18	10	96	254	10	5
Dugger	......	14	71	34	16	135	229	16	3
Green Hill	......	8	34	14	10	66	260	15	......
Hymera	......	14	103	43	21	181	199	17	1
West Linton	18	8	22	4	3	55	113	2	......
Jackson Hill No. 2	......	18	120	48	15	201	239	21	1
Phœnix No. 1	5	16	45	27	19	112	187	9	8
Phœnix No. 3	15	2	6	5	4	32	160	2	2
Phœnix No. 5	11	12	30	10	8	71	170	5	5
Shelburn	20	4	11	8	8	51	206	6	......
Star City	2	16	94	47	27	186	223	12	1
White Ash	49	......	......	9	6	64	100	4	1
Sunflower	......	6	32	10	5	53	203	3	......
Glendora	50	......	......	15	12	77	92	2	......
Hymera No. 2	......	4	20	5	7	32	23	2	......
Wilfred	......	12	67	2	15	96	51	2	......
Totals	251	142	702	319	194	1,608	2,879	139	29
VANDERBURGH.									
Diamond	29	......	......	5	5	39	257	3	1
First Avenue (see Note No. 3)	......	......	......	......	......	......	......	......	......
Ingleside (see Note No. 4)	......	......	......	......	......	......	......	......	......
Sunnyside	76	......	......	22	10	108	189	12	......
Union	24	......	......	6	6	36	237	4	......
Unity	59	......	......	8	8	75	264	5	4
Totals	188	......	......	41	29	258	947	24	5

Table Showing Number of Miners, Machine Runners and Helpers, etc.—Continued.

COUNTY AND NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Accidents.
GREENE.									
Black Creek	51	10	55	24	8	148	213	13	2
Fluhart	75	......	......	25	10	110	109	13	1
Gilmour	14	12	61	24	13	124	264	12	......
Hoosier	21	......	......	9	5	35	212	......	1
Island City No. 1	22	20	41	33	14	130	185	14	1
Island City No. 2	42	30	66	41	19	198	190	14	7
Island Valley No. 1	30	......	......	9	6	45	138	9	......
Island Valley No. 2	74	......	......	9	8	91	164	4	4
Island Valley No. 3	136	......	......	27	9	172	178	14	4
Midland	20	8	53	24	12	117	224	8	4
South Linton	136	......	......	28	9	173	163	14	6
Vulcan	17	2	14	3	6	42	145	1	......
Summit No. 2	6	16	88	53	8	171	182	17	1
Templeton	95	......	......	23	11	129	264	13	3
Victoria	50	......	......	6	7	63	143	3	2
Glenburn	65	12	73	48	16	214	245	20	17
Tower Hill	2	6	15	3	6	32	157	1	......
Green Valley	7	6	35	8	9	65	90	5	......
Lattas Creek No. 1	......	6	24	18	15	63	132	4	......
Atlas	......	6	16	6	8	36	80	3	......
Antioch	......	4	14	7	10	35	91	1	1
Fry	15	......	......	8	5	28	50	2	......
Totals	878	138	555	436	214	2,221	3,619	185	54
KNOX.									
Bicknell	32	......	......	8	7	47	194	8	2
Edwardsport	32	......	......	9	7	48	123	3	2
Knox	37	......	......	7	6	50	183	3	......
Lynn	10	......	......	1	3	14	125	2	......
Prospect Hill	27	......	......	6	4	37	243	3	......
Totals	138	......	......	32	27	196	868	19	4
VERMILLION.									
Bruillett's Creek No. 3	44	......	......	5	6	55	127	6	......
Bruillett's Creek No. 4	72	......	......	18	8	98	163	11	......
Bruillett's Creek No. 5	133	......	......	17	8	158	152	10	......
Buckeye	47	......	......	11	6	64	175	7	6
Cayuga	14	......	......	3	2	19	281	2	1
Crown Hill	58	......	......	7	6	71	246	4	1
Oak Hill	156	......	......	26	10	192	211	13	......
Prince	134	......	......	20	8	162	233	11	......
Torrey No. 4	37	......	......	14	4	55	40	6	......
Willow Grove	60	......	......	8	6	74	211	4	2
Keller	12	......	......	5	6	23	61	2	......
Totals	767	......	......	134	70	971	1,900	76	10

Table Showing Number of Miners, Machine Runners and Helpers, etc.—Continued.

COUNTY AND NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Accidents.
VIGO.									
Brick Works	12	......	......	3	2	17	257	2	......
Chicago No. 6	79	......	......	16	5	100	255	10	2
Diamond	155	......	......	52	13	220	227	18	2
Ehrlich	47	......	......	10	6	63	237	5	......
Grant No. 2	157	......	......	34	11	202	231	16	2
Glen Oak	9	12	63	31	14	129	220	17	2
Hector	70	......	......	13	7	90	242	7	......
Klondyke	73	......	......	14	7	94	116	9	......
Miami	102	......	......	13	8	123	228	6	1
Nickelplate	74	......	......	17	11	102	211	8	......
Park No. 10	8	34	65	35	16	158	240	14	3
Peerless	90	......	......	22	10	122	200	15	......
Ray	90	2	3	16	8	119	179	8	......
Red Bird	21	......	......	3	3	27	232	2	......
Rosebud No. 2	113	......	......	21	9	143	193	8	4
Royal No. 1	65	......	......	11	7	83	251	6	......
Larimer	15	......	......	3	2	20	248	1	......
Lawton	23	18	30	20	10	101	247	6	......
Union	129	......	......	31	13	173	256	20	5
Eagle	26	......	......	4	4	34	231	2	5
Totals	1,358	66	161	369	166	2,120	4,501	180	26
WARRICK.									
Air Line	18	......	......	3	3	24	93	2	......
Big Four	48	10	36	10	9	113	266	5	......
Big Vein No. 2	14	10	30	8	6	68	216	6	......
Caledonia	36	......	......	6	6	48	207	5	1
Chandler	12	......	......	3	3	18	151	5	......
DeForrest	18	......	......	3	3	24	187	2	2
Star No. 1	43	......	......	10	9	62	229	6	2
Totals	189	20	66	43	39	357	1,349	31	5
Grand total	7,337	490	1,779	2,287	1,246	13,139	29,409	1,147	251

NOTE No. 1. This mine was closed down in the fall of 1901, and remained closed until June, 1902. It was then started, but, owing to scarcity of miners, the company was compelled to close down again in September.

NOTE No. 2. The working force in this mine was reduced to less than ten men during the summer, owing to scarcity of miners.

NOTE No. 3. Worked less than ten men on account of works being closed off by a squeeze.

NOTE No. 4. The works in this mine were closed off by a squeeze about the first of the year. The company is now making arrangement to mine coal under the Ohio River.

TABLE

Showing Number of Miners, Total Wages of Miners and Average Wages Per Miner; Number of Inside Day and Monthly Men, Total Wages of Same, and Average Wages Per Man; Number of Outside Day and Monthly Men, Total Wages of Same, and Average Wages Per Employe, by Counties.

COUNTY.	Number of Miners.	Total Wages of Miners.	Average Earning per Miner.	Number of Inside Day and Monthly Men.	Total Wages of Inside Day and Monthly Men.	Average Earning per Inside Day and Monthly Man.	Number of Persons Outside.	Total Wages of Persons Outside.	Average Earning per Outside Man.
Clay	1,945	$820,521 15	$421 86	429	$266,187 25	$620 48	221	$131,364 42	$594 40
Daviess	303	129,228 56	426 49	83	42,892 65	516 77	44	17,279 06	390 43
Fountain	40	8,488 40	212 21	10	5,424 88	542 88	5	1,876 55	375 31
Gibson	76	45,315 16	596 25	27	14,356 86	531 73	19	10,243 21	539 11
Greene	1,571	831,005 15	529 22	436	254,399 49	583 48	214	133,898 64	625 68
Knox	138	52,129 58	377 74	31	17,048 95	548 96	27	12,309 96	455 92
Parke	1,122	572,656 71	510 39	249	186,523 81	749 09	136	97,448 94	716 53
Perry	18	7,270 59	403 92	3	1,903 29	634 43	2	1,501 41	750 70
Pike	483	219,288 85	454 01	113	68,149 46	603 09	80	45,562 00	569 52
Sullivan	1,095	493,646 65	450 82	319	220,086 66	689 92	194	120,466 91	620 96
Vanderburgh	188	106,948 90	568 87	41	22,545 43	549 89	29	19,637 67	677 16
Vermillion	767	435,149 38	567 28	134	97,661 30	728 81	70	52,026 21	743 23
Vigo	1,585	861,812 61	543 09	369	246,937 05	669 20	166	122,034 82	735 14
Warrick	275	122,181 19	444 29	43	26,195 35	609 19	39	21,736 36	557 34
General average	9,606	$4,805,642 88	$500 27	2,287	$1,470,312 43	$642 46	1,246	$787,385 18	$631 85

TABLE OF IDLE TIME.

Showing Number of Days Lost in Indiana Mines in the Year 1902 and the Different Causes Thereof.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
No orders	40	40	217	621	562	289	381	335	91	54	35	14	2,679
No cars	433	374	508	219	303	507	381	421	470	405	431	308	4,760
Strikes	4	2	....	11	72	25	4	40	30	4	6	2	200
Funerals	6	5	3	....	4	1	2	....	6	8	4	2	41
Suspensions	....	9	....	214	....	....	....	87	26	....	....	....	336
Other causes	....	16	51	85	26	38	44	52	70	52	45	85	564
Totals	483	446	779	1,150	967	860	812	935	693	523	521	411	8,580

CHANGES IN OWNERSHIP.

The Diamond No. 5 Mine, in Clay County, owned by the Diamond Block Coal Company, was sold to the Brazil Block Coal Company, January 31st.

The Buckeye Mine, in Greene County, owned by the Linton Coal and Mining Company, passed into the hands of the Island Coal Company, in July, and is now known as the Island No. 3 Mine. The latter company owns a very large coal field adjacent to this property, which will be mined from .this opening. The company intends equipping the mine with a veiw to making it one of the largest producers in the county.

The Mecca No. 1 Mine, in Parke County, formerly owned by the Otter Creek Coal Company, changed owners September 1st, and is now owned and operated by the Rock Run Coal Company.

The Genoa Coal Company closed down and abandoned the Carbon Mine, Pike County, in March. Later the property was sold to the Aberdeen Coal Company, which reopened it and began operations in September. At last inspection there were twenty miners employed. The mine now bids fair to become a good producer.

The Alden Mining and Mercantile Company's property in Pike County, changed hands in July, being bought by the Winslow Coal and Gas Company, which is now operating four drift openings, the coal from all of which is handled over the same dump.

The management of the Shelburn Mine, in Sullivan County, changed hands the first of the year, being leased by a company composed of twenty miners, known as the Keystone Coal Company, who have very successfully operated it since that time.

The Briar Hill Mine, located near Dugger, Sullivan County, was bought February 4th by the Clark and Weaver Coal Company, which spent considerable money in remodeling the tipple and making repairs generally. This company operated the mine until November, when it sold out to the Sullivan Coal Company.

The Ingleside Mine, in Sullivan County, owned by the Whitsett Brothers, was leased to the West Linton Coal Company, in July, which has spent considerable money making necessary repairs. The mine is now in fair condition to produce coal at a price which will compare favorably with other mines in that locality.

The Chicago No. 6 Mine, in Vigo County, formerly owned by the Big Vein Coal and Mining Company, was bought by the Weaver Coal and Coke Company, in October.

ABANDONED MINES.

Clay County.

The Columbia No. 5 Mine, located on the Center Point Branch of the Vandalia Railroad, and owned and operated by Zeller, McClellan & Company, was worked out and abandoned March 13th. This mine was opened in 1898, and has been one of the largest producers in the block coal field.

The Dewey Mine, located north of Cardonia, on a switch from the north branch of the Vandalia Railroad, owned and operated by the Jackson Coal and Mining Company, was worked out and abandoned March 31st. This mine was also opened in 1898, the first coal being hoisted in August of that year. The bottom block seam, or Coal III, was mined here, and was found in exceptionally good condition, making the mine a very profitable one.

The Diamond No. 3 Mine, located five miles west of Brazil, on the C. & I. C. R. R., owned and operated by the Diamond Block Coal Company, was worked out and abandoned January 9th. Coals III and IV top and bottom block seams, were mined here. The bottom seam was opened in 1897. This mine was classed as an average one among the block coal mines.

The Gladstone Mine, located one mile east of Coal Bluff, on the Coal Bluff Branch of the C. & I. C. R. R., owned and operated by the Brazil Mining Company, was worked out and abandoned March 15th. The date of opening of this mine does not appear of record in this office.

Daviess County.

The Black Diamond Mine, located near Washington, owned and operated by Osha Brothers, was worked out and abandoned about January 1st. This was a small local mine operated for wagon trade only.

The Logan's Grove Mine, located near Washington, owned and operated by Wilson Brothers, was worked out and abandoned in June. This mine was opened in 1901, and was operated for local trade only.

Greene County.

The Island Valley No. 1 Mine, located two miles southwest of Linton, on the I. & V. Branch Railroad, owned and operated by the Island Valley Coal and Mining Company, was worked out and abandoned December 13th. This mine was opened in 1893 by a joint stock company principally composed of miners. Up until the last year, the mine has had a daily capacity of about 400 tons.

PARKE COUNTY.

The Lyford No. 2 Mine, owned and operated by the Wabash Valley Coal Company, located at Lyford, on a switch of the C. & E. I. R. R., was abandoned February 28th. This mine was operated by several companies within the past four years, none of which seemed to make a success of it. The coal seam has not been exhausted, as the area owned by the company has scarcely been tapped.

The Parke No. 8 Mine, owned and operated by the Parke County Coal Company, and located one mile northwest of Rosedale on the Terre Haute and Logansport Branch of the Vandalia Railroad, was burned down November 14th. The mine was so nearly worked out that it was not deemed advisable to rebuild. (See accidents to mine property.)

SULLIVAN COUNTY.

The Jackson Hill No. 3 Mine, owned and operated by the Jackson Hill Coal and Coke Company, and located at Jackson Hill, was abandoned in May. The mine was opened in 1901 to Coal III. The roof over this seam was found in such condition as to preclude profitable mining.

VERMILLION COUNTY.

The Torrey No. 4 Mine, owned and operated by the Torrey Coal Company, and located three and one-half miles northeast of Clinton, was abandoned in April. Coals VI and VIII were mined here, the lower seam being opened in 1897. While comparing favorably in producing capacity with other bituminous mines, it was not a profitable mine, on account of squeezes, water, etc. The coal seam has not been worked out.

NEW MINES.

Twenty new mines have been reported to this office within the year, situated as follows: One in Clay County, seven in Greene County, six in Parke County, four in Sullivan County, one in Vermillion County and one in Vigo County. Eleven of these, as shown by the following table, are electric machine mines, all of which are located in the bituminous field. In addition, the other parts of the equipment of each mine are very complete, nearly all of them having first-motion hoisting engines, self-dumping cages, shaker screens and other modern appliances.

The mines so equipped are capable of producing and handling a large output at the lowest cost consistent with good mining. They should rank among the largest machine-mine producers within the next year.

Five of the pick mines have been opened in the block coal field and the other four in the bituminous. With two exceptions, i. e., the Harrison Mine, in Parke County, these mines have been opened and equipped in a modern manner. Some of them now have, and others, within a short time, will have a producing capacity classing with the best pick mines of the State. Together with several mines now almost ready to ship coal, these mines will materially increase the total producing capacity of Indiana mines.

The following table shows names of companies of these new mines, the name and location of mines, the railroads on which the mines are located, the geological number and thickness of coal seams, the depth and size of shafts, the kind of mines, the kind of machines used, if any, when mines were opened and the date of the first shipment of coal:

TABLE.

OWNER.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick.	Kind of Machine.	Commenced.	Coal Shipped.	County.
Zeller, McClellan & Co	Lawrence No. 7	E. & I	IV	3' 7"	82	8 x 21	Pick	....	9, '01	2, '02	Clay.
Lattas Creek Coal Company	Lattas Creek No. 1	S. I	IV	5'	153	7 x 14.5	Mach	El. chain	3, '02	7, '02	Greene.
Green Valley Coal Company	Green Valley	S. I	IV	5' 2"	127	8 x 14	Mach	El. chain	4, '02	7, '02	Greene.
Vulcan Coal Company	Vulcan	I. C	V	7'	......	7 x 10	Both	El. chain	Fall, '01	2, '02	Greene.*
Johnson Bros.' Coal Company	Atlas	I. & V	IV	5' 6"	132	9 x 13	Mach	El. chain	8, '01	7, '02	Greene.†
Tower Hill Coal Company	Tower Hill	S. I	III	7'	132	9 x 13	Mach	El. chain	12, '01	7, '02	Greene.
Antioch Coal Company	Antioch	S. I. Branch	IV	4' 6"	176	9 x 13	Mach	El. chain	3, '02	9, '02	Greene.‡
Fry Coal Company	Fry	S. I	IV	3' 7"	87	8 x 16	Pick	....	8, '01	12, '02	Greene.‖
C. B. Harrison	Harrison	Vandalia	....	3' 6"	......	....	Pick	....	....	....	Parke.§
Brazil Block Coal Company	Brazil Block No. 9	C. & I. C	IV	4' 6"	120	8 x 16	Mach	El. chain	8, '00	6, '02	Parke.
Zeller, McClellan & Co	Superior No. 3	C. & I. C.	III IV	3' 8" 4'	40 64	8 x 21	Pick	....	5, '02	7, '02	Parke.
Minshall Vein C. & M. Co	Minshall No. 1	T. H. & L.	III	4' 6"	150	8 x 18	Pick	....	10, '01	4, '02	Parke.
Plymouth Block Coal Company	Pan-American	Big Four	III	4'	70	8 x 18	Pick	....	Fall, '01	1, '02	Parke.
W. P. Harrison	Harrison	T. H. & L.	IV	....	......	....	Pick	....	....	....	Parke.¶
Hymera Coal Company	Hymera No. 2	E.&T.H.B'h	V	7'	105	9 x 20	Mach	El. chain	5, '02	11, '02	Sullivan.
Willfred Coal Company	Willfred	E.&T.H.B'h	VI	5' 6"	103	9 x 18	Mach	El. chain	5, '02	10, '02	Sullivan.
W. S. Bogle Coal Company	Glendora	S. I. Branch	VI	5'	110	8 x 18	Mach	El. chain	'02	10, '02	Sullivan.
Sun Flower Coal Company	Sun Flower	I. C.	VI	6'	......	....	Mach	El. chain	Fall, '01	1, '02	Sullivan.
Keller Coal Company	Atherton	C. & E. I	VI	6' 9"	165	8 x 16	Pick	....	'02	9, '02	Vermillion.
Home Coal Company	Eagle	Vandalia	VI	5'	60	7 x 14	Pick	....	'01	1, '02	Vigo.

*Machines abandoned at this mine in October.

†Opened in 1901 by Coal Bluff Mining Company. After completion it was sold to present owners, who built railroad switch and equipped.

‡A breaker has been installed suitable for the preparation of coal for the various markets.

‖Opened by local capital. Sold by them to present owners.

§This mine does only a local business, supplying a wagon trade.

¶Operated as a small mine for several years.

IMPROVEMENTS.

Ninety-two thousand, eight hundred and twenty-six dollars and thirty-six cents have been expended on improvements of various kinds at Indiana mines within the year. The following, while not representing the total amount of money expended, shows some of the most important changes made:

GREENE COUNTY.

The Midland Coal Company has recently completed its second outlet, or manway, which will also be used as the intake air shaft, and the mine will be ventilated from this point. The shaft is 240 feet deep, a depth which permits equipment of the second outlet with either a stairway or a hoisting apparatus. In this instance the latter has been decided upon. At last inspection, made December 6th, the foundation for the hoisting engine had been laid, and other arrangements were being made for permanent equipment.

This company has also, within the past year, equipped the mine with machinery for rescreening the small coal. The apparatus consists of a bin into which the small coal is run after being screened through the first screen, from which it is elevated and run over gravity screens, so arranged as to be very effective in removing all small particles of dirt and sulphur. The elevating is done by means of buckets attached to a sprocket chain, which is driven by a 15 H. P. Direct Motion Engine.

The Indiana Southern Coal Company has completed the manway at their Gilmour Mine.

The Island Coal Company has equipped its No. 2 mine with a Mitchell dump, which has considerably reduced the cost of labor in the dumping of coal, as well as screening it more perfectly.

PERRY COUNTY.

Bergenroth Brothers have equipped their Troy Mine with a 10-foot fan. Heretofore the mine has been ventilated with a furnace, and the above change has effected a great improvement in the ventilation.

PIKE COUNTY.

The David Ingle Coal Company has equipped its No. 4 Mine with a tail rope haulage of about one-quarter mile in length, which will greatly increase the capacity of the mine. It has also installed a new 12-foot Crawford, McCrimmon ventilating fan, shaker screens and a coal crusher of about 300 tons' capacity. This and some other minor improvements will place No. 4 among the best producers in the southern part of the State.

Sullivan County.

The Chicago-Indiana Coal Company has sunk a new air shaft on the south side of their Dugger Mine, and has equipped it with an electric fan. This now places the ventilation of this mine in excellent condition.

This company has also replaced the electric third-rail motor haulage with traction motors weighing 11 tons each, which give much better satisfaction.

The White Ash Coal Company has equipped one side of the White Ash Mine with a high-speed electric fan.

Vanderburgh County.

The Crescent Coal Company has spent a large amount of money in building wagon chutes, and in the improvement of its surface plants at the Unity Mine.

Warrick County.

The Big Four Coal Company has equipped its Big Four Mine with four compressed air machines. It is the intention, however, to increase this number and to do their mining entirely with machines. This company has also put in a 12-foot fan, the mine heretofore having been ventilated by a furnace.

The balance of the money was spent upon mine buildings, increase in number of mining machines, and the improvement of the mines generally.

TABLE OF COAL LAND.

Showing Name of Owner, Acres of Surface, Acres of Coal, Geological Number of Seam, Thickness of Seams, Total Acres of Coal Owned, Average Thickness of Seams, Location of Land and Means of Transportation.

OWNER.	Acres of Surface.	Geological Number of Seam and Acres of Coal.	Thickness of Seam.	Geological Number of Seam and Acres of Coal.	Thickness of Seam.	Geological Number of Seam and Acres of Coal.	Thickness of Seam.	Geological Number of Seam and Acres of Coal.	Thickness of Seam.	Geological Number of Seam and Acres of Coal.	Thickness of Seam.	Total Acres of Coal.	Average Thickness of Seams.	COUNTY.	TOWNSHIP.	RAILROAD.
		III		IV		V		VI		VII						
A. M. Ogle	1,000	1,000	6′	1,000	5′							2,000	5′ 6″	Greene	Wright	S. I.
O'Garra-King & Co	720	720	6′	720	5′							1,440	5′ 6″	Clay	Lewis	S. I.
Island Valley Coal Co	420	420	6′	720	4′ 6″							740	5′ 3″	Clay	Lewis	S. I.
Terhune Coal Co	800	*		800	4′ 6″	800	6′	800	5′			2,400	5′ 2″	Greene		Penn. or S. I.
Coal Bluff Minin g Co	1,200	1,200	6′	1,200	4′ 2″	900	5′ 9″	350	5′			3,650	5′ 11″	Greene	Wright	Penn. or S. I.
Jefferson Coal Co	750					750	5′ 2″	750	5′			1,500	5′	Sullivan	Cass	I. C.
Northwestern Coal Co	500	500	6′	500	5′ 2″							1,000	5′ 7″	Greene	Wright	S. I.
Mammoth Vein Coal Co	1,000	*				1,000	5′ 6″	1,000	5′			2,000	5′ 3″	Sullivan		E. & T. H.
Pan Handle	950	*						950	5′ 2″			950	5′ 2″	Sullivan	Cass and Jefferson.	I. C.
Richmond Coal Co	700	*						700	5′ 6″			700	5′ 6″	Sullivan	Cass	I. C.
Central Coal Co	750	*						750	5′			750	5′	Sullivan	Cass	I. C.
Collins Coal Co	1,200	*						1,200	5′			1,200	5′	Sullivan	Jefferson.	
Little Giant Coal Co	1,554	*		*				1,554	5′			1,500	5′	Sullivan	Jefferson.	
Manufacturers Fuel Co	2,660	*		*		2,660	5′ 8″	2,660	5′ 6″	2,660	3′ 6″	5,320	5′ 4″	Sullivan		S. I., E. & T. H.
Johnson Bros	1,000	*		1,000	5′ 6″					1,000	4′ 6″	1,000	5′ 6″	Greene		I. & V.
Antioch Coal Co	1,200	*		1,200	4′ 6″	120	6′					1,320	5′ 3″	Greene	Wright	S. I.
Hoosier Coal Co	180					180	6′					180	6′	Greene		S. I.
Coal Bluff Mining Co	1,200	1,200	5′ 6″	1,200	4′ 4″	900	5′ 6″	350	5′			3,650	5′ 1″	Greene	Wright	S. I.
Tower Hill Coal Co	1,500	1,500	7′									1,500	7′	Greene	Wright	S. I.
Green Valley Coal Co	800	800	6′	800	5′							1,600	5′ 6″	Greene	Wright	S. I.
Ledsinger Coal Co	600	600	7′	300	5′							900	6′	Greene	Wright	S. I.
Zeller-McClellan Coal Co	2,100	2,100	7′	100	5′ 2″	500	5′ 2″	500	6′			5,200	5′ 10″	Sullivan	Jefferson	S. I., E. & T. H.
Wilfred Coal Co	650							650	5′			650	5′	Sullivan		E. & T. H.
W. S. Bogle Coal Co	1,492					1,492	5′ 6″	1,492	5′			2,984	5′ 3″	Sullivan	Hamilton.	S. I.
Keeler Coal Co	750					750	5′ 8″	750	5′			1,500	5′ 4″	Sullivan	Hamilton.	S. I., E. & T. H.
Zeller, McClellan & Co	65	65	3′ 6″	50	4′	†						115	3′ 9″	Parke		
Hymera C. and M. Co	675	675	5′	675	5′	675	7′					2,025	6′	Sullivan	Jackson	S. I.
J. Smith Talley	1,050			1,050	4′ 6″							1,050	4′ 6″	Greene	Wright	S. I.
J. Smith Talley	4,000					4,000	5′					4,000	5′	Sullivan	Cass	E. & T. H., I. C.
H. Laughlin	1,500	1,500	6′ 6″	600	4′	200	6′					2,300	5′ 6″	Sullivan		
Cummins Coal Co	1,100									1,100	5′	1,100	5′	Sullivan		
Totals	8,390	8,440		8.975		11,477		6,402		4,760		10,590				

* Not drilled. † Both block seams.

FATAL ACCIDENTS.

Clay County.

January 21st—Isaac Caddie, a driver, employed at the Glen Mine, was fatally injured. The accident occurred while coming out of a slight down-grade entry on his way to the bottom of the shaft with a loaded trip. The mule he was driving stopped suddenly, crushing the decedent betweeen the car and mule, causing internal injuries, from which he died the next day.

February 3d—Domineck Savant, a miner, working in the Pratt Mine, was instantly killed by falling slate; estimated weight, 20 tons. He was loading his first car of coal in the morning. An examination of his working place showed that it was badly in need of props. Evidence at the inquest tended to show that Mr. Savant had knowledge of this fact, and that he was trying to get his loose coal loaded out before commencing to set props.

February 27th—David Haskins, a miner, was killed by falling slate at the Cornwell Mine, while loading a car. An inspection of his working place showed a slip running across the face of the room, which was but partially widened out, and that he had set three props under the slate, which must have loosened as soon as the slip was exposed. A few more props might have prevented this accident.

March 17th—August Johnson, a miner, was instantly killed in the Brazil Block No. 10 Mine by a premature blast. No one was present at the time of the accident, but at the investigation it was learned that Mr. Johnson was charging a shot with loose powder. It is thought that he was using a scraper to push the powder to the back of the hole when it ignited by a spark from his lamp, or from a spark occasioned by contact of the scraper and a piece of sulphur. The latter is most probably the correct theory.

Greene County.

February 20th—Howard Sexton, a loader, was killed by falling slate in the Midland Mine. The accident was caused by the falling of a slate band of about 14 inches thickness, which lies between two benches of coal in some parts of this mine. Mr. Sexton was mining off some loose coal at the face of the entry beneath a ledge of this slate band about five feet in width, when it fell upon him, killing him instantly.

June 10th—R. A. Dow, a flat trimmer, employed at the Island No. 2 Mine, was crushed to death between the frame timbers of the car shed and a railroad car. With a pinch-bar he had just started a loaded car from the dump and stepped aside to allow an empty car to stop under the dump. The space into which he stepped, between the track and car shed, was so narrow that the car could not pass without crushing him.

October 8th—Peter Burns, a miner, was injured by falling draw-slate, at the Templeton Mine. At the time his injuries were thought to be not serious. Death resulted a few days later, presumably from internal injuries.

Parke County.

February 13th—Ed Gibbons, a driver, was killed in Lyford No. 2 Mine. As no one else was present, it is not known just how the accident occurred. The presumption is, however, that he fell under and was run over by a mine car. When found he was lying on the roadway, life being extinct.

February 22d—Milton Croft, a miner, was burned by a smoke explosion at Lyford No. 1 Mine, sustaining injuries from which he died March 4th.

The accident was due to gross carelessness. There were twelve shots tamped on fuse and all fired simultaneously. It is estimated that not less than seventy-five pounds of powder were burned in said twelve shots; also a few sticks of dynamite. Investigation showed that a number of the shots were misplaced. In one instance a drill-hole measured four feet past the cutting, or loose end.

October 31st—Robert Simpson, a miner, working in the Columbia No. 2 Mine, was killed by falling slate. At the time of the accident he was drawing an entry pillar and was mining off some loose coal from beneath a horseback. The piece of slate which fell upon him was of from six to eight tons in weight.

Mr. Simpson is reported as having been a very careful workman. An inspection of his working place showed it to be well timbered. On the investigation, testimony was given to the effect that the roof had been examined and sounded by his son, who pronounced it safe a few minutes before the accident. It seems, however, that both father and son failed to notice a slip which ran up into the roll, and which caused the slate to fall without warning.

December 29th—Charles Everhart, a miner, was instantly killed in the Superior No. 1 Mine, owned an operated by Zeller, McClellan & Company. At the time of the accident he was loading out a car of dirt from a shot which had been fired in the bottom, when a large piece of draw-slate fell upon him. An examination of his working place showed it to be well timbered and a good roof above the draw-slate.

Pike County.

July 10th—William Cox, a miner, was fatally injured by falling slate in the Ayrshire No. 3 Mine. He was working off a standing shot at the end of a pillar which he was drawing, when a piece of slate eleven feet long, three feet wide, and ranging from one to nine inches in thickness, fell upon him. When found, he was unconscious, and he remained so until his death, a few hours later.

July 17th—Elmer Kellams, employed as rope rider at the Petersburg Mine, was killed while attempting to cross the cage seat at the bottom of the hoisting shaft. He was caught by a descending cage. His skull and one of his jaws were fractured. From the effects of this accident he died seven days afterward.

August 15th—Ed Hays, a miner, was killed at the Blackburn Mine. On this date Mr. Hays and two other miners, who were working in an adjoining room, had three shots to fire, one in Room 7, Hays's working place, and two in Room 8. One of the shots in Room 8 had been tamped on fuse. At firing time both shots were lighted, one with a fuse, the other with a squib. The latter exploded. Hays, thinking both shots had been fired, started back into his room to fire his shot. When within a few feet of the face of his room, the shot which had been tamped on fuse, as above described, exploded, blowing through the pillar and killing him.

December 31st—William Janes (colored), a miner employed at the Winslow Gas Coal Company Mine, was fatally injured by a fall of slate. There were dependent and are surviving him, his wife and two children. At the time of the accident Mr. Janes was turning a room-neck. When he went into the mine in the morning there was some slate down in his working place and some hanging loose. Upon calling the attention of the management to the condition of the place, Mr. Janes was instructed to take down the loose slate and clean up the place, which he agreed to do. He was advised by a miner in an adjoining room not to go under the loose slate to fire a shot which was ready to be fired, but it seems that he attempted to fire the shot, and while so doing a piece of slate, eight feet long, three feet wide and six to seven inches thick, fell upon him, inflicting injuries from which he died within three hours afterward.

SULLIVAN COUNTY.

July 7th—John Batey, assistant mine boss at the Dugger Mine, was fatally injured by falling slate. On the morning of above date, Batey, in company with three timbermen, went into a room which had been reported unsafe, for the purpose of timbering and securing it. While sounding and examining it, the roof gave way, falling on Batey and injuring him internally, from the effects of which he died within two hours.

September 18th—George Goodman, a timberman, was killed by falling slate in the Farnsworth Mine. This accident was very similar to that in the Dugger Mine, inasmuch as Goodman's duties were to take down or make safe any loose slate in the mine. On the afternoon of the above date, he and another miner, David Bushnell, had gone to a room which had been reported in bad condition, for the purpose of making it safe, and had just commenced sounding the roof, when it gave way, falling upon and covering both of them completely, seriously injuring Bushnell and killing Goodman almost instantly.

December 12th—Ferdinand Cochran, a driver, was instantly killed in the Dugger Mine. Investigation of the accident was made by the Coroner of Sullivan County and the Inspector of Mines. The following facts, in brief, were established: That the body was found under a mine car about 300 feet from the top of the hill down which he had just driven. That his lamp was found near the top of the hill. That at that point the slate had fallen to a height of about seven feet for a distance of 40 feet. The natural presumption is that when Cochran was driving through this seven-foot space he was standing straight up on the front end of his car, and that when he came to the set-off, or where the entry was but five feet high, he did not get low enough to pass under the same, and that his lamp was knocked from his cap, and he then attempted to continue his run in the darkness to the double parting, the point to which he had started. When nearly at the foot of the hill the mule turned round to the side of the car, throwing Cochran off the tail-chain and under the car. There were no spraggs in the cars, although it seems that Cochran had been ordered to use them.

Vermillion County.

January 30th—Andrew Jacobson, a miner, was fatally injured at the Buckeye Mine by falling draw-slate. At the time of the accident, he was mining off a loose shot under a ledge of draw-slate five or six inches thick, this ledge extending in over the shot or loose coal which he was mining down. Investigation shows that he set one prop under this slate, but that he should have set at least three. After having mined off some of the standing coal, it is presumed he uncovered a break in the draw-slate, which suddenly gave way and fell upon him, inflicting injuries from which he died three days later.

September 9th—William Hannis and John Bonner, shot firers, employed by the miners of the Willow Grove Mine, were fatally injured by a smoke explosion, the former dying on the 14th, and the latter on the 26th following. The immediate cause of the accident was a windy or misplaced shot fired into a dense body of smoke created by shots which had been fired a few minutes before. On investigation it was learned that the men were firing three shots in the last room, completing their work for that day, also, that the three shots, each of which was tamped on fuse, were lighted at the same time, and the probability is that they exploded at the same time. This, considering the fact that each shot was heavily charged with powder, might of itself cause an explosion.

Vigo County.

December 20th—James Farr was crushed to death by an ascending cage at the bottom of the hoisting shaft at the Rosebud Mine, owned and operated by the Seeleyville Coal and Mining Company. At the time of his death, Farr was employed as a cager. A few minutes prior to the accident a car of coal had been placed on the north cage and the signal given the engineer to hoist. Farr, by some mistake, in attempting to cage another car, pushed it into the sump or cage seat of the south cage which at the time was at or near the top of the shaft. At about the time he pushed the car into the sump, the engineer started to hoist the north cage, and some one gave the signal to stop and lower it back to the bottom, so that the car could be taken off, this being necessary before the car could be gotten out of the sump and hoisting could be resumed. Without giving the engineer any warning of the conditions or of their intentions, Farr and two other persons, a Mr. McDonald and Mr. Hughes, attempted to remove the car from the north cage. The engineer after lowering the cage to the bottom did not entirely close off the steam from the engine but stood with it partially turned on ready to hoist when the signal should be given. When the car was pushed off the cage, it lessening the load by about three-quarters against which the steam pressure was then almost equal, the engine took motion and hoisted the empty cage up the shaft some six or seven feet, causing Farr to fall down on the bottom of the cage where he lay with his head extending out over the edge, where he was caught against the face plate at the bottom of the curbing, instantly crushing him to death. A few words spoken through the speaking tube, or a danger signal given the engineer would have prevented this most distressing accident.

Warrick County.

January 21st—Benjamin Shelton, a miner, was killed in the Star No. 1 Mine. On investigation it was learned that Mr. Shelton had two shots ready to fire at firing time, and that another miner was to assist him; that when the former applied his lamp to the squib the shot exploded, instantly killing him. (See following accident.)

June 27th — John Tremper, a miner, was fatally injured by a premature blast in the last above mentioned mine. The cause of this accident was a defective squib. It was learned at the investigation that the shot exploded instantly on his applying a light to the squib. Death resulted twenty-four hours afterward.

TABLE OF FATAL CASUALTIES.

CLAY COUNTY.

Date.	Name.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
January 21	Isaac Caddie	Coal Bluff	Driver	Mine car and mule	Glen	Coal Bluff Mining Company.
February 23	Domineck Savant	Perth	Miner	Falling slate	Pratt	Coal Bluff Mining Company.
February 27	David Haskins	Cardonia	Miner	Falling slate	Cornwell	Jackson Coal Mining Company.
March 17	August Johnson	Diamond	Miner	Premature blast	B. B. No. 10	Brazil Block Coal Company.

GREENE COUNTY.

Date.	Name.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
February 20	Howard Sexton	Midland	Loader	Falling slate	Midland	Midland Coal Company.
June 10	R. A. Dow	Linton	Flat trimmer	Railroad car	Island No. 2	Island Coal Company.
October 8	Peter Burns	Linton	Miner	Falling slate	Templeton	Western Indiana Coal Company.

PARKE COUNTY.

Date.	Name.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
February 13	Ed Gibbons	Lyford	Driver	Mine car	Lyford No. 2	Wabash Valley Coal Company.
February 22	Milton Croft	Lyford	Miner	Smoke explosion	Lyford No. 1	Wabash Valley Coal Company.
October 31	Robert Simpson		Miner	Falling slate	Columbia No. 2	Zeller, McClellan & Co.
December 29	Charles Everhart		Miner	Falling slate	Superior No. 1	Zeller, McClellan & Co.

PIKE COUNTY.

Date.	Name.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
July 10	William J. Cox	Ayrshire	Miner	Falling slate	Ayrshire No. 3	S. W. Little Coal Company.
July 17	Elmer Kellams	Petersburg	Rope rider	Descending cage	Petersburg	J. Woolley Coal Company.
August 15	Ed Hays	Blackburn	Miner	Shot blowing through pillar	Blackburn	S. W. Little Coal Company.
December 31	William Jones	Winslow	Miner	Falling slate	Alden	Winslow Gas and Coal Company.

SULLIVAN COUNTY.

July 7	John Batey	Dugger	Driver boss	Falling slate	Dugger	Chicago-Eastern Indiana Coal Company.
September 18	George Goodman	Farnsworth	Timberman	Falling slate	Farnsworth	Washington Fuel Company.
December 12	Ferdinand Cochran	Dugger	Driver	Mine car	Dugger	Chicago-Eastern Indiana Coal Company.

VERMILLION COUNTY.

January 30	Andrew Jacobson	Clinton	Miner	Falling slate	Buckeye	McClellan, Sons & Co.
September 9	John Bonner	Clinton	Shot firer	Windy shot	Willow Grove	Willow Grove Coal Company.
September 9	Wm. Hannis	Clinton	Shot firer	Windy shot	Willow Grove	Willow Grove Coal Company.

VIGO COUNTY.

December 20	James Farr	Cloverland	Cager	Caught by cage	Rose Bud	Seeleyville Coal and Mining Company.

WARRICK COUNTY.

January 21	Benjamin Shelton	Newburgh	Miner	Premature blast	Star No. 1	John Archbold Coal Company.
June 27	John Tremper	Newburgh	Miner	Premature blast	Star No. 1	John Archbold Coal Company.

SERIOUS ACCIDENTS TABLE.

Date.	Name.	Occupation.	Cause.	Injury.	Mine.	County.
Jan. 3....	Wm. Bailey...........	Miner............	Fall of slate..........	Back and hips bruised	Wild Cat.............	Greene.
Jan. 3....	Chas. Daniels..........	Machine runner.	Machine	Leg fractured......................	Wild Cat.............	Greene.
Jan. 3....	Henry Brown..........	Driver............	Kicked by mule	Face lacerated......................	Wild Cat.............	Greene.
Jan. 3....	Walter Manary........	Miner	Fall of coal	Collar bone fractured...............	B. B. No. 10	Clay.
Jan. 3....	Robert Hunter.........	Miner	Fall of coal	Collar bone fractured...............	Eureka No. 2.........	Clay.
Jan. 4....	Samuel Jones..........	Miner	Fall of slate..........	Legs and body bruised	B. B. No. 1	Clay.
Jan. 4....	David Carlin..........	Miner	Fall of slate..........	Body bruised........................	Glen Oak.............	Vigo.
Jan. 6....	Jep. Booth............	Miner	Fall of slate..........	Collar bone broken..................	Crawford No. 7.......	Clay.
Jan. 9....	S. W. Roll.............	Miner	Fall of coal	Leg fractured........................	Oswald..............	Gibson.
Jan. 17 ...	Ed. Fisher.............	Miner	Fall of slate..........	Body bruised........................	Island Valley No. 3..	Greene.
Jan. 18....	John Southard.........	Miner	Falling coal..........	Collar bone fractured	South Linton	Greene.
Jan. 30....	A. Jacobson...........	Miner	Fall of slate..........	Crushed about hips.................	Buckeye.............	Vermillion.
Feb. 1....	Ralph Cummix........	Driver............	Mine cars............	Leg fractured........................	Cornwell.............	Clay.
Feb. 3....	Sid. Johnson..........	Driver............	Mine car.............	Finger cut off.......................	B. B. No. 12	Parke.
Feb. 5....	Michael Hockman.....	Loader	Railroad car	Face cut..............................	B. B. No. 12	Parke.
Feb. 6....	Wm. Bidwell..........	Driver............	Mine car.............	Hips dislocated......................	Jackson Hill No. 2...	Sullivan.
Feb. 7....	Charles Fox...........	Trapper mine....	Car	Not reported.........................	Buckeye.............	Vermillion.
Feb. 17....	Homer Drew..........	Driver............	Car and mule........	Ribs fractured.......................	Ayrshire No. 3.......	Pike.
Feb. 18....	A. J. Sanders	Miner.............	Fall of coal	Leg fractured........................	B. B. No. 10	Clay.
Feb. 19....	James Lewis..........	Driver............	Kicked by mule	Not reported	Gifford	Clay.
Feb. 20....	Harris White	Miner.............	Fall of slate..........	Leg fractured........................	Eureka No. 3.........	Clay.
Feb. 22....	Fred Davis............	Miner.............	Smoke explosion	Body burned........................	Wabash Valley No. 1	Greene.*
Feb. 22....	C. H. Little	Miner.............	Smoke explosion	Body burned........................	Wabash Valley No. 1	Greene.*
Feb. 22....	Daniel Bauser.........	Miner.............	Smoke explosion	Body burned........................	Wabash Valley No. 1	Greene.*
Feb. 22....	John Colman	Miner.............	Smoke explosion	Body burned........................	Wabash Valley No. 1	Greene.*
Feb. 22....	Joseph Lovel	Miner.............	Smoke explosion	Body burned........................	Wabash Valley No. 1	Greene.*
Feb. 22....	Milton Croft..........	Miner.............	Smoke explosion	Body burned........................	Wabash Valley No. 1	Greene.*
Feb. 24....	John Eddy............	Loader	Mine car.............	Hand mashed........................	Island No. 2..........	Greene.
Feb. 25....	Ed. Haines............	Miner.............	Mine cars	Leg fractured........................	Union	Vigo.
Feb. 26....	W. Van Cannon	Cager.............	Coal fall down shaft.	Hand mashed........................	Buckeye	Vermillion.
Feb. 21....	James Easter	Cager.............	Falling coal	Arm fractured	Hymera	Sullivan.
Feb. 12....	Marsh Moore	Miner.............	Shot through pillar..	Head and face cut..................	Jackson Hill No. 2...	Sullivan.†
Feb. 12....	Jesse Shonk...........	Miner.............	Shot through pillar..	Head and face cut..................	Jackson Hill No. 2...	Sullivan.†
Feb 13....	George Kammerer.....	Miner.............	Went back on shot ..	Face and eyes.......................	Littles...............	Pike.
Mar. 1....	Charles Roby	Driver............	Mine car	Fractured rib.......................	Island No. 1..........	Greene.
Mar. 4....	Albert Ward..........	Miner.............	Windy shot	Body burned........................	Broad Hurst	Vigo.§
Mar. 4....	William Ward.........	Miner.............	Windy shot	Body burned........................	Broad Hurst	Vigo.§
Mar. 4....	Michael Ward	Miner	Windy shot	Body burned........................	Broad Hurst	Vigo.§
Mar. 4....	James White	Miner	Windy shot	Body burned........................	Broad Hurst	Vigo.§
Mar. 6....	Linsey Day	Loader	Falling slate.........	Body bruised	Parke No. 10.........	Vigo.
Mar. 6....	Charles Taylor.........	Driver	Mine car.............	Breast and ribs crushed............	Island No. 2	Greene.

Mar. 8	Sherman Robling	Miner	Fall of coal	Ribs fractured	Blackburn	Pike.
Mar. 10	John Willey	Mine boss	Fall of stone	Legs fractured	Blackburn	Pike.
Mar. 11	Onton Mlinch	Miner	Fall of slate	Back injured	Superior No. 2	Parke.
Mar. 20	L. Duchaney	Driver	Mine car	Leg and fingers crushed	Wild Cat	Greene.
Mar. 21	William Reep	Mach. runner	Machine	Leg bruised	Brazil Block No. 8	Clay.
Mar. 22	Wm. Buckhultz	Miner	Fall of slate	Head and face cut	Brazil Block No. 1	Clay.
Mar. 28	William Frost	Driver	Mine car	Arm fractured	Brazil Block No. 1	Clay.
Apr. 1	G. W. Steadman	Miner	Mine car	Collar bone fractured	Cloverland	Clay.
Apr. 2	Leslie Ogden	Loader	Mine car	Leg fractured	Lawton	Vigo.
Apr. 18	Theo. McNeeley	Miner	Fall of slate	Leg	Caledonia	Warrick.
Apr. 21	Michael McFadden	Miner	Pall of coal	Ankle fractured	Island No. 2	Greene.
Apr. 21	John Pascoe	Miner	Fall of slate	Leg fractured	Buckeye	Vermillion.
Apr. 23	Morton Calvert	Loader	Falling rock	Cut on head	Summit No. 2	Greene.
Apr. 21	Charles Neal	Driver	Mine car	Leg fractured	Wild Cat	Greene.
Apr. 26	H. Hanchins	Miner	Fall of slate	Injured internally	Ayrshire No. 3	Pike.
May 1	Robert Moore	Miner	Fall of coal	Collar bone fractured	Superior No. 1	Parke.
May 4	John Crimes	Driver	Fall of slate	Back and shoulder bruised	Caledonia	Sullivan.
May 4	U. Payton	Driver	Kicked by mule	Arm fractured	Glen Oak	Vigo.
May 7	Walter Carter	Miner	Missed shot	Body bruised	Turner No. 3	Clay.
May 9	James Hicks	Miner	Delayed shot	Injured internally (fatal)	Grant No. 2	Vigo.
May 10	Archie McTavish	Timberman	Falling rock	Back bruised	Wild Cat	Greene.
May 23	Harry Cleghorn	Loader	Mine car	Toe fractured	Union	Vigo.
May 29	James Mitchell	Miner	Fall of slate	Head and body bruised	Island No. 2	Greene.
May 24	Fred Morgan	Driver	Mine car	Leg fractured	Cloverland	Clay.
May 26	Robert Highfield	Miner	Fell in shaft	Face and body bruised	Caledonia	Sullivan.
May 29	J. L. Mitchell	Miner	Fall of slate	Head and body bruised	Island No. 2	Greene.
May 29	~~U. Payton~~	~~Driver~~	Kicked by mule	Arm fractured	Glen Oak	Vigo.
June 2	John Keller	Driver	Kicked by mule	Lost a thumb	Cox No. 3	Parke.
June 3	G. Gott	Miner	Fall of coal	Leg and face bruised	Wild Cat	Greene.
June 9	Thomas Nous	Miner	Fall of coal	Back injured	Phœnix No. 5	Sullivan.
June 13	Ed. Oliver	Miner	Fall of slate	Leg and side bruised	Mecca	Parke.
June 25	Fred Basler	Cager	Gas explosion	Body burned	Diamond	Vanderburgh.
June 28	Benjamin Williams	Miner	Fall of slate	Shoulders bruised	Superior No. 1	Parke.
July 2	John Lynch	Driver	Mine car	Legs bruised and cut	Gifford No. 1	Clay.
July 3	John Campbell	Miner	Fall of slate	Skull fractured	Union	Vigo.
July 14	Allen Rebemaster	Miner	Fall of coal	Leg fractured	Seeleyville No. 2	Vigo.
July 13	William Stone	Miner	Fall of slate	Back and hips bruised	Island Valley No. 2	Greene.
July 23	Thomas Lark	Driver	Mine car	Leg fractured	Chicago No. 6	Vigo.
July 28	Wilson Tribble	Miner	Fall of slate	Jaw fractured	Klondyke	Clay.
July 7	Alex. Rose	Miner	Fall of coal	Collar bone fractured	South Linton	Greene.
July 12	Wm. Merrifield	Driver	Mine car	Leg fractured	South Linton	Greene.
July 21	Scott Willis	Miner	Fall of slate	Spine injured	Ayrshire No. 4	Pike.
July 10	William Cox	Miner	Fall of slate	Body bruised	Ayrshire No. 3	Pike.
July 23	John Custer	Miner	Fall of slate	Leg fractured	Island Valley No. 3	Greene.
July 12	E. Purcel	Mach. runner	Machine	Hand mashed	Wild Cat	Greene.
July 9	Charles Fettinger	Miner	Fall of slate	Leg fractured	Winslow	Pike.
Aug. 2	Perry Smith	Miner	Fall of slate	Leg fractured	Seeleyville No. 2	Vigo.
Aug. 2	John Hoffman	Miner	Fall of coal	Toe fractured	Brazil Block No. 11	Clay.

SERIOUS ACCIDENTS TABLE—Continued.

Date.	Name.	Occupation.	Cause.	Injury.	Mine.	County.
Aug. 4	Henry Blevens	Driver	Falling slate	Arm fractured	Jackson Hill No. 2	Sullivan.
Aug. 7	Benjamin Dodson	Car trimmer	Railroad car	Hand mashed	Bicknell	Knox.
Aug. 19	John Moore	Miner	Fall of slate	Leg fractured	Massey	Pike.
Aug. 19	John Cooprider	Mach. runner	Machine	Fingers mashed	Phœnix	Sullivan.
Aug. 19	Nathan Biggs	Fireman	Not given	Finger mashed	Phœnix No. 5	Sullivan.
Aug. 22	Nathan Farr	Miner	Mine car	Hand mashed	Cox No. 3	Parke.
Aug. 25	George Keller	Driver	Mine car	Ribs and shoulders bruised	Cox No. 3	Parke.
Aug. 25	Jacob McKinney	Driver	Fall of slate	Ear and head cuts	Turner No. 3	Clay.
Aug. 13	John Dwyer	Driver	Mine cars	Leg fractured	Crawford No. 3	Clay.
Aug. 14	Charles Lucas	Miner	Delayed shot	Head and face cuts	Blackburn	Pike.
Aug. 14	Edward Preston	Miner	Delayed shot	Head and legs cut	Blackburn	Pike.
Aug. 4	Jas. E. Cheney	Miner	Fall of coal	Leg fractured	Wild Cat	Greene.
Sept. 1	Allen Rain	Miner	Fall of slate	Head and leg bruises	Dugger	Sullivan.
Sept. 18	David Bushnell	Miner	Fall of slate	Body bruised	Farnsworth	Sullivan.
Sept. 18	Frank Nearshears	Miner	Fall of slate	Back injured	Union	Vigo.
Sept. 19	Henry Wilcox	Miner	Fall of slate	Back and hips bruised	Lawrence No. 6	Clay.
Sept. 15	Frank Cunningham	Miner	Fall of slate	Back and hips bruised	McIntosh No. 3	Parke.
Sept. 29	Albert Holt	Driver	Mine car	Leg fractured	Edwardsport	Knox.
Sept. 20	James Bennet	Machine runner	Machine	Hand crushed	Gifford No. 1	Clay.
Sept. 26	J. H. Littell	Driver	Mine cars	Foot mashed	Massey	Gibson.
Sept. 3	George Choran	Loader	Fall of coal	Leg fractured	B. B. No. 12	Parke.
Sept. 16	Ord. Levan	Driver	Car	Leg fractured	Island Valley No. 3	Greene.
Sept. 9	Walter Brown	Cager	Kicked by mule	Teeth knocked out	Wild Cat	Greene.
Oct. 1	P. Jones	Miner	Fall of coal	Feet mashed	Bicknell	Knox.
Oct. 1	Roscoe White	Driver	Mine car	Leg fractured	Caledonia	Sullivan.
Oct. 11	John Wirt	Miner	Premature shot	Head and face	Eagle	Vigo.
Oct. 25	William Smith	Driver	Mine car	Finger amputated	Crawford No. 5	Clay.
Oct. 27	Peter Fine	Miner	Fall of slate	Leg and ribs fractured	Princeton	Gibson.
Oct. 31	Peter Steber	Miner	Went back on shot	Leg fractured	Superior No. 2	Parke.
Oct. 27	Robert Pearce	Miner	Fall of coal	Foot mashed	Wild Cat	Greene.
Oct. 1	Andrew Rose	Driver	Mine car	Hips mashed	Bon Ton	Greene.
Oct. 21	Albert Irwin	Miner	Fall of slate	Ankle fractured	Dugger	Sullivan.
Oct. 13	Eagan Ahle	Driver	Mine car	Shoulder dislocated	Island Valley No. 2	Greene.
Oct. 24	William Miers	Driver	Mine car	Finger cut off	Island Valley No. 2	Greene.
Oct. 22	Jerry Shoptaw	Miner	Mine car	Ribs fractured	Island Valley No. 3	Greene.
Nov. 4	George Skokan	Miner	Went back on shot	Body badly bruised	Superior No. 1	Parke.
Nov. 6	Enoch O'Brien	Miner	Fall of slate	Back injured	South Linton	Greene.
Nov. 8	Roy Stevens	Driver	Mine cars	Leg cut	Cloverland	Clay.
Nov. 11	Claude McGarr	Miner	Fall of coal	Back fractured	Phoenix No. 1	Sullivan.

Nov. 12....	Thomas Thomas.......	Miner	Fall of coal	Leg fractured..........................	Island No. 2	Greene.
Nov. 18....	Isaac Pride	Miner	Fall of slate	Back and hips bruised	Cabel No. 9	Daviess.
Nov. 24....	Nick. Leidenger	Miner	Premature shot......	Burned face and arms	Gifford No. 2.........	Clay
Dec. 10....	Clements Hafley.......	Miner	Fall of coal	Fingers cut off........................	Pan-American	Parke.
Dec. 11....	Frank Stevenson	Jerryman	Mine car.............	Ankle bone fractured	Hymera...............	Sullivan.
Dec. 11....	Frank Harmon	Jerryman	Mine car.............	Leg fractured..........................	Hymera...............	Sullivan.
Dec. 10....	Sim. Woolley	Mine boss........	Mine car.............	Back injured	Star	Sullivan.
Dec. 19....	David Bangham	Car trimmer	Coal from dump	Leg fractured..........................	B. B. No. 12	Parke.
Dec. 22....	John Scharf	Driver............	Mine car.............	Hips crushed	Cloverland	Clay.
Dec. 24....	Thos. Brantlinger	Miner	Gas explosion	Body burned	Buckeye	Vermillion.
Dec. 29....	John Galloway	Driver............	Fell under mine car.	Body bruised	Buckeye	Vermillion.
Dec. 29....	Edward Matthennes...	Miner	Fall of coal	Breast and hips crushed	Lawrence No. 6......	Clay.
Dec. 29....	Clarence Hagerpole ...	Driver............	Fell under mine car.	Breast and shoulder bruised	Chicago No. 6.........	Vigo.
Dec. 28....	John Blond	Miner	Fall of coal	Foot mashed..........................	Minshall No. 1.......	Parke.
Dec. 30....	John Belt..............	Miner	Fall of coal	Back sprained	Minshall No. 1.......	Parke.
Dec. 30....	John Roberts	Driver............	Mine car.............	Finger cut off........................	Diamond No. 5	Clay.
Dec. 19....	Edward Jones	Driver............	Kicked by mule......	Head cut.............................	South Linton	Greene.

*Same accident. †Same accident. §Same accident.

TABLE

Showing the Number of Casualties Arising From Different Causes.

Cause.	Fatal.	Serious.	Total.
Falling coal	....	25	25
Falling slate	11	42	53
Kicked by mule	....	7	7
Mine cars	3	39	42
Railroad car	1	1	2
Smoke explosion	3	6	9
Shot through pillar	....	2	2
Delayed shot	2	7	9
Windy shot	....	4	4
Premature shot	2	2	3
Gas explosion	....	2	2
Falling down shaft	....	1	1
Machine	....	5	5
Caught by cage	2	....	2
Miscellaneous	....	2	2
Totals	24	145	168

COMPARATIVE TABLE

Showing Number of Tons Mined in Each Year, the Number of Persons Employed, and the Number of Tons Produced per Each Death, Since January 1, 1879, to January 1, 1903, Inclusive.

Year.	Tons Produced.	No. of Employes.	Deaths.	Tons Per Death.
1879	1,196,490	3,459	..	No report.
1880	1,550,375	No report.	..	....
1881	1,771,536	4,567	10	177,153
1882	1,900,000	No report.	..	....
1883	2,560,000	5,403	11	232,727
1884	2,260,000	5,716	9	228,888
1885	2,375,000	6,502	7	339,285
1886	3,000,000	6,406	7	428,571
1887	3,217,711	No report.	..	....
1888	3,140,979	6,685	17	184,763
1889	No report.	....	..	....
1890	3,791,211	6,550	5	758,242
1891	3,819,600	6,975	5	763,900
1892	4,408,471	7,600	19	232,024
1893	4,358,897	7,431	22	193,586
1894	No report.	....	..	....
1895	4,202,084	7,885	23	182,699
1896	4,068,124	7,112	28	170,290
1897	4,088,100	7,984	16	262,630
1898	5,146,920	No report.	22	233,950
1899	5,864,975	7,366	15	390,997
1900	6,283,063	8,858	18	349,059
1901	7,019,203	12,096	24	292 466
1902	8,763,197	13,139	24	365,133

ACCIDENTS TO MINE PROPERTY.

Parke No. 8.

A destructive fire occurred, on November 14th, last, at Rosedale in Parke County, at Mine No. 8, owned by the Parke County Coal Company, causing a complete loss of that property to the company. The fire consumed the tipple and building, and burned so much of the curbing in the shaft, as to cause the same to cave in to such an extent that nothing could be removed from the mine. It was so nearly worked out that it was deemed unwise to reopen it, and hence the pumps, mine cars, tracking and other property in the mine was lost, the miners also losing all their tools and other property in the mine.

White Ash Mine.

The buildings and structures about the mouth of the shaft of the White Ash Mine, owned by the White Ash Coal Company, located in Sullivan County, was burned last July. The machinery was saved, but the shaft was so badly damaged, as to require a new opening. This was equipped with the machinery from the old mine.

John Ingle Mine.

A serious squeeze occurred, at Evansville, Vanderburgh County, in February last, at the John Ingle Mine, owned by the John Ingle Coal Company. So extensive and serious was the squeeze that the company, taking into consideration the distance necessary to haul the coal, and the expenditure that would be necessary to repair the damage, decided to abandon the side of the mine closed by the accident. This company is now preparing to mine a tract of coal, owned by it, lying under the Ohio River. This is probably the first attempt in Indiana, to mine coal under any large stream of water. It is also interesting to note that this mine has been in operation since 1849, and is claimed by some to be the oldest mine in Indiana; but others claim that the first mine in this State was opened in Warrick County, by John T. and William Hutchinson, some years earlier.

First Avenue Mine.

Another squeeze, more damaging than that at the Ingle Mine, occurred at Evansville in January, 1902, at the First Avenue, owned by the Lozier Coal and Mining Company, closing nearly the entire mine. The company has been working fewer than ten men during the entire year, on account of this accident. The company has opened out the mine again and will soon be able to increase the output thereof largely.

The men working at this mine have commenced an action against the company for damages for the loss of their tools and for the coal they had to lose at the time of the squeeze.

TABLE.

Examinations of applicants for certificates of competency to serve as mine boss, fire boss and hoisting engineer have been held at two different times within the year at Terre Haute. The following are the names and addresses of those who succeeded in passing such examinations:

Mine Boss Examination Held April 21.

Names.	Addresses.	Names.	Addresses.
William Hittle	West Terre Haute.	Charles L. Vaughn	Linton.
John Spours	Coal Bluff.	W. D. Van Horn	Terre Haute.
Theo. Thompson	Hymera.	John H. Jones	Linton.
Thos. Harris	Midland.	J. G. Applegath	Littles.
Josiah Pedlar	West Terre Haute.	Edmund Archbold	Newburg.
John E. Williams	Danville, Ill.	N. E. Williams	Waterman.
Wm. E. Baddus	Linton.	Philip Harris	Silverwood.
O. P. Hendrickson	Dugger.	Herbert Sirden	Diamond.
Wm. R. Martin	Rosedale.	Albert Palmer	Center Point.
Walter Shiffton	Linton.	R. H. Davis	Perth.
Howard Stoops	Jasonville.	Wm. Wright	Brazil.
A. B. Zimmerman	Linton.	G. E. Urbain	Brazil.
James R Heeks	Fontanet.	L. M. McDonald	Linton.
R. J. McKisec	Linton.	Wm. Epperson	Linton.
F. E. Mitchell	Linton.	Matthew Baffle	Coal Bluff.
J. H. McQuade	Linton.	S. J. Britton	Harmony.
H. Klussmeier	Linton.	E. P. Shirley	Seeleyville.
Burch Lenning	Linton.	Peter Donie	Cloverland.
Wm. Small	Washington.	James Donahey	Brazil.
Jacob Butler	Linton.	W. W. Robertson	Linton.
James Kain	Washington.	James C. Heeman	Linton.
J. P. Juger	Montgomery.	H. M. Robertson	Linton.
Frank Raymond	Linton.	Claude Robertson	Linton.
Arnold Brown	Montgomery.	Joseph Stevenson	Linton.
John Jennings	Dugger.	Richard Ladson	Linton.

Fire Boss Examination, Held April 21.

Reuben Small	Linton	Wm. T. James	Linton.
Arthur M. Moreland	Jackson Hill	W. E. Evans	Jackson Hill.

Hoisting Engineer Examination, Held April 21.

W. E. Brookshire	Linton	Lafe Sharp	Linton.
Chas. H. Schumel	Evansville	Dana Littlejohn	Terre Haute.
Chas. Jackson	Linton	Seth Hattery	Linton.
C. T. Bowers	Evansville	E. D. Gorgus	Jessup.
Roscoe Russell	Clinton	Pleas Bledsoe	Jasonville.
O. P. Walraven	Midland	Isaac Bledsoe	Jasonville.
E. M. Hayes	Indianapolis	Chas. F. Brandon	Cloverland.
Robert Hoffman	Brazil	Jos. Fennell	Linton.
C. A. Dickey	Dugger	A. B. Patterson	Coal Bluff.
Geo. D. Skelton	Diamond	C. W. Robertson	Linton.
Wm. Williams	Turner		

Mine Boss Examination, Held November 11.

Names.	Addresses.	Names.	Addresses.
William Dean	Sullivan	Martin Robison	Vincennes.
J. L. Rhodes	Dugger	Wm. T. Doidge	Cardonia.
Alvin Koch	Coal Bluff	G. S. Klingersmith	Washington.
J. B. Miley	Petersburg	C. E. Buck	Lena.
Jas. Lamb	Montezuma	Andrew Davidson	Coxville.
L. P. Kelly	Coxville	Chas. Doige	Coxville.
Jacob Mandaback	Washington	Henry Burkhardt	Washington.
C. E. Daniels	Linton	O. C. Buck	Linton.
Matthew Leckie	Linton	Calvin Hunt	Linton.
Chas. Hunt	Linton	Marion Frazer	Fontanet.
Jas. Harper	Linton	Dick Potter	Dugger.
J. B. Hibbs	Linton	W. C. Wood	Diamond.
Walter Stunkard	Brazil	A. J. Maxwell	Linton.
John Kain	Fontanet	Matthew Armstrong	Fontanet.
A. D. Spears	Atherton	Chas. Dowdell	Waterman.
Thos. B. Bull	Clinton	W. S. Doige	Cardonia.
Samuel Dalzel	Brazil	C. P. Roetzel	Boonville.
Burrell Stiff	Linton		

Fire Boss Examination, Held November 11.

Thos. Pritchard	Linton	Thos. Lewis	Clinton.
Richard Moore	Clinton		

Hoisting Engineer Examination, Held November 11.

Walter Whitsett	Dugger	L. R. Calvert	Linton.
John Hoffman	Linton	Fin Ax	Linton.
Ezekiel Duncan	Dugger	Alonzo Pool	Linton.
H. G. Whitsett	Dugger	Robert Davidson	Coxville.
Henry Pool	Linton	Wm. H. Hetzel	Boonville.
Wm. T. Ferguson	Carlisle	Wm. Donham	Linton.
H. E. Morrill	Midland		

SERVICE CERTIFICATES.

Twenty-nine service certificates were granted within the year, as follows: Mine Boss, 16; Fire Boss, 2; Hoisting Engineer, 11. Following will be found the names and addresses of those to whom such certificates were issued:

Mine Boss.

Names.	Addresses.	Names.	Addresses.
Jas. M. Acree	Shoals	Daniel Isaac	Diamond.
Wm. Atkins	Ehrmandale	Albert Feller	Raglesville.
A. R. Menelee	Ehrmandale	Jas. M. Arthur	Alum Cave.
Jno. S. Evans	Brazil	A. B. Anderson	Indian Springs.
John Williams	Perth	Geo. E. Burbank	Oakland City.
Michael McGuirk	Fontanet	Geo. Ingle	Terre Haute.
Egbert Clegton	Heckland	Peter Sterling	Farmersburg.
John Kain	Chandler	H. Hollingsworth	Bicknell.

SERVICE CERTIFICATES—Continued.

Fire Boss.

Names.	Addresses.	Names.	Addresses.
Juo. M. Lowry	Shelburn	Robert Anderson	Princeton.

Hoisting Engineer.

Len. Orr	Sullivan	Reed McGrew	Linton.
Jas. H. Newman	Evansville	Daniel Templeton	Linton.
Porter Lofton	Shelburn	Robert Ruckles	Vincennes.
M. N. Lofton	Shelburn	Samuel Roman	Coal Creek.
Samuel Camden	Clay City	J. S. Ferris	Brazil.
Jas. J. Phillips	Newburg		

TABLE

Giving Names and Addresses of Mine Bosses at the Various Indiana Mines.

Name.	Address.	Mine.
John Bolin	Brazil	Brazil Block Coal Company No. 1.
Henry Payne	Brazil	Brazil Block Coal Company No. 8.
Samuel Ogden	Coxville	Brazil Block Coal Company No. 11.
Alexander Ferguson	Clay City	Briar Hill.
George Donie	Cloverland	Cloverland.
Mike Hoffman	Asherville	Columbia No. 5.
Moses Marks	Cardonia	Cornwell.
Walter Knox	Asherville	Crawford No. 2.
William Penz	Asherville	Crawford No. 3.
Griff Howell	Center Point	Crawford No. 5.
John Cox	Brazil	Dewey.
W. G. Spears	Brazil	Diamond No. 3.
Joe C. Winn	Brazil	Diamond No. 5.
Thomas G. Marshall	Carbon	Eureka No. 2.
John T. Summers	Carbon	Eureka No. 3.
William McIntyre	Carbon	Eureka No. 4.
H. B. Ehrlich	Turner	Fortner.
Andrew Gillmore	Cardonia	Gart No. 5.
William Rosser	Diamond	Gart No. 10.
A. E. Norkus	Brazil	Gifford No. 1.
O. C. Long	Coal Bluff	Gladstone.
Jacob Ehrlich	Staunton	Klondyke.
H. W. Jenkins	Perth	Glenn.
Fred George	Harmony	Lawrence No. 6.
James A. King	Brazil	Monarch.
M. D. West	Cloverland	Pearl.
John Barker	Perth	Pratt.
James Andrew	Brazil	Rob Roy.
William Meyers	Turner	Silverwood No. 3.
Ed Stewart	Jackson Hill	Jackson Hill No. 2.
Asa Roberts	Alum Cave	Phœnix No. 1.
Asa Roberts	Alum Cave	Phœnix No. 5.
Alex. Faulds	Alum Cave	Phœnix No. 3.
William Norton	Shelburn	Shelburn.
Simeon Wolley	Del Cardo	Star City.
William Green	Hymera	White Ash.
O. H. Henderson	Dugger	Freeman.
Thomas Lehman	Dugger	Sun Flower.
James Stewart	Sullivan	Glendora.
Theodore Thompson	Hymera	Hymera No. 2.
Adolph Becker	Evansville	Diamond.
Frank Guenther	Evansville	First Avenue.
John Odell	Evansville	Ingleside.
John Mushett	Evansville	Sunnyside.
Pius Schultheis	Evansville	Union.

Names and Addresses of Mine Bosses—Continued.

NAME.	ADDRESS.	MINE.
Fred Sutheimer	Evansville	Unity.
Richard Moore	Clinton	Bruillett's Creek No. 3.
J. C. McInnes	Clinton	Bruillett's Creek No. 3.
David James	Clinton	Bruillett's Creek No. 5.
William Chesterfield	Clinton	Buckeye.
R. M. Irwin	Cayuga	Cayuga.
William F. Brown	Clinton	Crown Hill.
William Hutchinson	Clinton	Oak Hill.
Ira C. Dalrymple	Clinton	Prince.
James Boskill	Clinton	Willow Grove.
W. G. Spears	Atherton	Atherton.
Samuel Holden	Coal Bluff	Chicago No. 6.
Richard Jackson	Burnett	Diamond.
John P. Acree	Cedarville	Ehrlich.
James Luis	Burnett	Grant No. 2.
Ed Jaench	Burnett	Glen Oak.
Thomas Maxwell	Seeleyville	Hector.
George Davis	Burnett	Klondyke.
James Baxter	Brazil	Miami.
Samuel Lindsay	Hoosierville	Crawford No, 7.
Thomas Thompson	Hoosierville	Crawford No. 7.
Walter Knox	Asherville	Crawford No. 6.
Anthony Kocher	Washington	Cable No. 4.
Anthony Kocher	Washington	Cable No. 9.
Albert Feller	Raglesville	Hoosier No. 4.
Arnold Brown	Montgomery	Montgomery No. 2.
Ed Dant	Montgomery	Montgomery No. 3.
Daniel Davis	Cannelburg	Mutual.
Simeon Grill	Washington	Logan Grove.
A. W. Stuckey	Raglesville	Union.
Phil Harris	Silverwood	Silverwood No. 4.
James Anderson	Princeton	Oswald.
William Jackson	Oakland City	Massey.
Reuben Small	Linton	Black Creek.
Tobe Roberts	Linton	Island No. 3.
Richard Ladson	Jasonville	Gilmour.
Mike King	Linton	Hoosier.
S. C. Risher	Linton	Island City No. 1.
John Eddy	Linton	Island City No. 2.
Archie Zimmerman	Linton	Island Valley No. I.
George Epperson	Linton	Island Valley No. 2.
Joe Fennel	Linton	Island Valley No. 3.
Henry Butler	Midland	Midland.
William T. James	Linton	South Linton.
Joe Gibson	Linton	Vulcan.
William McQuade	Linton	Summit No. 2.
John A. Templeton	Linton	Templeton.
W. Badders	Linton	Victoria.
John Kelley	Linton	Glenburn.
Thomas Thomas	Midland	Tower Hill.
Isaac Valentine	Jasonville	Green Valley.
Martin Navin	Jasonville	Lattas Creek No. 1.
R. M. Freeman	Bicknell	Bicknell.
H. G. Conrad	Edwardsport	Edwardsport.
Charles Harding	Bicknell	Knox.
W. H. Lynn	Bicknell	Lynn.
Martin Robertson	Vincennes	Prospect Hill.
R. F. Jenkins	Diamond	Brazil Block Coal Company No. 12.
George H. Doidge	Coxville	Cox No. 3.
Victor Allais, Sr	Montezuma	Lucia.
Jeff Ladson	Liford	Liford No. 1.
John Chesterfield, Jr.	Brazil	Mary.
Morgan Roberts	Mecca	Mecca No. 1.
John L. Suttie	Brazil	McIntosh.
Ed Allias	Montezuma	New Century.
George Meyers	Brazil	Superior No. 1.
Nap Harris	Brazil	Superior No. 2.
Silas Jones	Mecca	Minshall No. 1.
Thomas Dalton	Carbon	Pan-American.
James Donahey	Brazil	Superior No. 3.
William Schmuck	Troy	Troy.
James M. Coakley	Brazil	Brazil Block Coal Company No. 9.
George Briggs	Cable	Hartwell.
John Jones	Ayrshire	Aberdeen.
Bart Stinson	Ayrshire	Ayrshire No. 3.
William T. Smith	Ayrshire	Ayrshire No. 4.
J. Johnson	Ayrshire	Ayrshire No. 5.

Names and Addresses of Mine Bosses—Continued.

NAME.	ADDRESS.	MINE.
John Willey	Petersburg	Blackburn.
Herman Rose	Littles	Littles.
H. T. Brewis	Petersburg	Petersburg.
John Willey	Petersburg	Rogers.
C. C. Hall	Farnsworth	Bunker Hill.
James Jones	Farnsworth	Caldeonia.
Reese Griffith	Dugger	Dugger.
William Mason	Sullivan	Green Hill.
James McComb	Hymera	Hymera.
G. W. Lackey	Dugger	West Linton.
C. E. Peck	Brazil	Nickelplate.
Thomas Bingham	Heckland	Parke No. 10.
Charles Nash	Coal Bluff	Peerless.
George West	Seeleyville	Ray.
R. F. Bieler	West Terre Haute	Vigo.
J. D. Lewis	Seeleyville	Rosebud No. 2.
John Scott	Seeleyville	Royal No. 1.
Josiah Hodgers	West Terre Haute	Larimer.
William F. Decker	Burnett	Lawton.
James Johnson	Fontanet	Union.
William L. Irwin	West Terre Haute	Eagle.
T. B. Hall	Chandler	Air Line.
John E. Kelley	Boonville	Big Four.
John Wooley	Boonville	Big Vein No. 1.
Lewis Schultz	Boonville	Big Vein No. 2.
L. M. Gaisser	Boonville	Caledonia.
Win Huber	Chandler	Chandler.
Mart Wilson	DeForrest	DeForrest.
George F. Archbold	Newburg	Star No. 1.
Jeff Rhodes	Linton	Antioch.
W. D. Vanhorn	Jasonville	Fry.
John Quigley	Linton	Atlas.
Harry Conkle	Shelburn	Wilfred.

LIST OF MINES.

Table Showing the Names and Addresses of Persons and Corporations Operating Coal Mines in the State of Indiana During the Year 1902, With Names of Mines in Each County.

CLAY COUNTY.

Name.	Address.	Mine.	Remarks.
Brazil Block Coal Company	Brazil	B. B. No. 1	
Brazil Block Coal Company	Brazil	B. B. No. 8	
Brazil Block Coal Company	Brazil	B. B. No. 11	
Brazil Block Coal Company	Brazil	Diamond No 3	Abandoned.
Brazil Block Coal Company	Brazil	Diamond No. 5	
Brazil Block Coal Company	Brazil	Gart No. 5	
Brazil Block Coal Company	Brazil	Gart No. 10	
Clay City Coal Company	Clay City	Briar Hill	
Zeller-McClellan Coal Company	Brazil	Cloverland	
Zeller-McClellan Coal Company	Brazil	Lawrence No. 6	
Zeller-McClellan Coal Company	Brazil	Lawrence No. 7	
Zeller-McClellan Coal Company	Brazil	Columbia No. 5	Abandoned.
Jackson Coal and Mining Company	Brazil	Cornwall	
Jackson Coal and Mining Company	Brazil	Dewey	Abandoned.
Crawford Coal Company	Brazil	Crawford No. 2	
Crawford Coal Company	Brazil	Crawford No. 3	
Crawford Coal Company	Brazil	Crawford No. 5	
Crawford Coal Company	Brazil	Crawford No. 6	
Crawford Coal Company	Brazil	Crawford No. 7	
Eureka Block Coal Company	Terre Haute	Eureka No. 2	
Eureka Block Coal Company	Terre Haute	Eureka No. 3	
Eureka Block Coal Company	Terre Haute	Eureka No. 4	
C. Ehrlich Coal Company	Turner	Fortner	
C. Ehrlich Coal Company	Turner	Klondyke	
Collins Coal Company	Brazil	Gifford No. 1	
Collins Coal Company	Brazil	Gifford No. 2	
Brazil Mining Company	Chicago, Ill	Gladstone	
Coal Bluff Mining Company	Terre Haute	Pratt	
Coal Bluff Mining Company	Terre Haute	Glen	
American Clay Manufacturing Company	Brazil	Monarch	
Cloverland Coal and Mining Company	Cloverland	Pearl	
Andrew Coal and Mining Company	Brazil	Rob Roy	
Indiana Bituminous Coal Company	Terre Haute	Silverwood No. 3	

DAVIESS COUNTY.

Cabel & Co	Washington	Cabel No. 4	
Cabel & Co	Washington	Cabel No. 9	
Raglesville Coal Company	Raglesville	Hoosier No. 4	
Daviess County Coal Company	Montgomery	Montgomery No. 2	
Daviess County Coal Company	Montgomery	Montgomery No. 3	
Mutual Mining Company	Cannelburg	Mutual	
Wilson Bros	Washington	Logan Grove	

FOUNTAIN COUNTY.

Indiana Bituminous Coal Company	Terre Haute	Silverwood No. 4	

GIBSON COUNTY.

Princeton Coal and Mining Company	Princeton	Oswald	

GREENE COUNTY.

NAME.	ADDRESS.	MINE.	REMARKS.
Black Creek Coal and Mining Company	Linton	Black Creek	
Island Coal Company	Linton	Island City No. 1	
Island Coal Company	Linton	Island City No. 2	
Island Coal Company	Linton	Island No. 3	Buckeye.
Indiana Southern Coal Company	Chicago, Ill	Gilmour	
Hoosier Coal Company	Bloomfield	Hoosier	
Island Valley Coal Company	Linton	Island Valley No. 1	Abandoned.
Island Valley Coal Company	Linton	Island Valley No. 2	
Island Valley Coal Company	Linton	Island Valley No. 3	
Midland Coal Company	Midland	Midland	
South Linton Coal and Mining Company	Linton	South Linton	
Vulcan Coal Company	Indianapolis	Vulcan No. 1	
Summit Coal Company	Chicago, Ill	Summit No. 2	
Western Indiana Coal Company	Terre Haute	Templeton	
L. T. Dickason Coal Company	Chicago, Ill	Victoria	
L. T. Dickason Coal Company	Chicago, Ill	Glenburn	
Tower Hill Coal Company	Bloomington	Tower Hill	New mine.
Green Valley Coal Company	Linton	Green Valley	New mine.
Lattas Creek Coal Company	Terre Haute	Lattas Creek No. 1	New mine.
Johnson Coal and Mining Company	Columbus, O	Atlas	New mine.
Antioch Coal Company	Chicago, Ill	Antioch	New mine.
Fry Coal Company	Terre Haute	Fry	New mine.

KNOX COUNTY.

Bicknell Coal Company	Bicknell	Bicknell	
Vulcan Coal Company	Indianapolis	Edwardsport	
Lynn Coal Company	Bicknell	Lynn	
Knox Coal Company	Bicknell	Knox	
Prospect Hill Coal Company	Vincennes	Prospect Hill	

PARKE COUNTY.

Brazil Block Coal Company	Brazil	B. B. No. 12	
Brazil Block Coal Company	Brazil	Cox No. 3	
Brazil Block Coal Company	Brazil	B. B. No. 9	
Rock Run Coal Company	Montezuma	Lucia	
Rock Run Coal Company	Montezuma	Mecca No. 1	
Wabash Valley Coal Company	Chicago, Ill	Lyford No. 1	
Wabash Valley Coal Company	Chicago, Ill	Lyford No. 2	Abandoned.
Otter Creek Coal Company	Brazil	Mary	
I. W. McIntosh Coal Company	Brazil	McIntosh No. 3	
New Century Coal and Mining Company	Montezuma	New Century	
Parke County Coal Company	Rosedale	Parke No. 8	Burned down
Standard Block Coal Company	Terre Haute	Standard	Abandoned.
Zeller, McClellan & Co	Brazil	Superior No. 1	
Zeller, McClellan & Co	Brazil	Superior No. 2	
Zeller, McClellan & Co	Brazil	Superior No. 3	
Minshall Vein Coal Company	Terre Haute	Minshall No. 1	
Plymouth Block Coal Company	Carbon	Pan-American	

PERRY COUNTY.

Bergenroth Bros	Troy	Troy	

PIKE COUNTY.

NAME.	ADDRESS.	NAME.	REMARKS.
Aberdeen Coal Company	Littles	Aberdeen	
D. Ingle Coal Company	Ayrshire	Aryshire No. 3	
D. Ingle Coal Company	Ayrshire	Ayrshire No. 4	
D. Ingle Coal Company	Ayrshire	Ayrshire No. 5	
D. Ingle Coal Company	Ayrshire	Ayrshire No. 6	
S. W. Little Coal Company	Evansville	Blackburn	
S. W. Little Coal Company	Evansville	Littles	
S. W. Little Coal Company	Evansville	Rogers	
S. H. Wulfman Coal Company	Huntingburg	Hartwell	
J. Wolley Coal Company	Evansville	Petersburg	
Aberdeen Coal Company	Littles	Carbon	
Massey Coal Company	Oakland City	Massey	

SULLIVAN COUNTY.

Washington Fuel Company	Chicago, Ill	Bunker Hill	
Rainbow Coal and Mining Company	Chicago, Ill	Caledonia	
Indiana-Chicago Coal Company	Chicago, Ill	Dugger	
Green Hill Coal and Mining Company	Sullivan	Green Hill	
Hymera Coal and Mining Company	Chicago, Ill	Hymera No. 1	
Hymera Coal and Mining Company	Chicago, Ill	Hymera No. 2	New mine.
West Linton Coal and Mining Company	Linton	Ingleside	
Jackson Hill Coal and Coke Company	Jackson Hill	Jackson Hill No. 2	
Jackson Hill Coal and Coke Company	Jackson Hill	Jackson Hill No. 3	Abandoned.
New Pittsburg Coal and Coke Company	Chicago, Ill	Phœnix Nos. 1, 3, 5.	
Keystone Coal Company	Shelburn	Shelburn	
Harder-Hafer Coal Company	Chicago, Ill	Star City	
White Ash Coal Company	Terre Haute	White Ash	
Sullivan Coal Company	Dugger	Freeman	
Sunflower Coal Company	Dugger	Sunflower	
W. S. Bogle Coal and Mining Company	Chicago, Ill	Glendora	
Wilfred Coal Company	Shelburn	Wilfred.	

VANDERBURGH COUNTY.

Diamond Coal Company	Evansville	Diamond	
H. A. Lozier Coal Company	Evansville	First Avenue	
John Ingle Coal Company	Evansville	Ingle	
Crescent Coal Company	Evansville	Unity	
Evansville Coal and Mining Company	Evansville	Union	

VERMILLION COUNTY.

Bruillett's Creek Coal Company	Clinton	Bruillett's Nos. 3, 4, 5.	
McClellan Sons & Company	Clinton	Buckeye	
Cayuga Press Brick Company	Cayuga	Cayuga	
Clinton Coal Company	Clinton	Crown Hill	
Oak Hill Coal Mining Company	Clinton	Oak Hill	
Keller Coal Company	Chicago, Ill	Prince	
Torrey Coal Company	Chicago, Ill	Torrey No. 4	Abandoned.
Willow Grove Coal Company	Clinton	Willow Grove	
Charles Keeler Coal Company	Chicago, Ill	Atherton	

VIGO COUNTY.

Name.	Address.	Mine.	Remarks.
Terre Haute Brick and Pipe Company	Terre Haute	Brick Works	
Big Vein Coal and Mining Company	Chicago, Ill	Chicago No. 6	
Coal Bluff Mining Company	Terre Haute	Diamond	
Coal Bluff Mining Company	Terre Haute	Peerless	
Coal Bluff Mining Company	Terre Haute	Lawton	
Coal Bluff Mining Company	Terre Haute	Union	
J. Ehrlich Coal Company	Seeleyville	Ehrlich	
Grant Coal Company	Burnett	Grant No. 2	
Glen Oak Coal and Mining Company	Chicago, Ill	Glen Oak	
Loughner Coal Company	Seeleyville	Hector	
Bruillett's Creek Coal Company	Clinton	Klondyke	
Miami Coal Company	Brazil	Miami	
Brazil Mining Company	Chicago, Ill	Nickelplate	
Parke County Coal Company	Rosedale	Parke No. 10	
Vigo Coal Company	Seeleyville	Ray	
Fauvre Coal Company	Indianapolis	Vigo	
Seeleyville Coal and Mining Company	Seeleyville	Rosebud No. 2	
Seeleyville Coal and Mining Company	Seeleyville	Royal No. 1	
Harris-Lankford Mining Company	W. Terre Haute	Larimer	
Home Coal Company	W. Terre Haute	Eagle	

WARRICK COUNTY.

Hall & Marsh	Evansville	Air Line	
Big Four Coal Company	Boonville	Big Four	
J. Wolley Coal Company	Evansville	Big Vein No. 1	
Caledonia Coal and Mining Company	Boonville	Caledonia	
J. A. Bryan	Evansville	Chandler	
Charles Menden	Evansville	DeForrest	
John Archbold Coal Company	Evansville	Star No. 1	

IN THE FOLLOWING SUMMARY WILL BE FOUND MOST OF THE IMPORTANT TOTALS FOR THE STATE FOR THE YEAR.

SUMMARY, 1902.

Number of counties having shipping mines	14
Number of mines working more than ten men	166
Number of new mines opened	21
Number of mines abandoned	11
Number of miners employed	9,606
Number of inside day and monthly men employed	2,287
Number of outside day and monthly men employed	1,246
Total number of all employes	13,139
Amount of wages paid to miners	$4,776,742 80
Amount of wages paid to inside day and monthly men	1,499,564 84
Amount of wages paid to outside day and monthly men	802,623 48
Total amount of wages paid to all employes	7,078,913 12
Amount of money spent on improvements	92,826 36
Number of mining machines used	261

Number of mules used	1,147
Number of days worked	29,409
Number of tons of hand mined block coal produced	816,938
Number of tons of machine mined block coal produced	266,652
Number of tons of hand mined bituminous coal produced	4,636,587
Number of tons of machine mined bituminous coal produced	2,389,994
Number of tons of hand mined coal produced	6,106,551
Number of tons of machine mined coal produced	2,656,646
Total tons of coal produced	8,763,197
Number of tons of coal shipped outside Indiana	4,181,233
Number of tons of coal consumed in Indiana	4,581,964
Number of fatalities	24
Number of serious accidents	145
Total number of accidents	169
Number of acres of coal lands purchased	34,066

ON THE PETROLEUM INDUSTRY IN INDIANA IN 1902.

By W. S. Blatchley.

Once again we have to record a banner year in the history of the Indiana Petroleum Industry. Since 1898 the tendency has been upward and forward, and each year has shown a production greater than the one preceding. That the yearly output depends largely upon the price, and not upon the capacity of the field, is shown by the fact that the years 1897 and 1898 were the only ones, since the striking of oil in the State, in which the production fell off, and during those years the price was low, ranging only between 40 and 60 cents per barrel. Since 1898, there has been, for the most part, an upward tendency in price and as a result the output has been more than doubled.

The price of oil was more uniform during the year 1902 than in any year in the history of Indiana production. From January 1st until October 4th, there was a change of but four cents per barrel. Starting the year at 80 cents, it was raised to 83 cents on April 16th, and to 84 cents on June 26th. This price it held until October 4th, when it began to rise each week or ten days, reaching a maximum of $1.10 at the very close of the year. There was no fall in price during the year, and nothing to dishearten or lessen the hope of the operator for better conditions. As a result new work went on rapidly, the number of bores sunk was greater than in any preceding year, and the output far exceeded that for any other year. The average price per barrel, taking both time and amount received into consideration, was 85.6 cents as against 83.4 in 1901.

The total production of Trenton Rock Oil in Indiana in 1902 was 7,535,561 barrels which, at the average price of 85.6 cents, amounted to $6,450,440. Compared with 1901, this was an increase in production of 1,810,087 barrels, or 31.6 per cent. as against a gain of 16.5 per cent. in 1901. The amount received by the producers was $1,675,395, or 35.1 per cent., more than in 1901.

The tables which follow comprise the principal statistics of the Trenton Limestone Oil Producing fields of the State for the year 1902. The first table gives a complete record of the monthly production of petroleum from these fields for the twelve years beginning January 1, 1890, and ending December 31, 1902. This does not include the amount used in the field for fuel and other purposes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period.

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1903, BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
January	6,171	15,841	111,824	259,000	300,568	365,582	290,746	317,014	297,291	353,451	425,140	554,038
February	5,981	18,946	96,025	232,107	230,559	241,743	309,922	272,780	220,440	302,493	384,735	460,073
March	5,159	24,794	134,549	282,376	310,303	386,586	341,961	325,301	290,257	364,590	432,922	573,412
April	4,973	26,184	146,493	287,330	352,077	395,032	328,779	310,034	325,774	381,804	447,261	579,711
May	5,757	31,033	186,939	321,502	397,001	417,963	340,023	311,208	344,831	426,363	482,118	635,752
June	8,136	40,888	209,616	333,479	403,569	434,167	369,803	320,477	334,282	446,492	481,807	633,452
July	10,809	49,203	221,666	327,349	434,376	422,968	375,249	314,861	329,086	437,087	506,065	696,911
August	11,603	56,109	248,353	345,031	420,132	407,238	371,921	332,777	347,621	466,127	523,106	697,040
September	16,500	66,034	245,615	319,588	409,169	415,675	362,528	326,264	332,283	418,716	519,087	672,611
October	19,029	95,699	252,568	339,424	393,153	394,283	408,179	319,490	326,781	467,521	532,960	725,973
November	20,801	129,270	245,607	304,030	373,789	337,331	430,958	200,644	326,802	406,684	510,788	656,457
December	21,715	144,067	236,038	337,450	361,436	362,164	423,069	300,457	332,266	441,347	479,485	650,131
Totals	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714*	4,912,675	5,725,474	7,535,561

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1903, WITH VALUE.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
Total production (barrels of 42 gallons)	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561
Total value at wells of all oils produced, excluding pipeage	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411	$1,871,849	$2,228,276	$3,331,750	$4,740,731	$4,775,045	$6,450,440
Value per barrel	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63	$0 43	$0 59⅖	$0 87½	$0 96½	$0 83⅖	$0 85⅗

*This sum in the table on page 12, Report of this Department for 1899, was 11,000 barrels greater, that being the amount of Corniferous rock petroleum produced at Terre Haute in that year and included in the monthly production of Trenton rock oil.

From the first of the above tables it will be seen that the largest production of Trenton Rock Petroleum in Indiana in any one month was in October, 1902, when 725,973 barrels were brought to the surface. The total production of Indiana Trenton Rock Oil for the twelve years reached the enormous total of 46,011,394 barrels, which sold for $32,300,175, or an average of $2,700,000 per year. In 1901 Indiana ranked fifth among the oil-producing States of the Union, being exceeded by Ohio with 21,648,083 barrels; West Virginia with 14,177,126 barrels; Pennsylvania with 12,625,378 barrels, and California with 8,786,330 barrels, produced. Unless California made decided gains in 1902, Indiana bids fair to soon rank fourth in output. The percentage of increase in Indiana was greater in 1902, than in any year since 1893.

In the third table there is shown the number of wells completed in Indiana by months from June, 1891, to January, 1903.

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1903, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891........	......	......	......	......	......	......	6	6	15	15	15	8	65
1892........	11	13	18	13	17	19	17	30	25	52	33	47	295
1893........	20	30	31	36	45	47	47	55	27	72	56	76	542
1894........	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895........	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896........	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897........	41	35	40	47	49	52	60	45	55	89	119	54	686
1898........	41	23	29	43	38	55	53	80	72	82	92	86	694
1899........	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900........	113	67	98	148	165	163	158	155	135	152	118	108	1,580
1901........	111	72	81	121	167	171	167	169	184	207	220	132	1,802
1902........	176	113	169	182	247	297	288	279	323	295	320	243	2,932
Total...	......	......	......	......	......	......	......	......	......	......	......	......	13,289

From this table we learn that 1,130 more bores were sunk for oil in Indiana in 1902 than in any previous year. Of the 2,932 bores put down, all but three were in the Trenton limestone fields. The three excepted were in the Corniferous limestone field near Loogootee, Martin County. The great increase in new work was due to several causes, chief among which was the fair price of oil which increased whenever a change was made. The great majority of bores were sunk in already proven territory, by companies whose members are content to drill fair producing wells and secure what oil they can find beneath their leases, rather than seeking far and wide for new territory which is apt to produce a "gusher" or two.

From the table it may also be learned that up to January 1, 1903, 13,289 bores had been sunk for oil in Indiana. On that date there were 8,963 producing wells in the State as against 6,765 on January 1, 1902, a gain of 2,198 for the year. By subtraction, it may be learned that of the total number of bores sunk for oil in the State, 4,326 have proven dry or have been abandoned as nonproductive. The number abandoned in 1902 was 291, or 53 more than in 1901, while the number of dry holes drilled during the year was 443, or 152 more than in 1901. Of the total number of bores drilled in 1902, 15.1 per cent., or one per cent. less than in 1901, were dry.

The following table shows the •

NUMBER OF PRODUCING WELLS, NUMBER OF DRY HOLES, TOTAL BORES AND AVERAGE INITIAL PRODUCTION OF WELLS DRILLED IN EACH OF THE OIL-PRODUCING COUNTIES OF INDIANA IN 1901 AND 1902.

County.	Producing Wells, 1901.	Producing Wells, 1902.	Dry Holes, 1901.*	Dry Holes, 1902.*	Total Bores, 1901.*	Total Bores, 1902.*	Percentage of Dry Holes, 1901.*	Percentage of Dry Holes, 1902.*	Average Initial Production of Productive Wells, 1901.	Average Initial Production of Productive Wells, 1902.
Adams	157	256	18	35	175	291	10.2	12.	29.5	23.
Blackford	211	283	47	75	258	358	18.2	21.	20.9	15.7
Delaware	23	27	19	50	42	77	45.2	65.	16.	15.8
Grant	488	942	80	108	568	1,050	14.1	10.2	21.6	18.5
Hamilton	1	1	......	......	1	1	....	....	40.	12.
Huntington	69	141	6	23	75	164	8.	14.	24.7	22.
Jay	50	74	20	20	70	94	28.5	21.3	17.6	14.1
Madison	59	41	45	54	104	95	43.2	56.8	21.7	13.6
Marion	......	2	......	......	......	2	....	....	....	3.
Miami	4	3	3	4	7	7	43.	57.1	13.7	11.6
Randolph	13	26	5	33	18	59	27.7	55.9	44.2	23.1
Wabash	4	2	2	......	6	2	33.3	....	5.	7.5
Wells	430	689	40	40	470	729	8.5	5.5	17.2	17.1
Martin	2	2	......	1	2	3	....	33.3	7.5	7.5
Totals	1,511	2,489	291	443	1,802	2,932	†16.1	†15.1	†21.5	†15.7

*These columns include bores sunk for oil which yielded gas.

† = average.

The two producing wells at Terre Haute yielded 9,214 barrels of Corniferous rock petroleum during the year 1902. The Phœnix Well, which is the oldest and best oil well in the State, was shut down two months for repairs.

The output at Loogootee for the year was 3,763 barrels, making a total production of 12,977 barrels of Corniferous rock petroleum in the State, or a grand total of 7,548,538 barrels of petroleum in Indiana for the year.

On Some Mollusca Known to Occur in Indiana.

A Supplementary Paper to Call's Catalogue.

By W. S. Blatchley and L. E. Daniels.

INTRODUCTORY.

In the Twenty-fourth (1899) Annual Report of this Department, Dr. R. E. Call published an extensive paper entitled "A Descriptive, Illustrated Catalogue of the Mollusca of Indiana." In this paper he described, and for the most part figured, 184 species of land and fresh water shells from different parts of the State. During the past two years, Mr. L. E. Daniels, one of the authors of this paper, has spent the months from April to November in the field, collecting shells and other forms of life for the State Museum. As a result of his research, 91 species and varieties of mollusca not listed by Call have been taken in the State. In the present paper we publish descriptions of each of these and note the localities in which they have been taken. The descriptions are, for the most part, copied from the works of Binney, Say, Pilsbry, Baker, Sterki, and other special students of mollusca. The nomenclature and general arrangement of the land shells is that of Pilsbry's "Classical Catalogue with Localities of the Land Shells of America North of Mexico."

Our thanks are due Messrs. Bryant Walker, Detroit, Mich.; F. C. Baker, Chicago, Ill.; H. A. Pilsbry, Philadelphia, Pa.; Chas. T. Simpson, Washington, D. C.; A. C. Billups, Lawrenceburg, Ind., and Dr. V. Sterki, New Philadelphia, Ohio, for aid in determining and verifying specimens.

ON SOME MOLLUSCA KNOWN TO OCCUR IN INDIANA.

A Supplementary Paper to Call's Catalogue.

By W. S. Blatchley and L. E. Daniels.

Family HELICIDÆ.

1. Vallonia costata Muller.

"Small, depressed convex, rather solid, umbilicated; surface shining, with regular membranous ribs of good size, the intercostate spaces being finely striate; color reddish horn; periphery a trifle angled; sutures deeply impressed; whorls three and one-half, rapidly increasing, the last expanding and descending, somewhat angular on the periphery; spire flat, apex finely striate; aperture nearly circular, a little oblique, flattened above, angular below; peristome reflected, white, terminations approaching and connected by a thin callus; umbilicus open, large, spreading, exhibiting all the volutions. Greater diameter, 2.70 mm.; lesser, 2.25 mm.; height, 1.30 mm."—*Baker.*

Range.—Quebec to Washington, west to Colorado.

Indiana Localities.—A few specimens were taken beneath the bark of logs in a marsh at the south end of Lake Maxinkuckee, Marshall County. A number labeled "Indiana" are in the State Museum collection. This species is distinguished from *V. pulchella* by its numerous heavy ribs and darker color.

2. Polygyra leporina (Gould).

"Shell with a partially covered umbilicus, depressed, orbicular, thin, reddish horn-color, delicately striated, and, when fresh, having a delicate down on its surface; spire depressed, composed of five slightly convex whorls, the last of which is obtusely angular at its upper portion; base convex, excavated at the umbilical region, with a minute, partially covered umbilicus; aperture oblique, lunate; peristome incumbent, rose-colored, reflexed, bearing on its dilated basal edge two expanded teeth, separated by a deep, narrow fissure, its terminations joined by a quadrate, erect, oblique lamella, whose upper edge is joined to the upper angle of the aperture by a thread-like callus; an internal, fulcrum-like tubercle, with uneven outer edge on the base of the shell. Greater diameter, 6 mm.; lesser, 5.5 mm.; height, 3 mm."—*Binney.*

Fig. 1. *Polygyra leporina* (Gould).

Range.—Southern Indiana through Kentucky and Tennessee to Georgia, Missouri and Texas.

Indiana Localities.—In this State *leporina* was first taken in Henry County by E. Pleas.* Mr. Daniels has taken it one-half mile east of New Harmony, Posey County, and near North Vernon, Jennings County. In both places it occurs in small numbers beneath logs, near the borders of woods.

3. Polygyra plicata Say.

"Shell rimately umbilicated, discoidal, depressed above, convex below, light horn-color, sparingly hirsute, with separated rib-like striæ; spire planulate; whorls five, gradually increasing, the upper ones rounded, smoother, the last convex, plane below, scrobiculated, and with an insulated, smooth, prominent bulge behind the peristome, deflected at the aperture; rimation level, at first grooved, showing one and a half whorls, and ending in a narrow umbilicus; aperture subreniform, very oblique, contracted; peristome white, thickened, not reflected, continuous, its terminations approached, joined by a prominent, excavated, heavy, somewhat flexuose, emarginate, tongue-like callus, projecting almost across the aperture; within the columellar margin of the peristome is an erect, blunt, stout denticle (its inner end continued back within the aperture into an erect lamella joining the inner wall), somewhat overlapping and thus partially concealing from view a smaller, more deeply seated, erect, obtuse, stout denticle on the right margin of the peristome; an internal transverse tubercle on the base of the shell. Greater diameter, 7 mm.; lesser, 6 mm.; height, 3 mm."—*Binney.*

Fig. 2. ***Polygyra plicata*** Say.

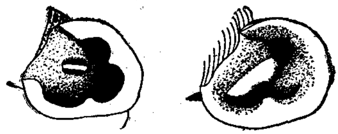
* The Nautilus, October, 1893, p. 68.

Range.—Alabama, Kentucky, Georgia and Tennessee.

Indiana Localities.—Beneath drift on the north bank of the Ohio River, near Clarksville, Floyd County.

4. POLYGYRA FRAUDULENTA Pilsbry.

"Differs from *P. tridentata* in having a compact shell of a reddish brown color (varying to white in some localities); the spire is low—convex, composed of six closely coiled whorls, the last being notably deflexed in front and strongly constricted behind the lip. The aperture is strongly 'dished' or basin shaped; the outer lip bears a broad tongue-shaped, inflected tooth, situated at the position of the



a *b*

Fig. 3. Apertures of Polygyra. (After Pilsbry). *a, tridentata* Say; *b, fraudulenta* Pilsbry.

periphery of the shell. The middle part of the basal lip bears a small squarish tubercle, which is often laterally compressed. The parietal wall bears an elevated oblique blade which is typically almost straight and never much curved. Greater diameter, 15 mm.; lesser, 13.50 mm.; height, 8.50 mm."—*Pilsbry.*

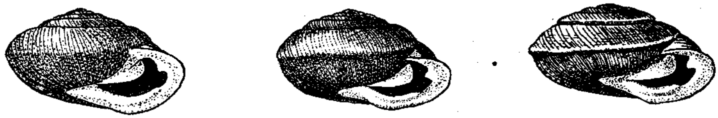
Range. — Ontario, Canada, to Michigan and Illinois, south to Georgia.

Indiana Localities.—This is the species called *P. fallax* Say by Stein and Call. *Fallax* occurs only east of the Alleghanies. *P. fraudulenta* probably occurs throughout the State, having been taken in Posey, Lawrence, Tippecanoe, Marion and Laporte counties. It occurs beneath logs and flat stones in rather moist situations.

4a. POLYGYRA PALLIATA-OBSTRICTA (Say).

The following remarks regarding the relation existing between the nominal species *P. palliata* and *P. obstricta* (Say) were prepared by Mr. H. A. Pilsbry, to whom a series of specimens collected in Posey County was submitted.

"A series of 18 specimens from Grand Chain, Posey County, taken by Mr. Daniels in bottom land near the Wabash River, and in its flood plain shows a complete series of transitions from *palliata* to *obstricta.* These supposed species have been separated not only on account of the acute keel of *obstricta,* and its absence in *palliata,* but more because of the rough epidermis of the latter.* This series, so far as I can see, shows intergradation in the development of the cuticular processes, as well as in the contour of the shell.



a b c

Fig. 4. *Polygyra palliata-obstricta* (Say).

"A few of the specimens agree almost exactly with Say's type specimen of *palliata*, the periphery being moderately angular, the angle disappearing on the last third or fourth of the whorl; and the surface, besides having low, coarse striæ, bears numerous cuticular asperities, as though a loose cuticle had been pinched up into many little points, and more or less wrinkled in consequence between them. (See *a*, Fig. 4.)

"Most of the shells are decidedly more acutely angular at the periphery than typical *palliata*, but have essentially the same sculpture (*b*, Fig. 4). A few of the specimens (*c*, Fig. 4) have the peripheral keel acute, and reduced to an angle only on the latter part of the whorl, and there is a distinct tendency of the cuticle to pucker into spiral lines between the rib-striæ; such ill-developed spirals being characteristic of *P. obstricta*. In some of these specimens the keel projects a little above the sutures, as usual in *P. obstricta*. They are similar to shells of the latter species found in the hills, about half a mile distant from the locality of the *palliata-obstricta* series. No sharp line, however, can be drawn between the bluntly angular, the sharply angular and the strongly carinate shells; all intergradations occur, even in the small series.

"As only *obstricta* was found in the hills, the question naturally arises, whether *obstricta* is a form of *palliata* dependent upon station. This is apparently negatived by the wide distribution of *palliata* in the northern States, where it inhabits both lowland and mountains, in alluvial, limestone and sandstone tracts, and is not accompanied by *obstricta*, and indeed not varying toward strongly angular or carinate forms over most of its area. A simpler view seems to be that while *P. palliata* occupies an area generally north of that of *P. obstricta* there is a broad belt of territory common to the two, in some parts of which intergradation takes place, or, in other words, remnants of a variable, undifferentiated, parent race still exist.

* See Binney, Manual of American Land Shells, p. 285.

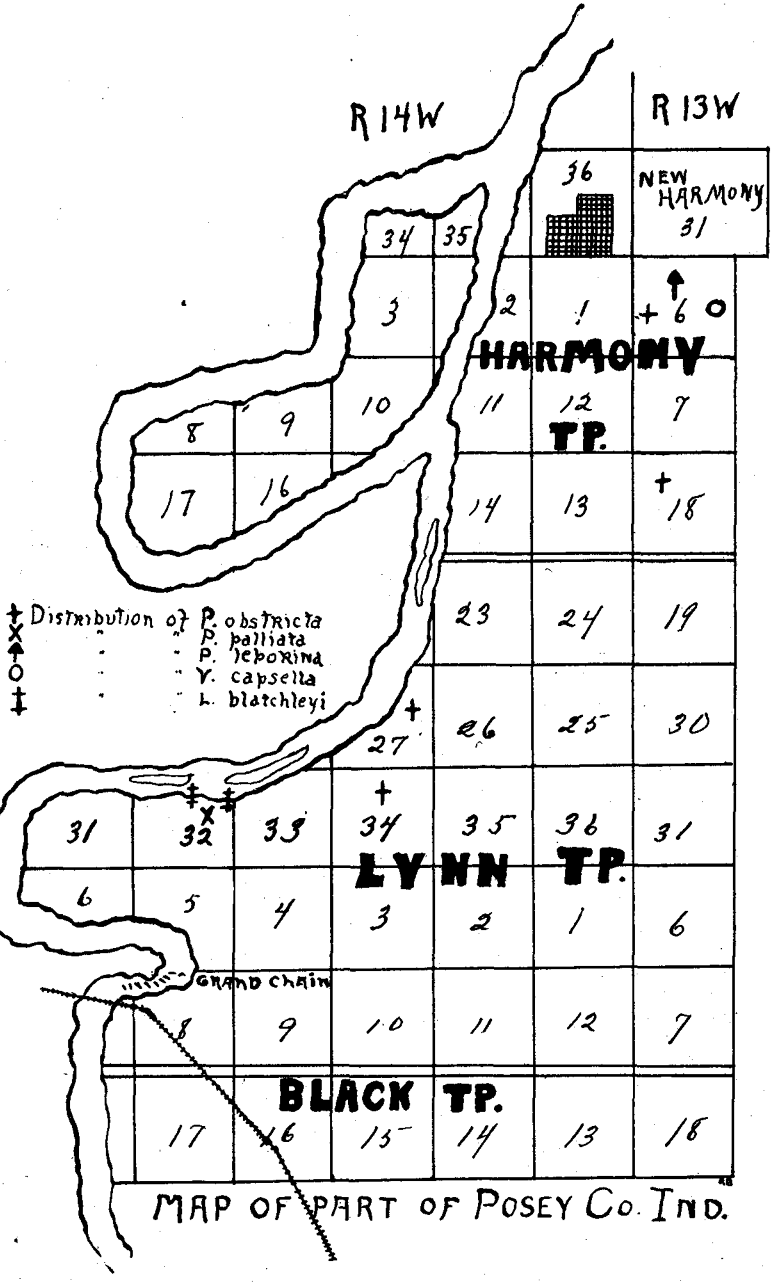


Fig. 4a. Showing distribution of certain species of Mollusca in Posey County.

"None of the Indiana shells I have seen are strictly referable to the variety *carolinensis* of Lea. That, in my opinion, is probably another remnant of the race ancestral to *obstricta,* but a little diversely modified.

"Further collections of the species under consideration should be made in as many localities as possible throughout the States where *palliata* and *obstricta* coexist, with full notes on the local conditions. It seems likely that more solid conclusions than those now attainable should result from the study of ample material."

5. **Polygyra monodon (Rackett). Plate I, Fig. 2.**

"Subglobose, solid, umbilicate or imperforate; surface covered with very fine, oblique growth lines which are so minute as to be scarcely visible even when viewed with a powerful glass; the surface is also set with short hairs scattered over the whorls; nuclear whorls smooth; periphery rounded; sutures well impressed; color yellowish to reddish horn; whorls five to five and a half, closely coiled, flatly rounded, the last gibbous on the last half, and constricted behind the peristome; spire somewhat elevated in some specimens, but flat in others, convex; aperture narrowly lunate, no teeth or notches on the peristome; parietal wall with a long, narrow, more or less elevated tooth, which begins near the center of the parietal wall and extends generally to the umbilical region in a line parallel with the basal reflection of the peristome; peristome white, thick, reflected; umbilicus widely open, or wholly imperforate; the region strongly depressed; base of shell rounded, with a transverse internal tubercle. Greater diameter, 9 mm.; lesser, 8.25 mm.; height, 5.25 mm."—*Baker.*

This is the shell formerly known as *leaii* Ward. It was originally described from Alpena County, Michigan. The larger, more hirsute form, with umbilicus frequently partly closed or wholly imperforate and described by Call and others as *Stenotrema monodon,* has been shown by Pilsbry to be Say's *H. fraterna,* and it is now known as *P. monodon fraterna.* (Plate I, Fig. 1.) The range of *P. monodon* is from Minnesota and Michigan south and southwest to Tennessee and Kansas.

Indiana Localities.—Stein mentioned the present species under the name *leaii,* from Posey County. Mr. Daniels has found it to be quite common about the swamps bordering the larger lakes of northern Indiana, notably those near lakes Wawasee and Tippecanoe, Kosciusko County; Maxinkuckee, Marshall County; James, Steuben County, and Lake Manitou, Fulton County. It occurs beneath chips, rubbish and fallen grasses and weeds, about the margins of the lakes. It has also been taken in grassy swales near Hammond and Pine, Lake County. It occurs in a semi-fossil state in thick loess deposits near New Harmony, Posey County.

Family PUPIDÆ.

6. STROBILOPS LABYRINTHICA (Say).

This species as described by Call (p. 382 of his Catalogue) included two others which had previously been separated by Pilsbry* chiefly by the number and length of the internal lamellæ of the basal and outer walls of the body whorl. His table used in their separation is as follows:

KEY TO THE SPECIES OF STROBILOPS.

a. Internal lamellæ on floor of body whorl two or three, short; color dark brown; one parietal fold conspicuously emerging from aperture. Form elevated conoidal.................. *S. labyrinthica* Say.

aa. Internal lamellæ on floor and adjacent side walls of body whorl six or more.

- *b.* Six long lamellæ; two parietal folds emerging; color white or pale brownish; form elevated.................. *S. virgo* Pilsb.
- *bb.* About eight short lamellæ arranged in a curved radial series; color dark brown; form elevated.............. *S. affinis* Pilsb.

The description of *S. labyrinthica* as limited by Pilsbry is herewith included.

"Shell umbilicated, elevated conoidal; brownish horn-color with strong ribs above, below nearly smooth; spire obtuse; whorls wider than high, regularly increasing in size from apex to aperture; body whorl obtusely angulate at the periphery, flattened below, impressed around the narrow umbilicus; aperture rounded above, basal margin flattened; peristome narrowly reflected, thickened; parietal wall with three revolving, deeply entering parallel lamellæ, the central further within the aperture and less developed, one conspicuously emerging from the aperture; two or three short internal lamellæ on base of body whorl. Greater diameter, 2.25 mm.; height, 1.75 mm."—*Walker*.

7. STROBILOPS VIRGO Pilsbry.

"Shell umbilicated, globosely elevated; white or pale brownish in color; finely and closely ribbed above, ribs subobsolete on the base;

* The Nautilus, September, 1893, p. 57.

spire high, dome-shaped; whorls five and a half, narrow, almost as high as wide, body whorl somewhat angled at the periphery, rounded below, impressed around the umbilicus, which is a mere perforation; aperture lunately rounded; peristome narrow, thickened, reflected; two parietal folds conspicuously emerging; six long lamellæ on the base and outer wall of body whorl. Greater diameter, 2.25 mm.; height, 2 mm."—*Walker.*

S. virgo has been taken in small numbers from beneath logs and rubbish in ravines and moist places near Cannelton, Perry County; New Harmony, Posey County; Princeton, Gibson County; Wyandotte, Crawford County, and Lake Maxinkuckee, Marshall County.

8. **Strobilops affinis Pilsbry.**

"Shell umbilicated, obtusely elevated; dark brown; finely and closely ribbed above, ribs lighter below; spire obtusely elevated; whorls five and a half, rather narrow, higher than wide, body whorl obtusely angled at the periphery, somewhat flattened, but rounded below, impressed around the umbilicus, which is rounded and deep; aperture lunately rounded; peristome thickened, narrowly reflected; about eight short lamellæ arranged in a forwardly curved radial series from the axis across the base and up the outer wall of the body whorl. Greater diameter, 2⅞ mm.; height, 2.50 mm."—*Walker.*

In Indiana *S. affinis* has been found near Lake James, Steuben County; Tippecanoe Lake, Kosciusko County, and Mitchell, Lawrenceburg, Wyandotte and Huntingburg, in southern Indiana. It is said to be very abundant at many localities in New York and Ohio.

9. **Bifidaria procera (Gould). Plate I, Fig. 3.**

"Cylindrical, long, shining; surface covered with well marked, oblique lines of growth, the apex smooth; color brownish or chestnut horn; whorls six, convex, the last three about equal in size and the first three rapidly diminishing to the nucleus, making an obtuse apex; sutures deeply impressed; aperture ovate or semi-circular, higher than wide; there are generally five teeth placed as follows: One on the parietal wall, large and somewhat compressed, long and bifid at the end; one on the columella, near the upper third, short, conical; a third on the upper third of the outer lip, thick, conical, short; a fourth on the base of the peristome, long, sharp; and a fifth placed behind the columella tooth, large and massive; peristome rather widely reflected, thickened, bluish white; terminations approaching and joined by a callus; umbilicus small, open. Length, 2.50 mm.; diameter, 1.00 mm.; aperture length, 0.50 mm."—*Baker.*

Range.—Eastern United States west to Minnesota and south to Texas and South Carolina.

Indiana Localities.—This mollusk has been taken in this State only near Hamer's Cave, two miles east of Mitchell, Lawrence County, and near Connersville, Fayette County. At the former locality Mr. Daniels found a half dozen beneath flat stones, associated with *B. armifera*, *contracta* and *pentodon*.

10. VERTIGO MORSEI Sterki.

"Shell large (for the group), cylindrical-turriculate, with a rather acute apex, imperforate rimate, with few obsolete striæ of growth, shining, translucent; whorls six, rather slowly and regularly increasing, the last scarcely higher than the penultimate and rather narrower, somewhat sloping toward the base, slightly ascending at the aperture; suture deep; aperture lateral, scarcely oblique, comparatively small; inferior and palatal well rounded, the latter with an angular impression and slightly protracted in about its middle, the upper half more strongly curved, peristome everted; on the palatal wall, at some distance from and parallel with the margin, a moderate crest, behind it a deep and large impression over the palatal folds, and in front of it a groove corresponding with the impression at the auricle; inside the crest there is a distinct callus of the same color as the shell; apertural lamellæ and folds typically nine; three on the parietal wall (the same as in *V. ovata*) the largest whitish; two on the columella, the superior strong, vertical above, then in an angle turning horizontally, the inferior horizontal, lamelliform, thin, high and directed obliquely upward; basal small, sometimes double, rarely 0; palatals high, and rather long, curved and directed upward; suprapalatal small, nodule-like. Greater diameter, 1.3 mm.; lesser diameter, 0.8 mm.; height, 2.7 mm."*—*Sterki.*

Known heretofore only from Kent County, Michigan, and Sandusky, Ohio.

This handsome little mollusk occurs in numbers about the margins of Lakes James, Tippecanoe and Maxinkuckee; where it lives beneath rubbish, such as fallen weeds, grass stems, and pieces of wood. It is found associated with *Vertigo ovata*, *Polygyra monodon* and the two species of *Strobilops* above mentioned.

* The Nautilus, December, 1894, p. 89.

Family ZONITIDÆ.

11. OMPHALINA LÆVIGATA (Pfeiffer).

"Shell somewhat convex, oftener depressed; epidemris greenish horn-color, shining, thin; whorls five, rather flattened, rapidly enlarging, with beautiful and regular oblique striæ and revolving microscopic lines, the last whorl expanding toward the aperture, not descending; aperture transverse, broadly lunar, ample, with a testaceous deposit within; peristome thin, acute, straight, extremities approaching, its lower extremity inserted into the center of the base and somewhat reflected; base smooth, perforate. Greater diameter, 18 mm., lesser, 15 mm.; height, 9 mm."—*Binney.*

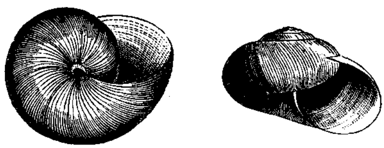


Fig. 5. *Omphalina lævigata* (Pfeiffer.)

A southern species whose range is given by Pilsbry as "North Carolina to St. John's Valley, Florida, west to Arkansas and western Louisiana."

In Indiana, Mr. Daniels found it in small numbers near Grand Chain, and Mt. Vernon, Posey County; Cannelton, Perry County, and Laurel, Franklin County. It occurs in dry upland woods beneath logs.

12. VITREA CELLARIA (Mull.).

"Shell very much depressed, thin, fragile, pellucid; epidermis light greenish-horn color, smooth, highly polished; whorls five, slightly rounded, with minute and almost imperceptible oblique striæ; aperture not dilated, its transverse diameter the greatest; umbilicus moderate, regularly rounded, deep; base rounded, thickened within by a testaceous deposit, bluish-white; peristome simple, acute. Greater diameter, 13 mm.; lesser diameter, 11.5 mm.; height, 5 mm."—*Binney.*

Fig. 6. *Vitrea cellaria* (Mull).

Introduced from Europe. Said to be quite common in the seaports of the Atlantic and Pacific coasts, and occasionally found inland in greenhouses.

In Indiana it has been noted only at Laporte, where it occurs in numbers beneath boards on the floor of a greenhouse. It does not seem to be harmful to the growing plants.

13. VITREA HAMMONIS (Ström). Plate I, Fig. 4.

"Small, depressed, thin, umbilicated; surface shining, the lines of growth well marked, impressed, more or less equidistant; color brownish-horn, transparent; periphery rounded; sutures well impressed; whorls four, rapidly enlarging, the last half of the last whorl

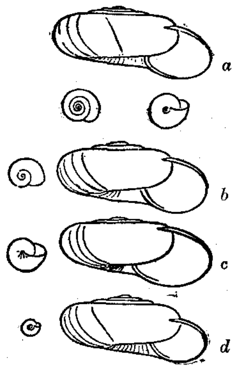


Fig. 7. Comparative figures of Vitrea and Zonitoides. (After Morse.) Enlarged. *a. Zonitoides arboreus* Say; *b, Vitrea hammonis* Ström; *c, Vitera indentata* Say; *d, Zonitoides minusculus* Binney.

very rapidly enlarging as it approaches the aperture; spire flat or a trifle convex; aperture large, transversely rounded, somewhat expanded; peristome simple, with thickened edge; umbilicus small, round, deep, showing several of the volutions, the umbilical region strongly concave; base of shell convex. Greater diameter, 4.25 mm.; lesser diameter, 3.75 mm.; height, 2.50 mm."—*Baker.*

Range.—North Carolina to Colorado, northwest through the northern States and British America.

Although not mentioned by Call, this is a rather common shell in Indiana, having been taken in a dozen or more localities. It occurs with *Zonitoides arboreus* (Say) under dead leaves and rotten logs, in open, usually moist woods. Specimens labeled "Indiana" were in the State Museum collection under the name of *Zonites viridulus* Menke. It was also listed by Pleas from Henry County.

14. VITREA WHEATLEYI (Bland).

"Shell umbilicated, depressed, thin, shining, pellucid, brownish horn-color, finely striated; spire subplanulate; suture slightly impressed; whorls little convex, the last more convex at the base, rapidly increasing, at the aperture scarcely descending; umbilicus pervious; aperture depressed, obliquely lunate; peristome simple, acute, the margins approximating, joined by a thin callus. Greater diameter, 5 mm.; lesser, 3.5 mm.; height, 2 mm."—*Binney*.

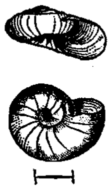


Fig. 8. *Vitrea wheatleyi* (Bland).

A southern species known chiefly from near Knoxville, Tennessee, and northern Alabama, though recorded by Sterki from Pennsylvania, Indiana and Michigan.

In the State Mr. Daniels has found it in small numbers associated with *Zonitoides arboreus*, the preceding and the next species, near New Harmony, Huntingburg, Brookville and Indianapolis.

15. VITREA INDENTATA (Say). Plate I, Fig. 5.

"Shell subperforated, flattened, thin, pellucid; epidermis highly polished, corneous; whorls rather more than four, rapidly enlarging, with regular, sub-equidistant, radiating, impressed lines, which on the body whorl extend to the center of the base, outer whorl expanding toward the aperture; suture well impressed; aperture rather large, transverse; peristome simple, acute, very thin, at its inferior extremity terminating at the center of the base of the shell; umbilicus none, but the umbilical region is indented. Greater diameter, 5 mm.; lesser diameter, 4.5 mm.; height, 2.5 mm."—*Binney*.

This species may be distinguished from *V. hammonis*, which it most resembles, by its subperforate umbilicus and peculiar equidistant impressed striæ. Its range as given by Pilsbry, is Dakota to New Mexico and Ontario to Florida.

It occurs in numbers throughout Indiana, in company with *Z. arboreus* and the two preceding species; having been taken at nearly every locality where collections were made.

16. VITREA CAPSELLA (Gould).

"Shell quite small, planorboid, pellucid, glistening, amber-colored; spire nearly plane, composed of about six and a half closely revolving, flattened whorls; surface with distant, impressed, radiating striæ; suture margined; aperture narrow, semilunar; peristome simple, not thickened by callus within; base perforated by a deep, rather small, funnel-shaped umbilicus. Greater diameter, 5 mm.; height, 2.5 mm."—*Binney*.

This is another species of southern range which has been found near Huntingburg and New Harmony by Mr. Daniels, where it occurs sparingly under dead leaves in the edges of woods. It has not before been recorded north of the Ohio River, its range as given by Pilsbry being Virginia and Kentucky to Alabama. Dr. Sterki, who identified the species, states that the Indiana specimens "have a rather wide umbilicus."

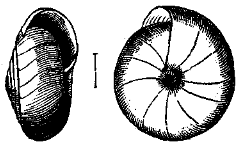


Fig. 9. *Vitrea capsella* (Gould).

17. EUCONULUS CHERSINUS Say.

"Shell subglobose-conic, pale yellowish white, pellucid, convex beneath; volutions about six, wrinkles not distinct; spire convex-elevated; suture moderate; body whorl slightly carinated on the middle; mouth nearly transverse, unarmed, the two extremities nearly equal; labrum simple; umbilicus none."—*Say*. Pilsbry adds: "Outlines of spire quite convex; whorls six and a half, appearing very closely coiled, as seen from above, the last only faintly angular, though in immature shells it is carinated. The base is quite convex and the umbilical perforation very narrowly open. Greatest diameter, 2.8 mm.; height, 3 mm." Baker says that *E. chersinus* "is a shell with a much more turreted spire and more closely coiled whorls than *E. fulvus* (Mull.). The teeth of the two species are widely different, *fulvus* having the formula 21-1-28, while *chersinus* has 18-1-18."

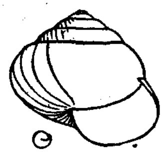


Fig. 10. *Euconulus chersinus* Say.

Specimens of this little mollusk, identified by Sterki and verified by Pilsbry, were taken from beneath bark and leaves in moist places near New Harmony, Huntingburg and North Vernon; also in a cypress swamp in Knox County, and near Pine, Lake County. It has heretofore been known only from Georgia and Florida.

18. ZONITOIDES NITIDUS (Muller). Plate I, Fig. 6.

"Orbicularly depressed, thin, umbilicated; surface shining, covered with rather strong lines of growth; color smoky-horn; periphery rounded; sutures impressed; whorls five, convex, regularly increasing, except the last, which is very large in proportion, and obtusely angled on the periphery as it approaches the aperture; spire rather elevated, convex; aperture lunate, oblique; peristome simple, acute, the basal margin bow-shaped; terminations of aperture not approaching; umbilicus round, broad, deep, exhibiting the volutions to the apex; base of shell concave about the umbilicus, convex on the last whorl. Greater diameter, 6 mm.; lesser diameter, 5 mm.; height, 4 mm."—*Baker.*

This is a common mollusk in northern Indiana, where it occurs about the margins of a number of the larger lakes, usually in company with *Polygyra monodon.* Its general range includes the northern United States and southern British America.

19. Zonitoides minusculus (Binney).—Plate I, Fig. 7.

"Small, depressed, thin, umbilicated; surface shining, lines of growth strong; color white, periphery rounded; sutures deeply impressed; whorls four, convex, slowly and regularly increasing in size; spire almost flat, a trifle convex; aperture very nearly circular, not expanded; peristome simple, acute, the basal margin rounded; terminations of aperture not approaching; umbilicus very large, deep, exhibiting all the volutions to the apex; columella with a thin, testaceous deposit; base of shell convex. Greater diameter, 1.50 mm.; lesser diameter, 1.30 mm.; height, 0.75 mm."—*Baker.*

Occurs commonly in the State, having been taken in six widely separated localities. It is found in company with *Z. arboreus* and allied species beneath the bark of logs, and rubbish in damp woods.

20. Zonitoides læviusculus (Sterki).

"Of the size and general appearance of *Z. minusculus* but differs in being much depressed. The spire is entirely flat or very little elevated. The whorls are markedly wider, from the nucleus; in specimens of the same size one-half to one less in number, very gradually increasing, and flatter above and below. The surface appears smooth and polished, and only with a strong magnifier radiating lines are seen. The umbilicus is rather wider in the adult, and the curvature of the whorl to the umbilicus is quite abrupt, appearing almost angular. The shell is colorless, glassy while fresh, and when weathered appears more milky white, while *minusculus* then is more chalky."—*Sterki.*

Specimens from Dr. Sterki, collected by E. Pleas near Dunreith, Henry County, Indiana, are in the State Museum. It is known otherwise from two localities in Texas, and from northwestern Ohio.

21. ZONITOIDES MILIUM (Morse).

"Shell widely umbilicated, depressed, transparent, shining, white, with a greenish tinge, marked with distinct and regular striæ of growth and microscopic revolving lines; the latter more conspicuous below; spire but slightly elevated; whorls three, rounded, rapidly increasing, the last planulate above, widely umbilicated below; aperture very oblique, subcircular, remote from the axis; peristome simple, acute, its terminations somewhat approached, that of the columella not reflected. Greater diameter, 1.5 mm.; height, 0.5 mm."—*Binney.*

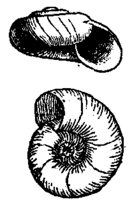


Fig. 11. ***Zonitoides milium*** **(Morse). Enlarged.**

The range of this species is from Ontario to Florida and west to Kentucky and Indiana. In this State it has been taken only near Princeton, Gibson County, where a few specimens were secured.

Family LIMACIDÆ.

22. AGRIOLIMAX AGRESTIS (L.).

"Color varying from whitish through every shade of cinereous and gray to black, and through various shades of yellowish or amber-color to brownish, and sometimes irregularly spotted with small black points or dots; eye peduncles and tentacles darker than the general surface, sometimes black; mantle sometimes mottled with a

Fig. 12. ***Agriolimax agrestis*** **(L.).**

lighter color; base of foot sallow white; sheath of eye peduncles indicated by black lines extending backward from their base under the edge of the mantle. Body when in motion cylindrical, elongated, terminating acutely, the sides toward its posterior extremity compressed upwards, so as to form a short carina or keel; foot very narrow. Mantle oblong-oval, fleshy, convex, and prominent, rounded at both extremities, equaling in length one-third of the length of the body, its surface marked by prominent, irregularly waved, concentrical lines and furrows having their center on the posterior part, and its edges free throughout the whole circumference. Upper surface of the body marked with longitudinal lines or shallow furrows, darker than the general surface, sometimes black, anastomosing with each other, and forming a sort of network; between the reticulated lines are narrow, irregular, oblong plates, or smooth, flattened tubercles, giving the surface the appearance of a mosaic work, with lines of dark cement; reticulations less distinct on the sides and disappearing toward the base; a prominent tubercular ridge extends from between the eye peduncles backward to the mantle, with a furrow on each side. Eye peduncles cylindrical, about one-eighth the length of the body, with small, black, ocular points on the superior part of the terminal bulb; tentacles immediately under, very short. Respiratory foramen near the posterior lateral edge of the mantle, large, surrounded with a whitish border. Orifice of rectum immediately adjacent, but a little above and anterior to the respiratory foramen. Foot narrow; locomotive band bounded by two distinct longitudinal furrows. Generally about 25 mm. in length, but when fully grown nearly 50 mm."—*Binney.*

This slug has been taken in numbers about Laporte, Indiana, where it occurs beneath logs, stones and rubbish in damp localities. It is an Old World species, introduced by commerce, and is common about Boston and other Atlantic seaports.

Family ENDODONTIDÆ.

23. Punctum pygmæum Drap. Plate I, Fig. 8.

"Subglobose, rather strong, umbilicated; surface dull or shining, marked by numerous strong, rounded, elevated striæ and very fine spiral lines, which are stronger on the base than elsewhere; color reddish or brownish; periphery rounded; sutures very deeply impressed, especially between the last two whorls; whorls four, convex, regularly and gradually increasing in size; spire elevated, convex; aperture somewhat oblique, crescentic, ample; peristome simple, rather solid; columella subreflected, the terminations of the aperture widely separated; umbilicus wide, deep, showing all the volutions to the apex. Greater diameter, 1 mm.; height, 0.50 mm."—*Baker.*

Range.—Northern United States and southern Canada, south to Texas and west to California. Taken near Seymour, Jackson County, and Vawter Park, Kosciusko County, beneath chips and chunks in open woods.

24. SPHYRADIUM EDENTULUM (Drap.)

"Shell minute, cylindrical, obtuse at apex, smooth, chestnut color; whorls five, well rounded, separated by a deep suture; aperture circular; the peristome nearly continuous, simple or scarcely everted, except at its columellar margin, where it partially conceals a small umbilicus; no trace of a tooth has been detected in any specimen. Length, 1.6 mm.; breadth, half as great." —*Binney*.

Fig. 13. *Sphyradium edentulum* (Drap.).

This is a northern form whose range is given by Pilsbry as Ontario to Vancouver's Island. It was found in numbers on the leaves of the Ostrich fern in a dense marsh on the border of Clear Lake, Steuben County; and in a tamarack swamp near Vawter Park, Kosciusko County.

Family SUCCINIDÆ.

25. SUCCINEA CALUMETENSIS Calkins.

"Shell oblong, ovate, thin, shining, finely striate; color golden; whorls three, the last broad, dilated; aperture below expanded, striæ of growth marked. Length, 12 to 13 mm."—*Calkins*.

Fig. 14. *Succinea calumetensis* Calkins.

This form was originally described from the banks of the Calumet River, Cook County, Illinois. Mr. Daniels found it common on aquatic grasses about the Half Moon Pond, Posey County, and the cypress swamp, Knox County, Indiana.

Family AURICULIDÆ.

26. CARYCHIUM EXILE H. C. Lea. Plate I, Fig. 9.

"Similar to *C. exiguum* (Say) but differing in the following particulars: the shell is elongated instead of cylindrical; there are five and a half whorls; the aperture is *just* one-third the length of the shell, instead of *over* one-third, and the surface is regularly and very distinctly striated. Length, 1.75 mm.; width, 0.75 mm.; aperture length, 0.50, width, 0.25 mm."—*Baker*.

This shell is by many conchologists considered a synonym of *C. exiguum* Say. Baker, however, regards them as probably distinct. In Indiana it has been taken near Vawter Park, Kosciusko County, and Berry Lake, Lake County.

Family LIMNÆIDÆ.

27. LIMNÆA STAGNALIS APPRESSA Say. Plate I, Fig. 10.

"Elongated (or oval), ventricose at the anterior end, thin, color yellowish-horn to brownish-black; surface shining, growth lines numerous, crowded, more or less elevated, crossed by numerous fine, impressed spiral lines; apex smooth, brownish horn-color; whorls six and a half, rapidly increasing, all but the last two rather flat sided; last whorl very large, considerably dilated and inflated; spire long, pointed, acute, occupying about half the length of the entire shell (sometimes very short); sutures distinct, sometimes impressed; aperture large, broadly ovate, dilated, particularly at the upper part; peristome thin, acute, in some specimens thickened by an internal callus; lower part rounded; columella crossed in the middle by a heavy plait, which starts from the base of the aperture and runs obliquely into the aperture of the shell about 10 mm. from the junction of the peristome to the body whorl; there is a spreading callus on the columellæ and labrum, which completely covers the umbilicus. Length, 57 mm.; width, 24 mm.; aperture length, 31 mm., width, 14.50 mm."—*Baker.*

This large and handsome Limnæid ranges through North America from the Atlantic to the Pacific. It is found generally in stagnant ponds and rivers about decaying vegetation. In Indiana it has been taken at Turkey Lake, Kosciusko County; in the Kankakee River, Laporte County, and in a pond near Millers, Lake County.

28. LIMNÆA REFLEXA KIRTLANDIANA Lea. Plate I, Fig. 11.

"Turreted, thin, irregularly striate, pale horn-color, imperforate; spire attenuated; sutures impressed; whorls six, slightly convex; aperture narrow-elliptical. Diameter, .26; length, .70 of an inch."—*Lea.*

This variety of *L. reflexa* has been taken by F. C. Baker near Roby, Lake County, Indiana.

29. LIMNÆA PALUSTRIS MICHIGANENSIS Walker. Plate I, Fig. 12.

"This form of L. palustris is characterized by the aperture being about one-half the total length, the outer lip is thickened within by a bluish white callus edged with brownish black; this shows as a white longitudinal band on the outside of the shell; spire acute, sutures impressed. Length, 17 mm.; width, 7 mm.; aperture length, 8.50 mm.; width, 4 mm."—*Baker.*

Occurs in numbers near Calumet Lake, Lake County, and Tippecanoe and Turkey lakes, Kosciusko County. Found in small streams and rivers, ponds and lakes, attached to floating sticks and submerged water plants; often in low ground after the water has receded.

30. LIMNÆA CAPERATA UMBILICATA Adams. Plate I, Fig. 13.

"Ovate, solid, translucent; color yellowish or brownish horn; surface shining, growth lines fine and numerous; shell encircled by raised spiral lines; whorls five, very convex, the last whorl inflated, occupying from one-half to three-fifths of the total length of the shell; spire short, obtuse; conic, sutures much impressed; aperture roundly ovate, one-half to three-fifths the length of the shell, the terminations rounded; peristome thin, sharp, thickened inside by a reddish deposit; columella strong, reflected over the narrowly open umbilicus; columella with a small fold. Length, 6 mm.; width, 4 mm.; aperture length, 3.50 mm.; width 2 mm."—*Baker.*

This variety has been taken by Baker in a swale near Liverpool, Lake County, Indiana. He states that "*umbilicata* is doubtless a form of *caperata,* but seems distinct enough to constitute a separate variety characterized by a short spire and swollen whorls."

31. LIMNÆA CATASCOPIUM Say. Plate I, Fig. 14.

"Rather solid, ovate, inflated; color light horn to blackish; surface dull to shining, lines of growth numerous, fine, crowded, wavy, crossed by numerous impressed spiral lines; apex small, rounded, chestnut colored; whorls five, rounded, subinflated, the last large and somewhat inflated; spire sharp to obtuse, conic; sutures impressed; aperture roundly ovate, large, from half to three-fourths the length of the entire shell, rounded below; somewhat narrowed above; peristome thin, sharp, thickened by a light, whitish callus just within the edge; columella oblique, with a heavy plait across the middle; the lower part of the columella has a flexure caused by the heavy plait; the lower part of the peristome and the whole of the columella is sometimes covered with a heavy coating of white, testaceous material, which is reflected over the umbilicus, completely closing it. Length, 15 mm., width, 7.50 mm.; aperture length, 8 mm., width, 4.50 mm." —*Baker.*

This species ranges from New England to Utah, and British America to Virginia. In Indiana it has been taken in Calumet Lake, Lake County, by Baker, who also separated specimens from a large lot named *L. palustris* belonging to the State Museum. It has also been taken in Henry County by Pleas, and is listed by Stein as "not common."

32. LIMNÆA COLUMELLA Say. Plate I, Fig. 15.

"Ovate, somewhat pointed, thin, fragile, transparent; color light greenish or yellowish horn; surface shining, covered with rather coarse growth lines, and encircled by impressed spiral lines; whorls four, rounded, rapidly enlarging, the last one three times the size of the rest of the shell; spires sharply conic, rather short; apex small, very dark brown; sutures impressed; aperture oval, dilated, expanded at the lower part; the aperture varies from long and narrow to wide and somewhat expanded; peristome thin, acute; columella narrow, twisted; terminations of peristome connected by a thin callus; umbilicus generally closed but sometimes very narrowly perforate where the callus is not fully developed; the columella is so narrow that a view may be taken from the base nearly to the apex, as in *Succinea retusa.* Length, 16 mm.; width, 8.50 mm.; aperture length, 11.40 mm., width, 6 mm."—*Baker.*

Ranges from New England to Iowa and from Canada to Georgia. It occurs in small ponds and bays of lakes where the water is more or less stagnant and where water-lilies are abundant. In Indiana it has been taken at Bass Lake, Starke County, and in Grassy Creek, Kosciusko County.

33. LIMNÆA WOODRUFFI Baker. Plate I, Fig. 16.

"Ventricose, very much inflated, solid; color, greenish-horn or olivaceous; surface shining, growth lines distinct; rough in some specimens, crossed by numerous fine impressed spiral lines; apex small, rounded, light horn-colored; whorls three to four, rounded, inflated, the last occupying nearly the whole of the shell; spire depressed; sutures impressed; aperture very large, roundly ovate, occupying about four-fifths of the length of the entire shell, roundly shouldered at the upper part; peristome thin, sharp; columella thickened, spreading, with a plait or fold in the middle; the lower part of the aperture is expanded, the columella callus, making a ridge which is reflected over the umbilical region; umbilicus open, deep. Length, 11.50 mm., width, 8 mm.; aperture length, 8 mm., width, 4.75 mm." —*Baker.*

This mollusk occurs in abundance along the lower end of Lake Michigan, having been taken in numbers opposite Pine, Millers and Michigan City. It inhabits rather deep water. Its principal distinguishing characters "are its very short spire, rapidly increasing and swollen whorls, and its roundly oval aperture with its broad shoulder at the upper part."

34. **Planorbis hirsutus Gould.**

"Shell small, somewhat transparent, of a brownish yellow color; both sides concave, the left rather more than the right, but the concavity is there more limited by the presence of a sub-angular ridge on the outer whorl; whorls three, the outer one rapidly increasing; surface exhibiting traces of revolving lines when denuded, but usually covered with a dark pigment or epidermis, bristling with rigid hairs which are arranged in close revolving lines; lines of growth very faint; aperture sub-oval, oblique, its diameter from side to side shorter than in the opposite direction; its plane very oblique. Long diameter, one-fifth inch, short diameter, one-fifteenth inch."—*W. G. Binney.*

This little fresh water univalve occurs in a number of the lakes of the northern third of the State and in their outlets; especially those which contain much aquatic vegetation. It is found attached to immersed stems and leaves of pond-weed (Potamogeton), water-lilies, cat-tails, etc. It is especially common in Grassy Creek, which connects Tippecanoe and the Barbee lakes, Kosciusko County.

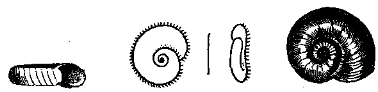


Fig. 15. *Planorbis hirsutus* Gould.

35. **Planorbis umbilicatellus Cockerell.**

"Shell somewhat flat above, but slightly sunk in the center, convex below, grayish white, somewhat glossy, closely and distinctly striate in the line of growth, with stronger ridges at intervals, most visible on the under side. Periphery rounded, but slightly compressed at each side. Suture rather deep. Aperture oblique and somewhat cardiform. Umbilicus deep and narrowly funnel-shaped. Whorls four and a half, compact, gradually increasing in size and faintly keeled or angulated on upper side. Diameter, 6.5 mm.; height, 2 mm."—*Cockerell.*

This little mollusk occurs with the above on aquatic vegetation. In Indiana it has as yet been taken only in Tippecanoe Lake. The specimens were identified by Sterki. It will probably be found in most, if not all, of the lakes of the State, its small size having caused it to be overlooked in the past.

36. **Segmentina armigera (Say).**

"Dextral, flat, somewhat carinated above and below the periphery; color pearl white to reddish brown, sometimes black; surface smooth, shining, lines of growth very fine, oblique; apex sunken below the level of the whorls, very small and rounded; whorls four, regularly and slowly increasing, obtusely carinated above and below the rounded periphery; spire concave, exhibiting all the whorls; sutures impressed; base of shell rounded; umbilicus round, deep, rather wide, concave, showing nearly all the volutions; aperture subovate, a trifle oblique, armed with five teeth, one on the parietal wall long, thin, S-shaped, extending in an oblique direction from a point near the upper carination of the body-whorl to a point near the lower carination; three on the peripheral wall, the two upper ones being prominent, short, thick and triangular, and the lower one more or less lamelliform and situated on the base of the aperture, and one small conic tooth near the superior junction of the peristome with the body-wall; peristome thin, acute, slightly thickened inside, the superior margin a trifle produced; interior of aperture pearly white, with a band of reddish just within the aperture extending parallel to the edge of the aperture. In some specimens there is a sixth tooth, small, acute, elevated, just below the large one on the parietal wall; this, however, is not always developed. Length, 2.75 mm., width, 6 mm.; aperture length, 2.25 mm., width, 1.50 mm."—*Baker*.

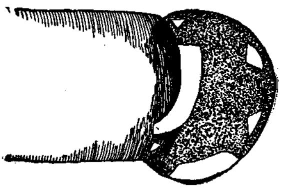


Fig. 16. *Segmentina armigera* (Say). Aperture, showing number and position of teeth. (After Baker.)

A common mollusk throughout the State; in the southern part occupying the smaller streams and swamps, especially those of the Wabash Valley; while in the northern part it is found in the swamps bordering the lakes. It is usually found clinging to submerged sticks, stones and aquatic plants. In Carr's Slough, White County, it has been taken by thousands.

Family ANCYLIDÆ.

37. ANCYLUS RIVULARIS Say.

"Small, depressed conic, fragile, sides nearly parallel, a trifle round but narrowed posteriorly; anterior slope long, convex, with a decided 'hump' toward the apex; posterior slope short, concave; sides convex; apex prominent, elevated, obtuse, directed posteriorly and a little to the right side; the apex divides the shell into about three equal parts, one posterior and two anterior; aperture as large as the shell, narrowed posteriorly; peristome entire, simple, acute; color light horn; interior of aperture whitish. Length, 3 mm., width, 2 mm.; height, 1.25 mm."—*Baker*.

Fig. 17. *Ancylus rivularis* Say.

"This small but distinct species may be known by its almost straight lateral outline and its apex, which is directed posteriorly and to the right side. It is quite abundant, but is almost always overlooked owing to its peculiar shape and inconspicuous habitat. The animal is very slow in movement and progresses similarly to *Planorbis;* it is able to turn its body half way around without moving its shell. The buccal organs can be plainly seen while the animal is feeding."

In Indiana *rivularis* has been taken in the sloughs near Millers, Lake County, by F. M. Woodruff, and in Bass Lake, Starke County, by L. E. Daniels. It is found on decaying aquatic vegetation.

38. ANCYLUS PARALLELUS Haldeman.

"Shell pale, thin, and delicate; lengthened, sides subrectilinear, diverging slightly forwards; apex rather sharp, conspicuous, with two-fifths of the shell posterior to it. Dimensions—Length, 0.25, width, 0.15, height, 0.08 inch."—*Adams.*

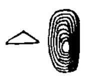


Fig. 18. *Ancylus parallelus* Haldeman

Occurs in numbers in Bass Lake, Starke County, usually on submerged decaying stems of the water-lily.

39. ANCYLUS SHIMEKII Pilsbry.

"Elevated, thin, transparent, horn-colored, with a yellowish brown epidermis; aperture ovate, conspicuously wider anteriorly, in many (especially young) specimens slightly reniform by a barely perceptible incurving of the right margin, the anterior, left and posterior margins regularly rounded, the right slightly incurved, straight, or but slightly convex; apex somewhat acute, elevated, strongly deflected posteriorly and to the right, and curved downward, in most specimens quite overhanging the posterior right margin of the shell; the apical portion of the shell (one-half or more) is strongly laterally, or rather, obliquely, compressed, a character which makes the young appear proportionally much narrower than the adults; the anterior slope of the shell is long and strongly convex, the posterior being short and concave. The surface is marked by fine lines of growth. Length, 3.10 mm.; width, 1.70 mm.; height, 1.10 mm."—*Shimek.*

Fig. 19. *Ancylus shimekii* Pilsbry.

Known by its very oblique shell, the apex in some individuals, fairly overhanging the margin. Found with the preceding in Bass Lake. Has also been taken at Rock Island and near Joliet, Illinois. It and other species of *Ancylus* were determined by Dr. Sterki.

40. ANCYLUS FUSCUS Adams.

"Shell thin, transparent without the epidermis, not much elevated, elliptical moderately curved at the sides; epidermis brown, visible through the shell, giving it the appearance of having the same color, thick, rough, slightly extending beyond the margin of the shell; apex obtuse, moderately prominent, scarcely behind the middle, inclining to the right so as to have only two-fifths of the width on that side. Length, .31 inch; width, .22 inch; height, .05 inch."—*W. G. Binney.*

Fig. 20. *Ancylus fuscus* Adams.

Easily distinguished by its epidermis. Allied to *A. rivularis* Say, but the latter is much more narrow, with its sides straight and its apex more acute. Taken only in Grassy Creek, between Barbee and Tippecanoe lakes, Kosciusko County. Known heretofore from Massachusetts and Ohio.

41. ANCYLUS DIAPHANUS Haldeman.

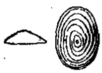


Fig. 21. *Ancylus diaphanus* Haldeman.

"Shell thin in texture, diaphanous, very wide, nearly circular, depressed; apex obtuse, almost central! Slope scarcely convex. Color very pale olivaceous, translucent, aperture white. Distinguished by its circular and flattened form, and central inconspicuous apex. Length, 5.5 mm.; width, 4.5 mm.; height, 2 mm."—*Haldeman.*

Specimens in the State Museum marked "Indiana." Recorded heretofore from Ohio and Wisconsin.

Family PHYSIDÆ.

42. PHYSA SAYI Tappan. Plate I, Fig. 17.

"Sinistral, polished, ovate, whorls five to five and one-half; spire elevated, very acute, the whorls moderately convex; color light horn to light chestnut; sculpture consisting of rather coarse growth lines, crossed by numerous fine, impressed spiral lines, giving the surface of the shell a wavy appearance, as figured for *P. gyrina;* sutures slightly impressed, bordered as in *heterostropha;* protoconch consisting of one and one-half smooth, glossy whorls of a dark chestnut color; aperture very large, long oval, three-fourths to four-fifths the length of the whole shell; peristome thin, generally not very much thickened within, whitish, sometimes bordered with reddish; columella slightly twisted and covered with a spreading callus; the lower part of the aperture is somewhat produced. Length, 19 mm.; width, 12 mm.; aperture length, 14 mm.; width, 6 mm."—*Baker.*

Resembles *P. ancillaria* Say, but that form is more inflated, has the outer lip more spreading and the body whorl more swollen; the spire being always much shorter and the whorls more convex than in *sayi*. This mollusk occurs in ponds, slow-flowing streams and lakes, where it may be found adhering to immersed vegetation or crawling over the muddy bottoms. In Indiana it has been taken in Turkey and Tippecanoe lakes, Kosciusko County, being rather common in the latter. It was originally described from Lake Pipin, Portage County, Ohio.

43. PHYSA RHOMBOIDEA Crandall.

"Shell rhomboid-ovate, large, heavy, robust, yellowish horn-color to pale yellowish brown, texture fine, surface undulating and shining when not covered with a dark coating, spire elevated, acute with dark brown tip, whorls five convex, sutures much impressed, aperture ovate, lip simple, not expanded, sometimes a little compressed, thickened on inner margin with reddish-brown callus, columella well covered with heavy deposit continuing and extending from the lip. On many of them the columella is folded so as to form a narrow umbilicus.

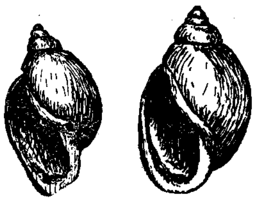


Fig. 22. *Physa rhomboidea* Crandall.

"It is distinguished by its robust appearance, deep sutures, constricted aperture and umbilicus which will be found in a large part of them. It is more like *P. solida* Philippi than any other species. Length, 16 mm.; diameter, 9 mm."—*Crandall.*

A southern form, before recorded from Missouri, Arkansas and New Mexico. Taken in Indiana only in the cypress swamp, Knox County.

44. PHYSA GYRINA ELLIPTICA Lea. Plate I, Fig. 18.

"Differing from typical *gyrina* in being more elliptical, having a shorter, more rounded spire, and hence more convex whorls, the spire, as described by Tryon, 'with the outline not elevated above a continuation of the general curve of the body.' The shell is also more solid and the outer lip thicker, with a very heavy, bluish-white callus. The surface sculpture is the same as in *gyrina*. Length, 12 mm., width, 7.50 mm.; aperture length, 9 mm., width, 3.75 mm."—*Baker.*

This form has been taken in Indiana only in the cypress swamp, Knox County.

45. **Physa integra Haldeman.** Plate I, Fig. 19.

"Oval, whorls four and one-half to five; spire short, pointed, the whorls convex; sutures well marked, sometimes bordered by a faint white line; color varying from light yellowish-horn to pale brown; sculpture as in *gyrina,* the lines being very deep and the wrinkled ridges very convex; protoconch consisting of one and one-half smooth, rounded, wine-colored whorls; aperture oval, rather wide, produced at the anterior end, about two-thirds the length of the entire shell; peristome thin, thickened within the aperture by a heavy white or yellowish-white callus, which shows through the shell very plainly; it is never bordered by a color stripe; the callus of two or three former peristomes may always be seen on the body whorl and sometimes one or two on the spire; columella broad, flat, white, a callus spreading over the parietal wall. Length, 12 mm., width, 8 mm.; aperture length, 7.50 mm., width, 3 mm."—*Baker.*

Quite common in Lake Michigan, near Michigan City; also in a large spring near Wyandotte, Crawford County. Baker says that in his experience "it is more common than *sayi* but less so than *gyrina.*"

Family PLEUROCERIDÆ.

46. **Lithasia obovata biconica Pilsbry MS.**

"The adult shell is more lengthened than *obovata,* and more or less biconic, rapidly tapering toward both ends from the middle, which, while not angular, is prominent; the penultimate whorl decidedly higher than in *obovata,* and the aperture is distinctly shorter in shells of the same size. The last whorl slopes steeply below the suture, and is not swollen there. Length, 16; diameter, 10.5; length of aperture, 10 mm. (truncate adult). Length, 17.5; diameter, 12; length of aperture, 11.2 mm. (truncate adult). Length, 19; diameter, 10; length of aperture, 10.2 mm. (truncate adult). Length, 18.5; diameter, 9.5; length of aperture, 10 mm. (truncate adult).

"Wabash River in Gibson County, Indiana, at the Southern Railroad bridge abutment opposite Mt. Carmel, Illinois.

"The adult of *L. obovata* is bluntly oval in outline; the penultimate whorl is short, and the last whorl is puffed out below the suture, as in Fig. 23, representing a shell from the Ohio River at Louisville.

"None of the numerous synonyms of *L. obovata* seem to have been based upon this biconic form, which seems sufficiently distinct to require a name to signalize its deviation from the type. I may mention that Mr. Bryant Walker has examined the specimens and regards them distinct from *obovata*, though related to that species."—*Pilsbry.*

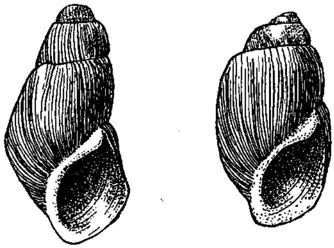


Fig. 23. *Lithasia obovata biconica* Pilsbry MS. *a, Lithasia obovata biconica; b, Lithasia obovata.*

47. Pleurocera alveare (Conrad).

"Shell short conical, ventricose; whorls flattened, with a line of wide compressed tubercles at the base of the penultimate whorl; body whorl angulated; angle armed with prominent tubercles; base hardly convex, with about five prominent lines; aperture obliquely elliptical; less than half the length of the shell. The spire is very regularly conical, and the base strongly ribbed."—*Conrad.*

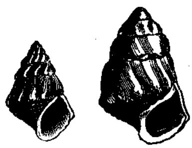


Fig. 24. ***Pleurocera alveare*** (Conrad).

A number of specimens are in the State Museum, labeled "Indiana." Mr. Daniels has taken it in the Wabash River, in Gibson County, opposite Mt. Carmel, Illinois.

48. Goniobasis louisvillensis Lea.

"Shell smooth, fusiform, dark horn-color, without bands; spire short; sutures regularly impressed; whorls about five, somewhat convex; aperture, rather large, long elliptical, white within; outer lip acute, slightly sinuous; columella white, thickened above and twisted. Operculum ovate, reddish-brown, rather thin, with the polar point on the left, near the base. Diameter, .25; length, .56 of an inch.

Fig. 25. *Goniobasis louisvillensis* Lea.

"This shell is somewhat like *G. depygis* Say, from the same locality; but is much shorter in the spire and has a differently formed aperture."—*Lea.*

G. louisvillensis is quite common at the Falls of the Ohio, just above New Albany, on the Indiana side, from which locality it was originally described. Specimens taken by Dr. J. H. Lemon and presented to the State Museum, were identified by Bryant Walker.

49. GONIOBASIS GRACILIOR (Anthony).

"Shell conical, smooth and shining, color dark brown, texture light; whorls about eight, upper ones nearly flat, the last is usually slightly constricted beneath the suture, and beneath this stricture on the periphery of the last whorl revolve one or two broad bands of yellowish-green; sutures impressed, and of a paler color than the rest of the shell; aperture small, pyriform, and inwardly ornamented with alternate bands of a dark ruby color and translucent white, which render this part of the shell peculiarly lively and beautiful; outer lip sinuate; columella dark brown, arcuate, and produced into a distinct sinus. Diameter, 7 mm., length, 19 mm.; length of aperture, 6 mm., width, 5 mm.

Fig. 26. *Goniobasis gracilior* (Anthony).

"This is a very distinct and beautiful species, remarkable for its long, slender form, its polished surface, and for a profound stricture on the body-whorl of many of the specimens, though this last character is not always present; when it is present it furnishes a mark by which this species can be readily distinguished from any other."—*Anthony.*

A common species in Lake Wawasee, Kosciusko County, and Lake Manitou, Fulton County, occurring on the bottom close to shore in water a foot or two in depth. Originally described from lakes in Starke County, Ohio.

50. GONIOBASIS BREVISPIRA Anthony.

"Shell small, elongate, ovate, truncate, rather solid, plain, shining, brownish-green, paler at the sutures; whorls 4-5, convex, somewhat declining at the sutures; aperture ovate; lip dilated before, sinuated behind. Length, 3 mm.; width, 7.5 mm."—*Anthony.*

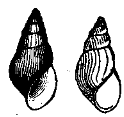


Fig. 27. *Goniobasis brevispira* Anthony.

Taken in numbers from a large spring near Wyandotte, Crawford County, and in the Tippecanoe River, in Carroll County. Occurs probably in many of the clearer, rapid flowing streams of the State.

51. GONIOBASIS INDIANENSIS Pilsbry, MS.

"Shell similar in form to *G. semicarinata* (Say), and of the light dirty horn-color and somewhat transparent texture prevalent in that species. Sculpture consisting of one prominent keel above the suture, with two or three acute threads between it and the suture above. This sculpture becomes obsolete on the later whorls, and in adult shells is very faint or not visible on the last whorl, which is well rounded. In immature shells the major keel is peripheral on the last whorl, and there are several minor ones below it. In some individuals the smooth stage supervenes at an earlier age than in others, and the sculpture of keel and threads may then be lost by erosion when the full size of the shell is attained. Adults measure, length, 15 mm.; diameter, 6.3 to 7 mm.

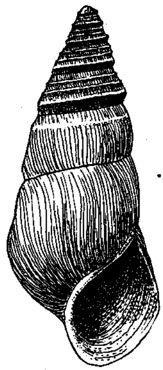


Fig. 28. *Goniobasis indianensis* Pilsbry, Ms.

"Blue River, Wyandotte, Crawford County, Indiana.

"This form is intermediate between *G. semicarinata* (Say) and *G. porrecta* (Lea). It differs from the former in the plurality of spiral keels and their greater prominence and longer persistence, while in *porrecta* the spiral sculpture is much better developed and ordinarily persists to the adult stage." —*Pilsbry.*

Mr. Daniels found this form quite common about the old mill dam near Wyandotte Cave. It was clinging to the stones in the swift running water below the dam.

Family AMNICOLIDÆ.

52. Bythinia tentaculata L. Plate I, Fig. 20.

"Globose, rather thick, transparent to opaque; color ranging from yellowish to greenish, sometimes brownish; surface shining, smooth, lines of growth very fine; sutures very deeply impressed; whorls five, convex, the last rapidly enlarging and equaling all the others combined; spire elevated, broadly conic; apex small, round, reddish brown; aperture broadly rounded-ovate, narrowed above; peristome thin, rounded, simple, continuous, thickened a little on the inside, bordered all around with yellowish; base of shell rounded, imperforate. Length, 9.50 mm., width, 6 mm.; aperture length, 4.50 mm., width, 3 mm.

Fig. 29. ***Bythinia tentaculata*** **L. Operculum enlarged. (After Baker).**

"May be easily distinguished by the size of the last whorl, which more than equals in length that of all the rest.

The species was introduced into this country many years ago and is now found from Vermont and New York to Wisconsin. It is particularly abundant in Lake Michigan. While in motion, the animal of *Bythinia* is rather slow, the tentacles move about nervously and the rostrum is thrust out to its fullest extent. Thus far it has been collected only in Lake Michigan."—*Baker.*

Taken in numbers opposite Michigan City, Millers and Pine. Occurs on the bottom of the lake attached to sticks, stones and other submerged objects.

53. AMNICOLA LUSTRICA Pilsbry.

"Narrow (for the genus), thin, translucent; color waxy, light brownish or greenish; surface smooth and shining, lines of growth very fine, but distinct when viewed with a lens; sutures very deeply impressed; spire elevated, conical; whorls five, rounded, regularly increasing in size; aperture roundly ovate, slightly angled above, waxy inside; peristome continuous, thin, appressed to the body whorl only for a short distance near the upper terminations; base broadly rounded, with a narrow and deep umbilicus. Operculum similar to that of *A. limosa.* Length, 4 mm., width, 2 mm.; aperture length, 1.50 mm., width, 1.10 mm."—*Baker.*

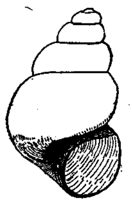


Fig. 30. *Amnicola lustrica* Pilsbry.

Ranges from New York to Illinois and Massachusetts. Taken at Berry Lake, Lake County, by Baker, and Wawasee and Tippecanoe lakes by Daniels.

54. AMNICOLA WALKERI Pilsbry.

"Thin, narrowly umbilicate, conic, shaped like *Lyogyrus brownii* Carpenter; slightly yellowish corneous; thin, smooth, with faint growth-lines. Whorls four, very convex, separated by deeply constricting sutures, the last whorl rounded below; apex obtuse. Aperture oblique, rather small, mainly basal, a little longer than wide, but nearly circular, the inner margin a trifle straightened above; peristome continuous, in contact with the preceding whorl for an extremely short distance above. Operculum amnicoloid. Height, 3 mm., diameter, 2 mm.; length of aperture, $1\frac{1}{4}$ mm., width, $1\frac{1}{8}$ mm."—*Baker.*

Fig. 31. *Amnicola walkeri* Pilsbry.

Originally described from High Island Harbor, Lake Michigan. Since taken at Grand Rapids, Michigan, and Joliet, Illinois. A number were found in Grassy Creek, Kosciusko County, by Daniels.

55. AMNICOLA EMARGINATA Kuster.

"Small, globose, rather solid; color, different shades of green; surface smooth, polished, lines of growth very faint; sutures well marked; apex very obtuse; comprising one and one-half whorls; when viewed from the front the shell appears to have a truncated spire; spire very broadly truncate-conic; whorls four to four and one-half, very convex; aperture nearly round, appressed to the body whorl; peristome continuous, rather thick, simple; base rounded, with a small umbilicus. Length, 4 mm., width, 2 mm.; aperture length. 1.50 mm., width, 1.10 mm.

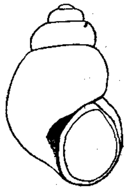


Fig. 32. *Amnicola emarginata* Kuster.

"This species at first sight might be taken for *A. lustrica*, but the spire is very *obtuse*, while that of *lustrica* is *acute*, and the last whorl is appressed to the body-whorl, at the aperture in *obtusa*, while in *lustrica* it is entirely free."—*Baker.*

Range from New York west to Iowa and Winnipeg, Canada, south to Kentucky. Taken in Indiana only in beach drift along Lake Michigan opposite Millers, Lake County, by Baker.

56. PALUDESTRINA NICKLINIANA Lea.

"Elongately ovate, turreted; color greenish-horn; surface shining, lines of growth numerous, crowded, raised so as to roughen the surface of the shell; sutures deeply impressed; whorls four to four and one-half, very convex; spire elevated, rather sharply conical; apex small, round, almost concealed in the volution of the second whorl; aperture roundly ovate; peristome sharp, a little thickened on the inside, continuous, the columellar lip being covered with a raised callus which connects the terminations; base of shell rounded; umbilical region rimate and indented. Length, 4.25 mm., width, 2 mm.; aperture length, 1.25 mm., width, 1 mm.

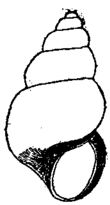


Fig. 33. *Paludestrina nickliniana* Lea.

"*Nickliniana* is a common little species, easily recognized by its narrow, turreted shell and well rounded whorls. The animals are gregarious, congregating together by hundreds. Frequently a piece of water-cress will be found literally black with the shells of this species."—*Baker.*

Berry Lake, Lake County, by Baker.

Family VALVATIDÆ.

57. VALVATA SINCERA Say. Plate I, Fig. 21.

"Depressed, more or less discoidal, rather solid; color brownish, transparent to opaque; surface shining, lines of growth numerous, regular, crowded, sometimes encircled by a few spiral lines; apex large, round, almost concealed in the succeeding whorls; spire very flat, almost discoidal; whorls three and one-half, rounded, rapidly increasing, the last considerably deflected; sutures impressed; aperture round, continuous, whitish or brownish inside; peristome rather thick, simple, continuous, the columellar portion being simply appressed against the body whorl; base rounded, umbilicus round, deep, exhibiting all the volutions. Length, 2.25 mm., width, 6 mm.; aperture length, 2.10 mm., width, 2.10 mm.

"This is a very common species, easily distinguished by its discoidal form and rounded whorls. Like the *Limnæids*, it delights to float on the surface of the water, shell downwards. It is very active, and not at all timid in captivity."—*Baker.*

Occurs in numbers in the beach drift along the south shore of Lake Michigan, opposite Michigan City, Millers and Pine.

58. VALVATA BICARINATA Lea.

"Depressed, solid, orbicular; horn-colored above and whitish beneath; surface shining, lines of growth distinct; apex large, horn-colored; spire much depressed, flattened; whorls three and one-half to four, rapidly increasing; the carinæ are normally two in number, but a third is frequently developed; one carina encircles the shoulders of the whorls and one the middle of the base, the periphery being sharply rounded; sutures pronounced; aperture rounded, angled more or less by the carinæ, continuous as in *tricarinata;* base keeled; umbilicus widely opened. Length, 3.50 mm., width, 5 mm.; aperture length, 2 mm., width, 2 mm.

Bicarinata should be considered a distinct species from *tricarinata,* since the shells of the two forms are always distinguishable, *tricarinata* being elevated, the width equaling the height, while *bicarinata* is depressed and the height is four-fifths of the width. The former is normally *tricarinate* while the latter is *bicarinate,* although both bi- and tricarinate forms occur in both species. In *tricarinata* the upper surface slopes *upwards* from the carina to the suture, while in *bicarinata* it slopes *downwards,* giving the upper surface a concave appearance."—*Baker.*

Occurs in Lake Michigan, along the borders of Lake, Porter and Laporte counties. The form *normalis* Baker has been taken opposite Millers, Lake County. It "differs from *bicarinata* in being tricarinate, the middle carina very strong and placed on the periphery."

Family VIVIPARIDÆ.

59. CAMPELOMA OBESA Lewis.

"Obesely-ovate, very ventricose; whorls five, convex, spire short-conic, sutures well impressed, aperture ovate. Dark olivaceous, bluish-white within the aperture. Length, 32 mm.; diameter, 20 mm.

"This species much resembles a half-grown *ponderosa*, but is more regularly oval in its outline and of lighter texture. It is regularly distinguished by its very ventricose, rounded form and dark olive green color."—*Lewis.*

This species occurs abundantly in the canal and White River, near Indianapolis. Specimens identified by Bryant Walker.

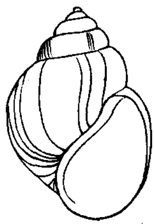


Fig. 34. *Campeloma obesa* Lewis.

Family SPHÆRIIDÆ.

60. SPHÆRIUM VERMONTANUM Prime.

"Shell very oblique, tumid, inequilateral, full; anterior margin abrupt, posterior drawn out to an angle, basal slightly curved; beaks large, full, prominent, placed very much toward the anterior, in which direction they are slightly inclined; sulcations coarse, moderately regular; epidermis light green; ligament conspicuous; valves solid, interior light blue; hinge-margin much curved, broad; cardinal teeth strong, representing the letter V reversed; lateral teeth elongated, strong. Length .56; width, .37; diameter, .25 inches."—*Prime.*

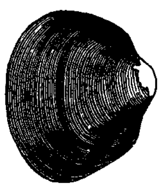


Fig. 35. *Sphærium vermontanum* Prime.

Collected by Baker in Lake Michigan, opposite Millers, Lake County.

61. SPHÆRIUM SIMILE Say. Plate II, Fig. 1.

"Large, inflated, rather solid, almost equilateral, transversely oval; umbones depressed, inflated, placed a trifle anterior to the center of the shell, marked by heavy ridges, but not so coarse as in *stamineum;*

dorsal margin very nearly straight, ventral border broadly curved; anterior and posterior margins almost equal, the posterior a little longer than the anterior, the two margins rounded; umbonal slopes rounded; surface shining, growth lines coarse; color dark brown, sometimes with a reddish tinge; ligament weak, very dark horn or black; cardinal teeth small, a single, long, stout, elevated, arched tooth in the right valve, and two stout, elevated teeth in the left valve, the upper tooth being short and curved and the lower tooth long and almost straight; lateral teeth double in the right and single in the left valve, short, elevated, lamellar, nearly straight; muscle scars and pallial line faintly impressed; nacre bluish; cavity of the beaks shallow. Length, 16.50 mm.; height, 11.75 mm.; breadth, 9 mm.

"The hinge teeth are arranged very peculiarly in this species, the laterals being in a direct line with the cardinals, and not at right angles to them, as in the previous species. It is one of the largest of the genus and distinguished from the related species by its transversely oval outline, its peculiarly placed teeth, and its umbonal marking, which is intermediate between *solidulum* and *stamineum*. The umbones are also placed very near the center of the shell."—*Baker.*

Common in Lake Wawasee, Kosciusko County. Occurs also in Lake Maxinkuckee, and in the Wabash River near New Harmony, Posey County.

62. SPHÆRIUM FABALE Prime. Plate II, Fig. 2.

"Of good size, transversely oval, somewhat compressed, almost equilateral, thin and fragile to quite solid; anterior and posterior margins rounded; ventral margin curved; dorsal margin slightly curved; umbones depressed, almost flush with the hinge line, placed near the center of the shell and quite heavily marked and regular; umbonal slopes gently rounded; surface smooth and shining in young or half grown specimens but dull in old examples; lines of growth typically very coarse and distinct, but finer in some specimens; color light green, yellowish or blackish, the latter a marked character in old specimens; ligament weak, color varying with the shell; cardinal teeth small, those in the left valve unequal, one placed near the dorsal margin and extending from the latter to a point midway between the dorsal and ventral margins of the hinge plate, and one placed near the ventral margin of the hinge plate; the dorsal tooth is nearly straight while the ventral tooth is very arcuate; in the right valve there is a single, large, arched tooth which extends from the center to the ventral border of the hinge plate, it is large at either end and small in the middle; lateral teeth double in the right and single in the left valve, rather small, elevated, pyramidal, slightly curved; hinge line rather solid; muscle scars indistinct; cavity of the beaks shallow; anterior bluish. Length, 11 mm., height, 9 mm.; breadth, 5.50 mm."—*Baker.*

Taken by Baker at Millers, Lake County, of which locality he writes: "This interesting region, at the extreme southern end of Lake Michigan, is said by Professor Garriott to be the most windswept locality in the Chicago area. This fact accounts for the enormous quantity of sea wrack which lines the shore at this point and which is not to be found in such profusion anywhere else along the shore. This sea wrack has proven prolific collecting ground for molluscan life."

Also taken by Daniels opposite Michigan City and in the Wabash River at New Harmony, Posey County.

63. SPHÆRIUM OCCIDENTALE Prime. Plate II, Fig. 3.

"Small, inflated, fragile, equilateral; umbones prominent but not much elevated, inflated, placed centrally, marked by very fine lines; dorsal and ventral margins rounded; anterior and posterior margins rounded; umbonal slopes rounded; surface shining, marked by very fine lines of growth; color light horn, sometimes darker; ligament as usual; cardinal teeth small, a single, elevated, lamellar, curved tooth in the right valve, the posterior curve of which is longer than the anterior and is club shaped, and two teeth in the left valve, that near the ventral border of the hinge plate being elevated and pyramidal, that on the dorsal border being long, lamellar, depressed, and curved, as in the preceding species; lateral teeth short, elevated, curved, single in the left and double in the right valve; muscle scars scarcely discernible; cavity of the beaks shallow; nacre light purplish or bluish. Length, 7.50 mm.; height, 7 mm.; breadth, 4.50 mm.

"This species is distinguished by its oval outline, which is more regular than that of any other Sphærium found in Indiana. It is very common, and when found at all is usually represented by hundreds of individuals."—*Baker.*

Taken by Mr. Daniels in the Kankakee River, at Shelby and Riverside; in Tippecanoe Lake, Kosciusko County, and in the cypress swamps of Knox County.

64. SPHÆRIUM FLAVUM Prime.

"Shell transversely rounded, compressed, equilateral, delicate, margins generally rounded, the posterior a little distended; beaks central, not full, more or less depressed; valves very slight, interior whitish; sulcations pretty deep, regular; epidermis light, of a greenish-yellow color; cardinal teeth small, in the shape of the letter V reversed; lateral teeth elongated. Length, 0.43; height, 0.31; diameter, 0.18 inches.

Fig. 36. *Sphærium flavum* Prime.

"This is a very slight and delicate species, quite distinct from any others."—*Prime.*

Known heretofore from Lake Superior, near Sault Ste. Marie. Taken by Daniels in Lake Wawasee, Kosciusko County, and from the beach of Lake Michigan, near Pine and Millers, Lake County. Identified by Sterki.

65. CALYCULINA TRUNCATA Linsley. Plate II, Fig. 4.

"Very fragile, small, inflated, almost equilateral, rhombic-ovate, translucent; umbones prominent, elevated, full, calyculate, approximating, placed centrally, smooth and shining; dorsal margin straight; ventral margin broadly rounded; anterior margin rounded; posterior margin sharply truncated, rounded on the ventral part; umbonal slopes rounded; surface smooth and shining, lines of growth very fine; color light yellowish green or greenish horn with a zone of yellow bordering the ventral margin of the valve; ligament weak, light horn-color; cardinal teeth small, a single, elevated, lamellar, arched tooth in the right valve, and two teeth in the left valve, the ventral tooth pyramidal, elevated, the dorsal tooth long, lamellar, curved and elevated; lateral teeth long, lamellar, elevated, straight, one in the left valve and two in the right valve; muscle scars scarcely visible; cavity of the beaks shallow; nacre light bluish with a yellow zone on the ventral border. Length, 9.25 mm., height, 7.50 mm., width, 5 mm.

"This species is very like *S. transversa*, but is shorter in comparison with its height, is rhombic in form and the beaks are placed centrally. The two species belong to a natural group of which *transversa* is the leading form."—*Baker.*

Ranges from New England west to Illinois and Wisconsin and south to Kentucky.

Occurs in lakes Wawasee and Tippecanoe, Kosciusko County, and in the cypress swamps of Knox County.

66. CALYCULINA SECURIS Prime. Plate II, Fig. 5.

"Small, fragile, but stouter than the two previous species, inflated, inequilateral, rhombic-orbicular; umbones elevated, full, much inflated, calyculate, approximate, placed a trifle anteriorly; marked by very fine lines of growth; dorsal margin arched; ventral margin rounded; anterior margin rounded, posterior truncated; umbonal slopes rounded, sub-angulate posteriorly; surface shining, lines of growth very faint; color varying from bright yellow to greenish horn, sometimes very dark horn; ligament as usual; cardinal teeth very small, a single, long, elevated, lamellar, arched tooth in the right valve, which has a large pyramidal projection near the anterior end giving the hinge the appearance of a double tooth, and two teeth in the left valve, one near the ventral margin of the hinge plate, elevated, pyramidal, and one near the dorsal border, lamellar, depressed, curved, extending diagonally toward the ventral border; lateral teeth long, lamellar, elevated, slightly curved, one in the left valve and two in the right; muscle scars faint; cavity of the beaks deep; nacre bluish white, darker near the postero-ventral portion, lighter in yellowish specimens. Length, 6 mm.; height, 5 mm.; width, 3 mm.

"A species at once distinguished by its rhombic-orbicular outline and inflated beaks and shell. It is the smallest *Sphærium* found in Indiana, and is wider in proportion to its length than any other species."—*Baker.*

Range same as preceding. Common in Grassy Creek and in Lake Wawasee, Kosciusko County.

67. CALYCULINA ROSACEA Prime.

"Shell small, rounded-oval, fragile, translucent, subequilateral, somewhat compressed, margins generally rounded; beaks nearly central, slightly inclined toward the interior, calyculate, approximate at apex; valves very slight, a little convex in the region of the umbones; striæ regular, hardly visible; epidermis shiny, reddish-brown; hinge-margin nearly straight, delicate, narrow; cardinal teeth nearly obsolete, lateral teeth slight, elongated. Length, .25; width, .18; diameter, .15 inches."—*Prime.*

Fig. 37. *Calyculina rosacea* Prime.

Common in Grassy Creek. A few specimens were also secured in Lake Wawasee.

68. PISIDIUM COMPRESSUM Prime.

"Shell solid, very oblique, trigonal, triangular, subequilateral, very much drawn up in the region of the beaks, inflated in adult; anterior side a little longer, narrower, produced at the end, posterior broader, sub-truncate; beaks placed a little posteriorly, small, raised, with a wing-shaped appendage on the summits, distant; striæ distinct, regular; epidermis very variable, yellow, gray or chestnut color; valves solid, varying in inflation, interior light blue; hinge thick; cardinal teeth small, robust, compressed, disposed in the shape of the letter V reversed; lateral teeth distinct, short, strong, placed at an obtuse angle with the hinge proper. Length, .16; width, .14; diameter, .09 inches."—*Prime.*

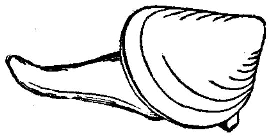


Fig. 38. *Pisidium compressum* Prime.

Ranges across the continent. Occurs in Lake Wawasee and Grassy Creek, Kosciusko County; Bass Lake, Starke County, and Lake Maxinkuckee, Marshall County, from all of which localities it has been collected by Daniels.

69. PISIDIUM OBTUSALE (Lam.?) C. Pfr.

"Mussel roundish-oval, very much inflated, under the lens extremely finely striate, near the inferior margin with a few deeper striæ and generally with strong lines of "year-growth," with a strong shell, shining, yellowish to grayish horn-colored; superior and inferior margins rather strongly curved, but each one perceptibly less curved toward the anterior; posterior margin strongly curved, anterior part not much longer, little attenuated, broadly rounded, outlines without any angles; beaks broad, prominent, near the middle of the mussel; the valves join at a right or somewhat obtuse angle at the inferior margin; hinge plate narrow, left valve with the exterior cardinal tooth very short, fine, covering half of the inner one, lateral teeth approximate to the cardinals; right valve with the cardinal tooth little curved, thickened posteriorly; animal with syphon depressed-conical, wide at the base, anteriorly* narrow, truncate. Longitude, 3.5; altitude, 2.5; diameter, 2.3 mm. Europe, north of the Alps. (*P. obtusale* is rather variable in size).—*Westerland.* (Translated.)

The present Indiana specimens measure: Longitude, 3.5 to 3.7; altitude, 3.2; diameter, 2.5 to 2.7 mm."—*Sterki.*

Taken in numbers in a spring near Lake James, Steuben County.

* Evidently means "posteriorly."

70. PISIDIUM NOV-EBORACENSE Prime.

"Shell rounded-oval, very inequilateral, inflated, margins rounded; anterior side considerably produced, narrower; beaks situated posteriorly, large, full, prominent; valves comparatively slight, interior light blue; striæ irregular; epidermis variable, generally greenish-yellow or brown; hinge-margin a little curved; hinge slight, narrow; cardinal teeth double, very small; lateral teeth elongated. Length, .35; width, .18; diameter, .13 inches. —*Prime.*

Fig. 39. *Pisidium nov-eboracense* Prime.

Collected in Lake Wawasee, Grassy Creek and Bass Lake, by Mr. Daniels. This and other species of Pisidium and Sphærium identified by Sterki.

71. PISIDIUM VARIABILE Prime. Plate II, Fig. 6 (enlarged).

"Small, solid, inflated, inequilateral, oblique; umbones very much elevated; full, very prominent, placed posteriorly, smooth and polished to the naked eye but marked by fine lines when viewed with a lens; all margins rounded, the anterior being somewhat pointed or triangular and quite long, while the posterior is short and very broadly rounded; umbonal slopes rounded, the anterior subexcavated; surface shining, marked by rather heavy, regular growth lines; color varying from light yellow or straw to greenish or brownish, with a zone of light or dark color near the ventral margin; in some specimens two zones are present, while in others the zone is hardly visible; ligament small and weak; cardinal teeth small, a single long, arched tooth in the right valve, and two more or less pyramidal teeth in the left valve; the right valve tooth is constricted in the center of the arch and gradually enlarges toward the distal end of the arch, the right arm of arch being the longer and reaching nearly to the base of the hinge plate; the upper left valve tooth is somewhat gourd-shaped, beginning small at the upper margin of the hinge plate and gradually enlarging to about the center of the plate; the lower left valve tooth is large, solid and pyramidal; lateral teeth elevated above the valve edge, triangular; the entire hinge plate about the lateral teeth is enlarged, thick and heavy; cavity of the beaks deep and full; nacre bluish-white, shining. Length, 4.50 mm.; height, 4.50 mm.; breadth, 3.10 mm."—*Baker.*

With the last two species in the lakes and streams mentioned.

72. PISIDIUM POLITUM Sterki.

"Mussel of medium size, well inflated, rather high, beaks slightly posterior, rather high and prominent, not full but well rounded; scutum and scutellum slightly marked. Superior margin rather short, rather strongly curved; inferior well curved, more so in front than behind; posterior margin distinctly truncated, with a well marked angle where joining the superior, and a less marked, rounded angle where joining the inferior margin; anterior end forming a slight but distinct angle situated rather high up. Surface very finely, irregularly striated, polished; whitish or straw colored, often leaden-grayish on the beaks, or even all over. Shell moderately thick, nacre whitish; muscular insertions not very distinct; hinge of essentially the same type as that in *Pis. abditum.* Length, 4.7 mm., height, 4 mm., diameter, 2.9 mm."—*Sterki.*

Fig. 40. *Pisidium politum* Sterki.

Recorded from Ohio, Pennsylvania, Michigan, Minnesota and Illinois. Taken in numbers in Grassy Creek, Kosciusko County, by Daniels.

73. Pisidium vesiculare Sterki.

"Mussel small, ovoid, very inequipartite, somewhat oblique, strongly inflated; beaks very posterior, moderately prominent; margins all well rounded, or the scutum forming a very slight angular projection; color yellowish to brownish horn; surface slightly striated, polished, often with a few coarser lines of growth; shell thin, translucent; nacre rather glassy, colorless; hinge rather small, markedly short; cardinal teeth lamellar, the right moderately curved with its anterior end thicker; anterior left distinctly directed upward, curved, often angular; posterior, oblique, moderately curved; groove between them narrow and deep; lateral teeth situated very close to the cardinals, short, especially those in the left valve abrupt, high; ligament short. Length, 2.3 mm.; height, 1.9 mm.; diameter, 1.7 mm." —*Sterki.*

One specimen taken from the stomach of a catfish (*Ameiurus nebulosus* Raf.) from Bass Lake, Starke County.

74. Pisidium pauperculum Sterki.

"Mussel of moderate size, rather oblique, moderately to rather strongly inflated; beaks slightly posterior, moderately large and prominent, rounded; scutum and scutellum slightly marked; edges acute or acutish, not pinched; superior and inferior margins moderately curved, posterior well rounded or slightly truncated, joining the inferior without any marked angle; antero-superior margin sloping, oblique, slightly curved, meeting the inferior at an angle situated rather inferior, more distant in the adult than in younger examples; surface very finely striated, polished; color pale or yellowish to greenish-horn, sometimes whitish or straw in old specimens; shell thin, translucent; hinge moderately strong; cardinal teeth of the right valve moderately curved, its posterior end thickened, those of the right valve lamellar, almost equal, the superior rather short, slightly oblique and little curved; lateral teeth rather strong; ligament short, thin. Length, 3.2 mm.; height, 2.7 mm.; diameter, 1.9 mm."—*Sterki.*

A common species east of the Mississippi River. Occurs in numbers in Lakes Wawasee and Maxinkuckee.

75. PISIDIUM SCUTELLATUM Sterki.

"Mussel of medium size, rather high, oblique, markedly protracted downward in its anterior part, well rounded, rather strongly inflated; beaks much posterior, rather large, prominent, rounded; superior margin short, little curved, or almost straight, scutum and scutellum well marked, forming projecting angles; the other margins well curved, or the posterior very slightly truncated, anterior end well rounded, or with a slight indication of an angle; surface polished, with irregular striæ and some coarse lines of growth; shell thin, transparent, of a yellowish-horn to amber color, often grayish or brownish-horn in old specimens, and whitish on the beaks; nacre glassy, inner surface microscopically rugulose; hinge fine, short, cardinal teeth lamellar, the one in the right valve moderately curved, its posterior end thicker; the inferior in the left valve curved, the superior little so or almost straight; lateral teeth very short, very abrupt, pointed, thin, little projecting into the cavity of the mussel; ligament small. Length, 4 mm.; height, 3.6 mm., diameter, 2.8 mm."—*Sterki.*

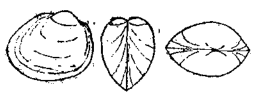


Fig. 41. *Pisidium scutellatum* Sterki.

Recorded heretofore from Michigan, Minnesota and Montana. Taken by Daniels in Lost Lake, Marshall County.

76. PISIDIUM SPLENDIDULUM Sterki.

"Mussel small, well inflated, rather ovoid in outline, scutum and scutellum rather well marked, the former often prominent; beaks slightly posterior, somewhat prominent, moderately large, rounded; color pale to deep horn, surface polished, with very fine, somewhat irregular striæ; shell thin, transparent; hinge rather fine but well formed, plate narrow; cardinal teeth longitudinal, lamellar, the right one rather long, slightly curved, most so at both ends, more or less thickened at the posterior end, and often with a groove; the two in the valve nearly

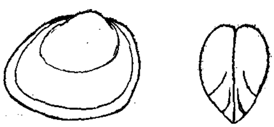


Fig. 42. *Pisidium splendidulum* Sterki.

equal, parallel, little curved, the superior is anterior for about one-third of its length; lateral teeth comparatively strong, all projecting into the interior of the mussel, pointed; ligament rather long. Length, 2.8 mm.; height, 2.4 mm., diameter, 1.7 mm."—*Sterki.*

Common in Grassy Creek and Lake Wawasee, Kosciusko County; also taken from the stomach of a catfish captured in Bass Lake, Starke County.

77. PISIDIUM ROPERI Sterki.

"Mussel rather large, strongly inflated when mature, very little so when young; oblong to ovoid in outline, margins regularly curved, with no projecting angles (in the adult); scutum and scutellum scarcely marked; beaks moderately posterior, very broad, surface somewhat glossy, with irregular, not sharp, striæ and some strongly marked lines of growth; color of the dry shell straw to yellowish-horn, often with one to several fine, concentric lines of purple; shell rather thin, nacre whitish, muscle insertions scarcely marked, hinge comparatively fine and short; cardinal teeth quite small, the right one moderately curved, slightly thickened at the posterior end; the left ones very short; the inferior slightly angular, truncated or pointed on top, the superior sometimes almost obsolete; lateral teeth short, small, scarcely projecting into the interior; ligament rather fine. Length, 5.5 mm., height, 4.4 mm., diameter, 3.8 mm."—*Sterki.*

Ranges from Maine to California. Taken in Grassy Creek and Tippecanoe Lake, Kosciusko County; also recorded from Danville, Indiana, by Sterki.

78. PISIDIUM MEDIANUM Sterki.

"Mussel of rather small size, elliptical in outline, much inflated, often of somewhat irregular growth; superior and inferior margins moderately curved, posterior well rounded, or with a slight angle above, anterior rounded or slightly truncated obliquely; beaks rather in the middle, slightly directed toward the posterior, rather high, prominent over the hinge margin; scutum and scutellum very slightly marked; surface with very fine, crowded striæ, somewhat shining, light horn to yellowish or straw colored; shell thin, nacre colorless, muscle insertions barely perceptible; hinge fine, plate narrow; cardinal teeth lamellar, slightly curved, the right one in its posterior part somewhat thicker, simple or with a fine, longitudinal groove; lateral teeth pointed, the outer ones of the right valve comparatively large; ligament fine. Length, 3.5 mm.; height, 2.8 mm., diameter, 2.3 mm."—*Sterki.*

Common in Michigan and Wisconsin. A number were taken from the stomachs of catfish caught in Bass Lake, Starke County.

79. **Pisidium tenuissimum** Sterki.

"Rather small, little to strongly oblique, moderately to rather well inflated, with the edges usually acutish, elongated or rather short, rhomboid to oblong-ovoid in outline; hinge margin little inferior, moderately curved, posterior end rounded or sub-truncate obliquely in a postero-anterior direction with a rounded angle above; anterior more or less curved, truncate obliquely with the rounded-angular end inferiorly, or the whole anterior part rather regularly parabolic, with the end in the longitudinal median line; beaks slightly posterior, somewhat broad, moderately elevated over the hinge line, somewhat mammillar; surface very finely, almost regularly striated, highly polished; color horn to smoky, or to greenish, or to light grayish; shell very thin, translucent; hinge very fine, plate very narrow, cardinal teeth very small, short, thin, scarcely or slightly curved; those of the left valve very close together, longitudinal-parallel, the upper little posterior; lateral teeth rather long, markedly straight, slender, thin, with short cusps; also the outer ones in the right valve quite distinct; ligament fine. Length, 3.4 mm.; height, 2.8 mm.; diameter, 2.1 mm."—*Sterki.*

Recorded heretofore from a number of lakes in Michigan. Taken by Daniels at Bass Lake and Lake Maxinkuckee.

80. **Pisidium affine** Sterki.

"Rather large, well-inflated, slightly oblique, beaks somewhat posterior, large and prominent in full-grown, broad and quite low in young specimens, rounded or slightly flattened on top; superior and inferior margins moderately curved; posterior sub-truncate, with slightly marked angles above and below; supero-anterior forming one regular curve from the beaks to the anterior end, which is low situated and well-rounded; surface distinctly and somewhat irregularly striated, with some coarser lines of growth, dull or somewhat shining; color lighter or darker grayish horn to plumbeous or brownish with a few irregular darker zones corresponding with the lines of growth, and often with fine darker mottlings, usually with a broad lighter zone along the margins; the young are pale horn or straw colored; shell moderately thick, nacre whitish, muscle insertions little; hinge rather stout, plate rather broad; cardinal teeth long, not very strong, the right one curved, its free edge often indented in the middle, its posterior end somewhat thicker, with a fine groove, the left anterior tooth curved, the posterior slightly so, oblique, rather behind the anterior, each covering the other for half their lengths; lateral teeth stout, rather long, their cusps short and somewhat pointed, the outer ones on the right valve of good size; ligament rather long and stout. Length, 6 mm.; height, 5 mm., diameter, 4 mm."—*Sterki.*

New York to Michigan and Minnesota. Common in Lake Wawasee, Kosciusko County.

81. PISIDIUM SARGENTI Sterki.

"Mussel of medium size, somewhat oblique, well inflated; beaks not much posterior, rounded or slightly flattened on top, well prominent over the hinge margin; the latter slightly curved in the adult, almost straight in the young and half-grown, with projecting, not or hardly rounded angles at the scutum and scutellum, which are slightly to well marked, narrow; posterior margin sub-truncate above, passing into the well rounded inferior with an uninterrupted curve, or with a slightly marked, rounded angle, more so in the young; supero-anterior margin little to moderately curved, sloping from the projecting angle at the scutellum to the rounded anterior end; surface regularly and rather coarsely striated, dull, rarely somewhat shining in older specimens; epiconch thin and often worn off, pale horn-colored in the young, lighter to darker grayish to brownish in older specimens, usually with a lighter zone along the margins; shell moderately thick, nacre glassy, colorless to white or bluish, muscle insertions distinct; hinge stout, plate rather broad, cardinal teeth well formed, short, the right one rather strongly curved, its posterior end thickened and grooved; the left anterior angular, stout, the posterior small, oblique; lateral teeth rather short, stout, their cusps short, pointed, the outer ones in the right valve well formed; ligament short, strong. Length, 5 mm.; height, 4.4 mm.; diameter, 3.4 mm.

"New York to Ohio, Michigan, Illinois and Minnesota, rather common in creeks, rivers and small lakes."—*Sterki.*

Taken from the stomachs of catfish captured in Bass Lake.

82. PISIDIUM STRENGI Sterki.

"Mussel of moderate size, regularly inflated, rather short; beaks slightly posterior, small, narrow, approximate, somewhat projecting over the hinge margin; superior and inferior margins well curved, the supero-anterior slightly so and forming a steep slope to the somewhat angled anterior end; the posterior end sub-truncate; scutum and scutellum indistinct; angles in front of and behind the beaks slight, rounded; shell rather thin, translucent; surface very finely striate, appearing smooth, with a few fine, irregular lines of growth, and with a slight, dull gloss; color of epiconch pale horn shading into grayish, whitish or yellowish; nacre almost glassy, muscle scars very slight; hinge fine, plate narrow; cardinal teeth small, thin; the right one curved, its posterior end deeply cleft, the left anterior curved or almost straight, the posterior short, oblique; lateral teeth small, somewhat pointed, the outer ones of the right valve quite small but distinct; ligament small. Length, 4 mm.; height, 3.7 mm.; diameter, 2.6 mm."—*Sterki.*

Ranges from Michigan to New York, Ohio and Indiana, a number of the type specimens having been taken by Daniels from the stomachs of catfish caught in Bass Lake, Starke County.

Family UNIONIDÆ.

83. TRUNCILLA SAMPSONII (Lea).

"Shell smooth, oblique, inflated, very much swollen at the umbones, emarginate behind, round before, very inequilateral; valves thick, slightly thicker before; beaks prominent, swollen, incurved, slightly undulate at the tips; epidermis yellowish, covered with green rays; cardinal teeth rather large, erect and corrugate; lateral teeth thick, short, corrugate and nearly straight; nacre silver white and slightly iridescent."—*Lea.*

Call regarded this species as a variety of *perplexus;* but Simpson, in his "Synopsis of the Naiades," lists it as distinct. Specimens are in the State Museum labeled "Wabash River," and Daniels has taken it in that river at Grand Chain, Posey County.

84. LAMPSILUS OVATUS Say.

"Shell subovate, convex, not remarkably thick, horn-color, not radiated; flattened and fuscous on the anterior margin; beaks decorticated, placed nearer central; umbo prominent; within parlaceous; cavity of the beaks capacious; primary teeth very oblique, almost parallel to the posterior margin and much compressed. Length, three inches; breadth, four inches."—*Say.*

Specimens in the State Museum marked "Ohio River" were probably taken by Dr. Stein in that stream, near Mt. Vernon, Posey County. Say mentioned it as "inhabiting the Ohio River and its tributary streams."

85. LAMPSILIS FALLACIOSUS Smith. Plate II, Fig. 7.

"Shell elongate elliptical, subsolid, inflated, rounded in front, and ending in a rather sharp point behind, at two-thirds of the height of the shell, with a moderate, rounded posterior ridge; beaks not prominent, their sculpture consisting of a few delicate parallel ridges, somewhat doubly looped, the hinder loops generally open behind; epidermis very smooth and shining, ashy straw color, often brownish on the back of the shell, generally feebly rayed with green; female shell decidedly swollen in the postbasal region, so that the base line is often incurved in front of the swelling; teeth rather delicate, there being one compressed pseudo-cardinal and one lateral in the right valve, and two pseudo-cardinals and two laterals in the left; beak cavities not deep; nacre brilliant, silvery. Length, 90 mm.; height, 40 mm.; diameter, 32 mm.

"This species has generally been confounded with its near ally, *Lampsilis anodontoides* Lea. It is smaller, more inflated, and in every way a more delicate form than the latter; it is not so high, the epidermis is brighter and more glossy, and generally rayed. The postbasal inflation of the female is usually more pronounced, and the posterior point is higher than in *anodontoides*. The latter is usually more yellow or tawny than *fallaciosus*, and is, on the whole, a heavier shell."—*Simpson*.

Occurs in the upper Mississippi drainage; south to the Cumberland and Arkansas rivers. In Indiana it has been taken by Daniels only in the Tippecanoe River, Carroll County. Specimens in the State Museum are marked "Wabash River, Indiana."

86. Lampsilis lienosus Conrad.

"Shell elliptical, inflated, slightly furrowed or contracted from beak to base; substance of the shell thickened toward the base; posterior dorsal and posterior basal margin rounded, extremity sub-angulated; beaks pointed, approximate, slightly prominent, with interrupted undulations; concentric lines prominent; epidermis dark olive, obscurely rayed, wrinkled on the margins; cardinal teeth double in both valves, slightly compressed, oblique, striated; nacre varying from bluish white to deep salmon or purple; cavity most capacious under the umbonal slope. The color of the interior is remarkably inconstant, but a purple approaching to salmon is the most prevailing tint, and the margin is bluish-white."—*Conrad*.

Measurements of Indiana specimens: Length of male, 55 mm., female, 46 mm.; height, male, 31 mm., female, 26 mm.; diameter, male, 19 mm., female, 18 mm.

Common in the canal and White River at Indianapolis. Dr. Stein probably had this species in mind when he listed *U. nasutus* Say from the same locality, as the latter species occurs only in the St. Lawrence Drainage. *Lienosus* is a southern species, Marion County being the most northern point from which it has been recorded.

87. LAMPSILIS NIGERRIMUS Lea.

"Shell smooth, elliptical, rather convex, inequilateral, rounded behind; substance of the shell rather thin; beaks small, slightly prominent, undulated at the tip; ligament rather long and thin; epidermis shining, black, striate, in the young radiate all over the disk; marks of growth rather distant; posterior slope compressed into a small carina; umbonal slope slightly raised and rounded; cardinal teeth rather large, somewhat compressed, oblique, acuminate, crenulate and double in both valves; lateral teeth long, lamellar, somewhat curved and separated from the cardinal tooth; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed near the edge of the plate and on the cardinal tooth; cavity of the shell rather shallow; cavity of the beaks shallow and subrotund; nacre white and very iridescent. Length, 1.3; height, 2.2; diameter, .7 inches.

"All the adults, male and female, of which I have many specimens, are very black and apparently without rays, but when held up to a strong light, delicate obscure rays may be observed, particularly about the umbonal slope. In the individuals of one-third growth and less, the epidermis is dark-green and covered with rays. The female differs much in outline from the male, and is much inflated on that portion of the disk which tends to the posterior basal margin. This enlargement makes that margin obliquely truncate."—*Lea.*

A southern form, whose range is recorded as "Alexandria, Louisiana to Eastern Texas." Listed by Stein from the White River. Taken by Daniels in that stream, near Rockford, Jackson County, where it is common. Identified by Simpson.

88. LAMPSILIS BLATCHLEYI Daniels*. Plate III.

"Shell long, elliptical or obovate, compressed, thin, inequilateral, slightly gaping behind; beaks low, but little inflated, pointed, with minute nodulous sculpture; dorsal and basal outlines lightly curved; anterior end somewhat narrowed, rounded; posterior end rounded and lightly and obliquely subtruncate above; surface with singular growth lines; epidermis somewhat concentrically wrinkled, projecting beyond the border of the shell, yellow green with faint green rays; pseudo-cardinals rudimentary, smooth, subcompressed; laterals straight, single in the right valve, partly double in the left; nacre brilliant, iridescent, having a somewhat coppery lustre in the cavities, becoming very thin and greenish at the edges. Length, 45 mm., height, 21 mm., diameter, 10 mm. Length, 40 mm., height, 17 mm., diameter, 8.5 mm."—*Daniels.*

* Nautilus, XVI, 1902, p. 13.

Wabash River, Section 32, Linn Township, Posey County, Indiana. Found only on gravel bars in swiftly running water. Fourteen specimens were collected in August, 1901. (For exact locality, see map. page 583.)

Five or six additional specimens were taken at the same place in August, 1902, the largest of which had the following dimensions: Length, 56 mm., height, 25 mm., diameter, 14 mm.

89. ANODONTA CORPULENTA Cooper.

"Shell large, inflated, thin to rather solid, slightly inequilateral, subrhomboid, rounded in front and on the base; hinge line slightly curved; dorsal wing somewhat prominent in young shells, ending in an angle behind at the obliquely truncate dorsal slope; posterior ridge rather low; umbonal region very full; beaks with coarse folds which are somewhat doubly looped; surface sub-shining, with strong, irregular growth lines, olive or greenish olive, sometimes having lighter or darker bands; dorsal slope usually having two or three faint dark rays; nacre bluish or reddish. Length, 170 mm.; height, 115 mm.; diameter, 70 mm. Length, 158 mm., height, 116 mm.; diameter, 66 mm.

"Generally less elongated and having the umbonal region more inflated than the varieties of *A. grandis*, and as a rule it is more rhomboid in outline. It is very close to *A. stewartiana*, but the latter is usually more elongated, is darker colored, and is normally covered with a somewhat dusky epidermis."—*Simpson MS.*

Range.—Missouri River; Upper Mississippi River Drainage, east to Indiana. Common in Clear Lake, Laporte County. Identified by Simpson.

90. ANODONTA KENNICOTTI Lea.

"Shell smooth, elliptical, somewhat inflated, inequilateral, obtusely angular behind and round before; substance of the shell rather thin; beaks prominent, pointed and granular at the tips; ligament long, thin and dark brown; epidermis varying from pale yellow to dark brown, without rays, with eight or ten rather close lines of growth; umbonal slope raised and rounded; posterior slope rather narrow, elliptical, slightly carinate, with two indistinct lines in each valve from the tips to the margin; anterior cicatrices confluent and very slightly impressed; posterior cicatrices confluent, large and scarcely perceptible, dorsal cicatrices placed over the center of the cavity of the beaks; cavity of the shell rather deep and wide; cavity of the beaks shallow and very obtusely angular, nacre bluish white and iridescent. Length, 1.2; height, 1.9; diameter, .7 inches. —*Lea.*

A northern species whose range, according to Simpson, is the "Upper and Middle St. Lawrence System; northwest into the McKenzie Drainage." Taken by Daniels in Lake Wawasee, Kosciusko County, where it occurs in marly deposits in shallow water.

91. Quadrula pyramidata Lea.

"Shell sub-pyramidal, longitudinal, inequilateral, anterior part swollen recurvely from the beaks to the basal margin, compressed at posterior margin, slightly depressed anterior to umbonal slope; substance of the shell very thick in the region of the teeth and beaks, thin at posterior margin; beaks very much elevated, recurved and incurved; epidermis very dark brown and finely wrinkled; cardinal teeth large, crenate and deeply impressed in the left valve, single and emerging from a pit in the right; lateral teeth long, slightly curved, distinct from the cardinal teeth and pointing toward the basal margin; anterior cicatrices distinct, the great one forming a deep pit; posterior cicatrices distinct, the smaller one being placed at the end of the lateral tooth; dorsal cicatrices situated on the under part of the cardinal tooth; cavity of the beaks deep and angulated; nacre beautifully flesh-colored, very rarely white. Length, 2.3; height, 2.1; diameter, 1.7 inches."—*Lea.*

Ohio, Cumberland and Tennessee River Systems. Taken by Daniels in the Wabash at Terre Haute and Lafayette, and in the Tippecanoe River, in Carroll County.

92. Quadrula subrotunda Lea.

"Shell suborbicular, nearly equilateral, subventricose; substance of the shell thick, somewhat thinner behind; beaks thick and elevated; ligament rather short and thick; epidermis yellow and smooth in the region of the beaks; brown and finely wrinkled towards the margin; interrupted rays pass from the beaks and are very visible over the umbones, but are lost in the wrinkles before they reach the margin; cardinal teeth thick and crenate; lateral teeth short, thick and very slightly curved; posterior and anterior cicatrices both distinct; dorsal cicatrices situated on the under side of the cardinal teeth; cavity of the beaks deep and angulated; nacre pearly white and iridescent. Length, 1.6; height, 1.6; diameter, 1.1 inches.

"This is perfectly distinct from any described species and seems peculiar in its yellow beaks and brown margin; as well as in the beautiful interrupted rays which pass over the umbones, leaving the anterior and posterior slopes usually of a yellow color. In form it approaches *U. ebenus*."—*Lea*.

Ohio, Cumberland and Tennessee River Systems; west to Arkansas and north to Wisconsin. Occurs plentifully at many different stations in the Wabash River and also in the Tippecanoe.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Polygyra monodon fraterna* Say.
2. *Polygyra monodon* Rackett.
3. *Bifidaria procera* Gould.
4. *Vitrea hammonis* (Strom.)
5. *Vitrea indentata* Say.
6. *Zonitoides nitidus* (Muller).
7. *Zonitoides minusculus* Binney.
8. *Punctum pygmæum* Drap.
9. *Carychium exile* H. C. Lea (enlarged).
10. *Limnæa stagnalis appressa* Say.
11. *Limnæa reflexa kirtlandiana* Lea.
12. *Limnæa palustris michiganensis* Walker.
13. *Limnæa caperata umbilicata* Adams.
14. *Limnæa catascopium* Say.
15. *Limnæa columella* Say.
16. *Limnæa woodruffi* Baker.
17. *Physa sayi* Tappan.
18. *Physa gyrina elliptica* Lea.
19. *Physa integra* Haldeman.
20. *Bythinia tentaculata* L.
21. *Valvata sincera* Say.

PLATE II.

Fig. 1. *Sphærium simile* Say.
2. *Sphærium fabale* Prime.
3. *Sphærium occidentale* Prime.
4. *Calcyculina truncata* Linsley.
5. *Calcyculina securis* Prime.
6. *Pisidium variabile* Prime (enlarged).
7. *Lampsilis fallaciosus* (Smith).

PLATE III.

Lampsilis blatchleyi Daniels.

PLATE I.

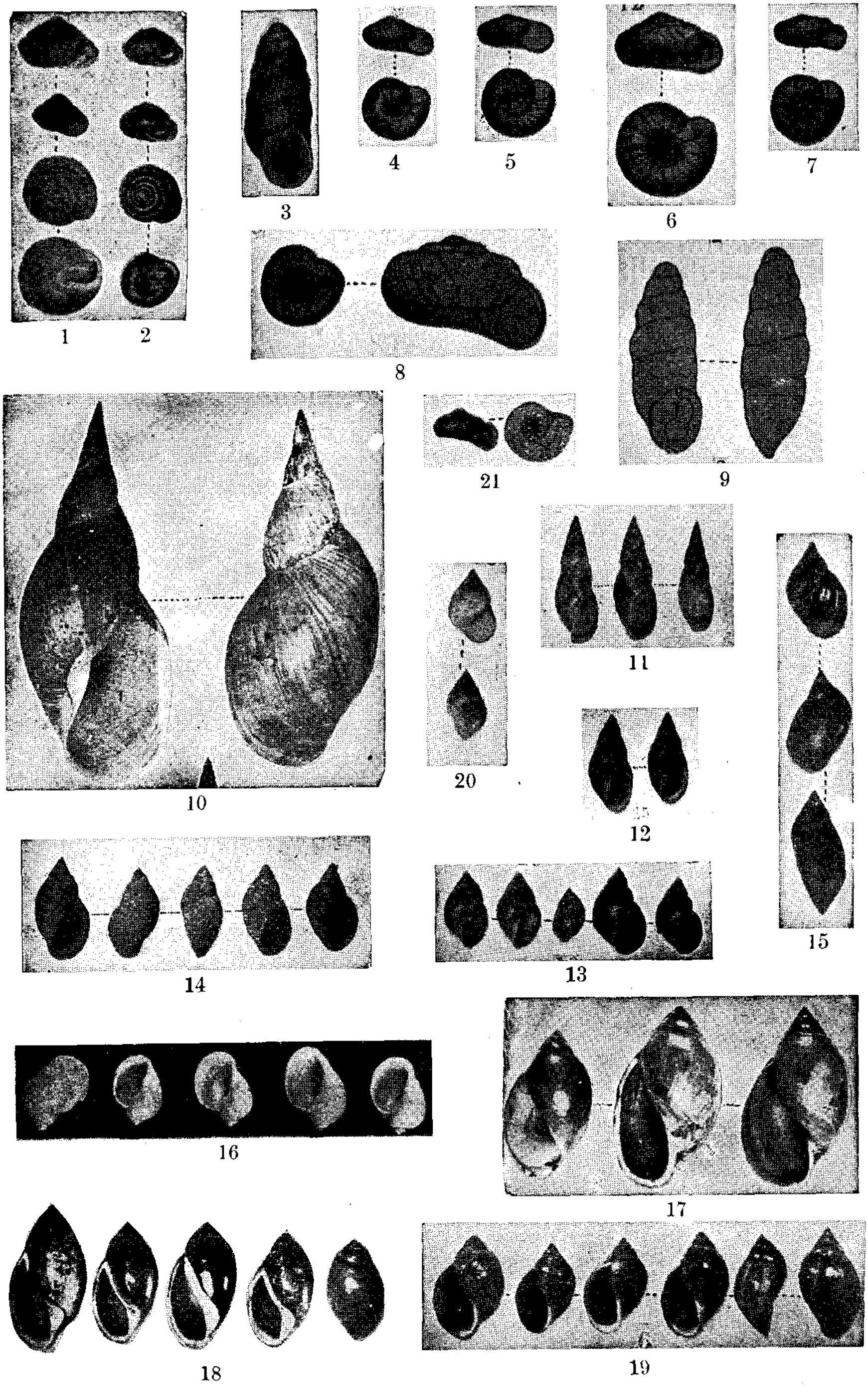
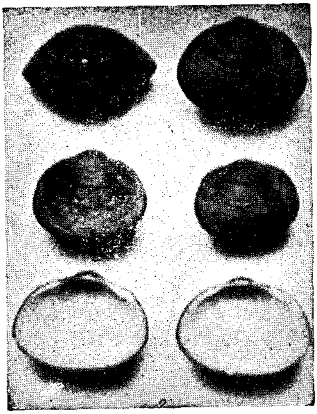
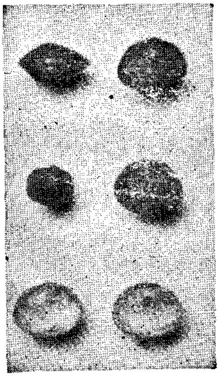


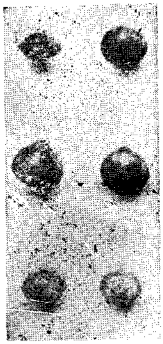
PLATE II.

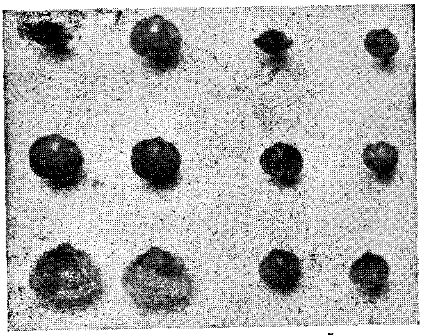


I

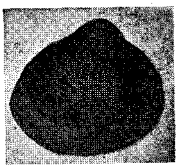


2





4 5



6

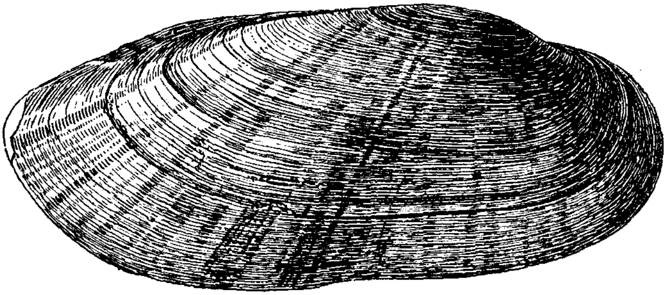
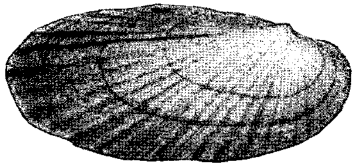
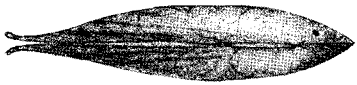
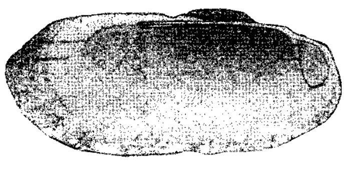


Fig. 7. *Lampsilis fallaciosus* (Smith).

Plate III.







Lampsilis blatchleyi Daniels.

A CHECK LIST OF INDIANA MOLLUSCA, WITH LOCALITIES.

BY L. E. DANIELS.

The following is a list of the Mollusca with localities which were known to occur in Indiana on January 1, 1903, 276 species in all. The nomenclature of the land shells is that of Pilsbry's catalogue, mentioned in the introduction to the preceding paper. That of the Unionidæ is Simpson's "Synopsis of the Naiades, or Pearly Fresh Water Mussels," published in Vol. XXII of the Proceedings of the U. S. National Museum. Where the name used in Call's "Catalogue of the Mollusca of Indiana" differs from that of the present list, Call's name follows in italics and in parenthesis. Representatives of all but a half dozen of the species are in the State Museum.

Family HELICIDÆ.

Sub-family HELICINÆ.

1. VALLONIA PULCHELLA (Mull.).

   Indianapolis, Mitchell and Arlington; common in southeastern Indiana.

2. VALLONIA COSTATA (Mull.).

   Arlington, Marshall County.

Sub-family POLYGYRINÆ.

3. POLYGYRA LEPORINA (Gld.).

   New Harmony, Posey County; North Vernon, Jennings County; Dunreith, Henry County (Pleas.); Gibson County (Stein).

4. POLYGYRA PLICATA Say.

   Clarksville, Floyd County.

5. POLYGYRA TRIDENTATA (Say). (*Triodopsis tridentata* Say).

   Found all over the State.

6. Polygyra fraudulenta Pils. (*Triodopsis fallax* Say).

Not *Polygyra fallax* (Say), which is an eastern species, according to Pilsbry.

Mt. Vernon, Lafayette, Laporte and Indianapolis.

7. Polygyra inflecta Say. (*Triodopsis inflecta* Say).

Abundant in nearly all parts of the State.

8. Polygyra profunda (Say). (*Mesodon profundus* Say).

Indianapolis, Corydon, Lawrenceburg, Brookville, Lower Wabash Valley.

9. Polygyra albolabris (Say.) (*Mesodon albolabris* Say).

All over the State.

10. Polygyra exoleta (Binn). (*Mesodon exoletus* Binn.)

Common over the southern two-thirds of the State.

11. Polygyra multilineata (Say). (*Mesodon multilineatus* Say).

All over the State in suitable localities.

12. Polygyra palliata (Say). (*Triodopsis palliata* Say).

All over the State.

13. Polygyra obstricta (Say). (*Triodopsis obstricta* Say).

Grand Chain and New Harmony, Posey County.

14. Polygyra appressa (Say). (*Triodopsis appressa* Say).

New Harmony, Mt. Vernon, Lawrenceburg, Cannelton and Wyandotte.

15. Polygyra elevata (Say). (*Mesodon elevatus* Say).

All over the State.

16. Polygyra pennsylvanica (Green). (*Mesodon pennsylvanicus* Green).

Brookville, Lafayette and Brookston.

17. Polygyra thyroides (Say). (*Mesodon thyroideus* Say).

All over the State.

18. Polygyra clausa (Say). (*Mesodon clausus* Say).

Brookville, Lafayette, De Long. Over nearly all of the State.

19. Polygyra mitchelliana (Lea). (*Mesodon mitchellianus* Lea).

Brookville.

20. Polygyra stenotrema (Fer.). (*Stenotrema stenotremum* Fer.).

Madison, Lawrenceburg; common at Wyandotte.

21. POLYGYRA HIRSUTA (Say). (*Stenotrema hirsutum* Say).

All over the State.

22. POLYGYRA MONODON (Fack.). (*Stenotrema leaii* Ward).

Arlington, Marshall County; Pine and Hammond, Lake County; Rochester; near the lakes in Kosciusko and Steuben counties.

22a. P. MONODON FRATERNA (Say). (*Stenotrema monodon* Rack.).

All over the State.

Family PUPIDÆ.

23. STROBILOPS LABYRINTHICA (Say). (*Strobila labyrinthica* Say).

Brookville, North Vernon, Princeton, Huntingburg, Cannelton; New Harmony, Posey County; cypress swamps, Knox County.

24. STROBILOPS VIRGO (Pils.).

Cannelton, New Harmony, Arlington, Princeton and Wyandotte.

25. STROBILOPS AFFINIS Pils.

Lawrenceburg, Mitchell, Wyandotte; New Harmony, Posey County; Cannelton, Perry County; Huntingburg; near Lake James, Steuben County, and Tippecanoe Lake, Kosciusko County.

26. PUPOIDES MARGINATUS (Say). (*Leucochila fallax* Say).

Brookville, North Vernon, Mitchell, New Harmony, Arlington and Pine. Dunreith (Pleas).

27. BIFIDARIA ARMIFERA Say. (*Leucochila armifera Say*).

Brookville, Lawrenceburg, Mitchell, New Harmony, Arlington, Seymour and Indianapolis.

28. BIFIDARIA CONTRACTA Say. (*Leucochila contracta* Say).

Vawter Park, Arlington, Brookville, Huntingburg, Indianapolis, North Vernon, Seymour, Mitchell and New Harmony.

29. BIFIDARIA PROCERA Gld.

Mitchell, Connersville (Walker).

30. BIFDARIA CORTICARIA (Say). (*Leucochila corticaria* Say).

Grand Chain, New Harmony; Morgan County. Dunreith (Pleas).

31. BIFIDARIA HOLZINGERI Sterki.

Dunreith (Sterki).

32. BIFIDARIA CURVIDENS Gld.

Wolf Lake, Lake County (Baker); Henry County and Connersville (Sterki). Dunreith (Pleas).

33. BIFIDARIA PENTODON Say. (*Pupilla pentodon* Say).

Tippecanoe and Turkey lakes, Kosciusko County, New Harmony, Mitchell, Arlington, Seymour. Dunreith (Pleas).

34. VERTIGO MILIUM Gld.

Lake James, Steuben County; Vawter Park, Brookville and Lawrenceburg (Call). Dunreith (Pleas).

35. VERTIGO OVATA Say.

Tippecanoe Lake, Kosciusko County; Lake James, Steuben County; Arlington. Dunreith (Pleas). Lawrenceburg and Indianapolis (Call).

36. VERTIGO MORSEI Sterki.

Near Tippecanoe Lake, Kosciusko County; Lake Maxinkuckee, Marshall County, and Lake James, Steuben County.

37. VERTIGO GOULDI Binn.

Henry County and Connersville (Sterki); Dunreith (Pleas).

38. VERTIGO TRIDENTATA Wolf.

Danville (Walker); Dunreith (Pleas).

Family ACHATINIDÆ.

39. COCHLICOPA LUBRICA (Mull.). (*Ferussacia subcylindrica* Linn.).

New Harmony, Indianapolis, Wolf Lake, Lake County (Baker); northern half of the State (Call).

Family CIRCINARIIDÆ Pilsbry.

40. CIRCINARIA CONCAVA (Say). (*Macrocyclis concava* Say).

All over the State.

Family ZONITIDÆ.

Sub-family ZONITINÆ Pilsbry.

41. OMPHALINA FULIGINOSA (Griff.). (*Zonites fuliginosus* Griff.).
Grand Chain, Posey County; Mitchell and Wyandotte; Dunreith (Pleas); Corydon, Madison and Bloomington (Call).

42. OMPHALINA FRIABILIS (W. G. B.). (*Zonites friabilis* W. G. B.).
Cypress swamps, Knox County.

43. OMPHALINA LÆVIGATA (Pfr.).
Grand Chain and Mt. Vernon, Posey County; Cannelton and Laurel.

44. OMPHALINA INORNATA (Say). (*Zonites inornatus* Say).
Laurel, Corydon, Madison and Lawrenceburg (Call).

45. VITREA CELLARIA (Mull.)
Laporte (in greenhouse).

46. VITREA HAMMONIS (Strom.).
Laurel, Indianapolis, Arlington, De Long, Vawter Park; Lake James, Steuben County, and cypress swamps, Knox County.

47. VITREA WHEATLEYI (Bland).
New Harmony, Brookville, Huntingburg and Indianapolis.

48. VITREA INDENTATA Say.
Cannelton, New Harmony, Mitchell, Indianapolis, Arlington, Brookville, North Vernon, Wyandotte, Seymour, Millers, Lawrenceburg and cypress swamps, Knox County.

49. VITREA CAPSELLA (Gld.).
New Harmony, Posey County; and Huntingburg, Dubois County.

50. EUCONULUS FULVUS (Mull.). (*Zonites fulvus* Drap.).
Arlington, Brookville, North Webster; Lake James, Steuben County, and Tippecanoe Lake, Kosciusko County.

51. EUCONULUS CHERSINUS Say.
New Harmony, North Vernon, Huntingburg; Pine, Lake County; Morgan County, and cypress swamps, Knox County.

Sub-family ARIOPHANTINÆ Pilsbry.

52. ZONITOIDES NITIDUS (Mull.).

Vawter Park, Tippecanoe Lake and North Webster, Kosciusko County; Arlington and De Long, Marshall County; Lake James, Steuben County.

53. ZONITOIDES ARBOREUS (Say). (*Zonites arboreus* Say).

All over the State.

54. ZONITOIDES LIMATULUS (Ward). (*Zonites limatulus* Ward).

Seymour and Indianapolis. Wabash and Terre Haute (Call).

55. ZONITOIDES MINUSCULUS (Binn.).

Wolf Lake, Lake County (Baker); Mitchell, Huntingburg, Grand Chain, Seymour and Vawter Park.

56. ZONITOIDES LÆVISCULUS (Sterki).

Dunreith, Henry County.

57. ZONITOIDES MILIUM (Morse).

Princeton, Gibson County.

58. GASTRODONTA INTERTEXTA (Binn.). (*Zonites intertextus* Binn.).

Grand Chain and Mt. Vernon, Posey County; Mitchell, Wyandotte; southeastern Indiana (Call).

59. GASTRODONTA DEMISSA (Binn.).

Wolf Lake, Lake County (Baker).

60. GASTRODONTA LIGERA (Say). (*Zonites ligerus* Say).

Grand Chain and New Harmony, Posey County.

61. GASTRODONTA INTERNA (Say). (*Zonites internus* Say).

Cannelton and Wyandotte.

Family LIMACIDÆ.

62. LIMAX FLAVUS L.

Lawrenceburg (Call).

63. AGRIOLIMAX AGRESTIS (L.).

Laporte County.

64. AGRIOLIMAX CAMPESTRIS (Binn.).

Common.

Family PHILOMYCIDÆ.

65. PHILOMYCUS CAROLINENSIS (Bosc.). (*Tebennophorus carolinensis* Bosc.).
Over nearly all the State.

Family ENDODONTIDÆ.

66. PYRAMIDULA ALTERNATA (Say). (*Patula alternata* Say).
All over the State.

67. PYRAMIDULA SOLITARIA (Say). (*Patula solitaria* Say).
Lafayette, Laporte, Terre Haute, New Harmony, Mt. Vernon, Lawrenceburg, North Vernon, Vawter Park.

68. PYRAMIDULA PERSPECTIVA (Say). (*Patula perspectiva* Say).
All over the State.

69. PYRAMIDULA STRIATELLA (Anth.). (*Patula striatella* Anth.).
Indianapolis, Brookville, Lawrenceburg, Corydon, Lafayette.

70. HELICODISCUS LINEATUS (Say).
Seymour, Huntingburg, North Vernon, New Harmony, Vawter Park, Lafayette and Indianapolis.

Sub-family PUNCTINÆ.

71. PUNCTUM PYGMÆUM (Drap.).
Seymour, Jackson County, and Vawter Park, Kosciusko County.

72. SPHYRADIUM EDENTULUM (Drap.).
Near Clear Lake, Steuben County, and Vawter Park, Kosciusko County.

Family SUCCINIDÆ.

73. SUCCINEA RETUSA Lea. (*Succinea ovalis* Gld.).
Kosciusko, Marshall, Laporte, Steuben and Lake counties.

74. SUCCINEA CALUMETENSIS Calkins.
Half Moon Pond, Posey County, and cypress swamps, Knox County.

75. SUCCINEA OVALIS Say. (*Succinea obliqua* Say).
Arlington and De Long, Fulton County.

76. SUCCINEA AVARA Say.
Kosciusko, Laporte and Whitley counties.

Family AURICULIDÆ.

77. CARYCHIUM EXIGUUM Say.

Tippecanoe Lake and Vawter Park, Kosciusko County; Lawrenceburg, New Albany and Indianapolis (Call).

78. CARYCHIUM EXILE H. C. Lea.

Vawter Park, Kosciusko County; Berry Lake, Lake County (Baker).

Family LIMNÆIDÆ.

Sub-family LIMNÆINÆ.

79. LIMNÆA STAGNALIS APPRESSA Say.

Turkey Lake, Kosciusko County; Lake Michigan, Millers; Kankakee River, Laporte County.

80. LIMNÆA REFLEXA Say. (*Limnophysa reflexa* Say).

Hammond, Millers, near Lake Michigan; Kankakee River, Laporte County. Common in northern Indiana.

80a. L. REFLEXA KIRTLANDIANA Lea.

Roby, Lake County.

81. LIMNÆA PALUSTRIS Mull. (*Limnophysa palustris* Mull.).

Turkey and Tippecanoe lakes, Kosciusko County; Carr's Slough, White County, and cypress swamps, Knox County.

81a. L. PALUSTRIS MICHIGANENSIS Walker.

Tippecanoe and Turkey lakes, Kosciusko County; Calumet Lake, Lake County (Baker).

82. LIMNÆA CAPERATA Say. (*Limnophysa caperata* Say).

Hammond, North Vernon, Calumet Lake and Roby (Baker).

82a. L. CAPERATA UMBILICATA Adams.

Liverpool, Lake County (Baker).

83. LIMNÆA CATASCOPIUM Say.

Calumet Lake, Lake County (Baker).

84. LIMNÆA COLUMELLA Say.

Bass Lake, Starke County; Grassy Creek, Kosciusko County.

85. LIMNÆA WOODRUFFI Baker.

Lake Michigan at Pine, Millers and Michigan City.

86. LIMNÆA HUMILIS Say. (*Limnophysa humilis* Say).

Turkey and Tippecanoe lakes, Kosciusko County; Bass Lake, Starke County; Round Lake, Whitley County, and Lake Maxinkuckee, Marshall County.

87. LIMNÆA DESIDIOSA Say. (*Limnophysa desidiosa* Say).

Grassy Creek, Kosciusko County. All over the State (Call).

Sub-family PLANORBINÆ.

88. PLANORBIS TRIVOLVIS Say. (*Helisoma trivolvis* Say).

All over the State.

89. PLANORBIS TRUNCATUS Miles.

George Lake, Lake County (T. Jenson).

90. PLANORBIS BICARINATUS Say. (*Helisoma bicarinata* Say).

Lake Michigan, Michigan City; Lake James, Steuben County; Bass Lake, Starke County; Clear Lake, Laporte County.

91. PLANORBIS CAMPANULATUS Say. (*Planorbella campanulata* Say).

Common over the northern part of the State.

92. PLANORBIS EXACUTUS Say. (*Menetus exacutus* Say).

Bass Lake, Starke County; Turkey Lake and Grassy Creek, Kosciusko County; Cedar Lake, Lake County; Lawrenceburg and Ft. Wayne (Call).

93. PLANORBIS PARVUS Say. (*Gyraulus parvus* Say).

Bass Lake, Starke County; Lake Maxinkuckee, Marshall County; Cedar Lake, Lake County; Lake James, Steuben County; Grassy Creek, Kosciusko County, and Pine Lake, Lake County.

93a. P. PARVUS CIRCUMSTRIATUS Tyron.

Lake Maxinkuckee, Marshall County.

94. PLANORBIS HIRSUTUS Gld.

Grassy Creek, Tippecanoe Lake and Turkey Lake, Kosciusko County; Cedar Lake, Lake County; Bass Lake, Starke County.

95. PLANORBIS DEFLECTUS Say. (*Gyraulus deflectus* Say).

Grassy Creek, Kosciusko County.

96. PLANORBIS UMBILICATELLUS Cockerell.

Tippecanoe Lake, Kosciusko County.

97. Segmentina armigera Say.

Carr's Slough, White County; cypress swamps, Knox County; Turkey and Tippecanoe lakes, Kosciusko County; Lake Maxinkuckee, Marshall County; Lake James, Steuben County.

Family ANCYLIDÆ.

98. Ancylus rivularis Say.

Bass Lake, Starke County; Liverpool, Lake County (Baker).

99. Ancylus parallelus Hald.

Bass Lake, Starke County.

100. Ancylus shimekii Pils.

Bass Lake, Starke County.

101. Ancylus fuscus Adams.

Grassy Creek, Kosciusko County.

102. Ancylus diaphanus Hald.

In State Museum, marked Indiana.

103. Ancylus tardus Say.

Grassy Creek, Kosciusko County; Ohio River, Lawrenceburg; Wabash and Maumee rivers (Call).

Family PHYSIDÆ.

104. Physa heterostropha Say.

New Harmony, Posey County; Tippecanoe and Turkey lakes, Kosciusko County.

105. Physa ancillaria Say.

Logansport; Collection Indiana State University from Turkey Lake, Kosciusko County (Call).

106. Physa sayi Toppan.

Turkey and Tippecanoe lakes, Kosciusko County.

107. Physa rhomboidea Crandall.

Cypress swamps, Knox County.

108. Physa gyrina Say.

New Harmony, Wyandotte, Indianapolis, cypress swamps, Knox County.

109. P. GYRINA ELLIPTICA Lea.

Cypress swamps, Knox County.

110. PHYSA INTEGRA Hald.

Wyandotte; Lake Michigan at Michigan City.

111. APLEXA HYPNORUM Linn. (*Bulinus hypnorum* Linn.).

Tippecanoe Lake and Vawter Park, Kosciusko County; Hammond, Lake County; Brookston, White County.

Family PLEUROCERIDÆ.

112. LITHASIA OBOVATA Say.

Falls of the Ohio River; Lawrenceburg (Call).

112a. L. OBOVATA BICONICA Pilsbry.

Wabash River, Gibson County.

113. ANGITREMA ARMIGERA Say.

Wabash River, Grand Chain, Posey County; Knox County. Common.

114. ANGITREMA VERRUCOSA Raf.

Wabash River, New Harmony, common; Ohio River, Lawrenceburg (A. C. Billups).

115. PLEUROCERA UNDULATUM Say.

Wabash River, Gibson and Posey counties. Common.

116. PLEUROCERA MONILIFERUM Lea.

Wabash River, Gibson County.

117. PLEUROCERA CANALICULATUM Say.

Wabash River, Gibson and Posey counties; Ohio River, New Albany.

118. PLEUROCERA SUBULARE Lea.

Manitou Lake, Rochester; Tippecanoe Lake, Kosciusko County; Wabash River, Terre Haute; Eel River, North Manchester.

119. PLEUROCERA ELEVATUM Say.

Ohio River at "The Falls" and Lawrenceburg.

120. PLEUROCERA ALVEARE Conrad.

Wabash River, Gibson County.

121. GONIOBASIS CUBICOIDES Anthony.

Blue River, Wyandotte; Big Indian Creek, Corydon; Wabash River, Huntington (Call).

122. GONIOBASIS DEPYGIS Say.

Falls of the Ohio. Specimens in State Museum marked Wabash River.

123. GONIOBASIS LIVESCENS Menke.

Lake Maxinkuckee, Marshall County; Bass Lake, Starke County; St. Mary's and Maumee and Ft. Wayne (Call).

124. GONIOBASIS INFANTULA Lea.

Falls of the Ohio near Shippingport (Call).

125. GONIOBASIS PULCHELLA Anthony.

Big Indian Creek, Corydon; Blue River, Wyandotte; White River, Indianapolis.

126. GONIOBASIS INTERLINEATA Anthony.

Christy Creek, type locality.

127. GONIOBASIS INTERSITA Hald.

Swan Creek, type locality (Mrs. Say).

128. GONIOBASIS SEMICARINATA Say.

Small streams flowing from Hamer's Cave at Mitchell; Muscatatuck River, North Vernon.

129. GONIOBASIS LOUISVILLENSIS Lea.

Falls of the Ohio.

130. GONIOBASIS GRACILIOR Anthony.

Turkey Lake, Kosciusko County; Manitou Lake, Rochester.

131. GONIOBASIS BREVISPIRA Anthony.

Tippecanoe River, Carroll County; Sharp's Spring, Wyandotte.

132. GONIOBASIS INDIANENSIS Pilsbry.

Blue River, Wyandotte, Crawford County.

133. ANCULOSA COSTATA Anthony.

Ohio River, New Albany.

134. ANCULOSA TRILINEATA Say.

Ohio River, Lawrenceburg. Described from the Falls of the Ohio.

135. ANCULOSA PRÆROSA Say.

Ohio River, Lawrenceburg; Falls of the Ohio. Common.

Family AMNICOLIDÆ.

Sub-family BYTHINIINÆ.

136. BYTHINIA TENTACULATA Linne.

Lake Michigan at Pine, Millers and Michigan City.

Sub-family HYDROBIINÆ.

137. AMNICOLA LIMOSA Say.

Lake Michigan, Michigan City; Bass Lake, Starke County; Tippecanoe Lake, Kosciusko County; Cedar Lake, Lake County.

137a. A. LIMOSA PARVA Lea.

Turkey and Tippecanoe lakes, Kosciusko County; Bass Lake, Starke County.

137b. A. LIMOSA PORATA Say. (*Amnicola porata* Say).

Tippecanoe Lake, Kosciusko County; Bass Lake, Starke County.

138. AMNICOLA LUSTRICA Pils.

Turkey and Tippecanoe lakes, Kosciusko County; Lake Maxinkuckee, Marshall County; Berry Lake, Lake County (Baker).

139. AMNICOLA WALKERI Pils.

Grassy Creek, Kosciusko County.

140. AMNICOLA CINCINNATIENSIS Anthony.

Lake Michigan at Millers.

141. AMNICOLA EMARGINATA Kuster. (*Bythinella obtusa* Lea).

Lake Michigan at Millers.

142. PALUDESTRINA NICKLINIANA Lea.

Berry Lake, Lake County.

143. SOMATOGYRUS SUBGLOBOSUS Say. (*Somatogyrus isogonus* Say).

Ohio River, Lawrenceburg; George Lake, Lake County (Baker).

144. SOMATOGYRUS INTEGER Say.

Ohio River near Madison; Ohio River, Charleston (Call).

145. POMATIOPSIS LAPIDARIA Say.

Indianapolis, Seymour, Lawrenceburg, Calumet Lake, Lake County.

Family VALVATIDÆ.

146. VALVATA SINCERA Say.

Lake Michigan, Millers and Michigan City.

147. VALVATA TRICARINATA Say.

Lake Michigan at Millers; Grassy Creek, Kosciusko County; Lake James, Steuben County; Lake Maxinkuckee, Marshall County; Cedar Lake, Lake County.

147a. V. TRICARINATA CONFUSA Walker.

147b. V. TRICARINATA UNICARINATA De Kay.

147c. V. TRICARINATA SIMPLEX Gld.

Cedar Lake, Lake County.

148. VALVATA BICARINATA Lea.

Lake Michigan.

148a. V. BICARINATA NORMALIS Walker.

Lake Michigan, Millers.

Family VIVIPARIDÆ.

149. VIVIPARA SUBPURPUREA Say.

Wabash River, Grand Chain, Posey County; Big Creek and Hovey's Lake, Posey County; Wabash River, Knox County; Ohio River, Mt. Vernon.

150. VIVIPARA CONTECTOIDES Binney.

Bass Lake, Starke County; Foote's Pond, Gibson County; Dan's Pond, Knox County; Lake Michigan, Millers.

151. VIVIPARA INTERTEXTA Say.

Cypress swamps, Knox County; Wabash River, Knox and Gibson counties.

152. CAMPELOMA PONDEROSUM Say.

Wabash River, Lafayette, Terre Haute, New Harmony; Ohio River, Mt. Vernon; Muscatatuck River, North Vernon.

153. CAMPELOMA SUBSOLIDUM Anthony.

Wabash River, Lafayette, Terre Haute; Kankakee River, Riverside; Eel River, North Manchester.

154. CAMPELOMA DECISUM Say.

Bass Lake, Starke County; Kankakee, St. Mary's, St. Joseph and Maumee rivers (Call).

155. CAMPELOMA RUFUM Hald.

Tippecanoe and Turkey lakes, Kosciusko County; Pine and Stone lakes, Laporte County; Lake Michigan, Millers. Lafayette, Indianapolis, Huntington and Ft. Wayne (Call).

156. CAMPELOMA INTEGRUM De Kay.

Webster Lake, Kosciusko County; Clear Lake, Steuben County; Lake Michigan, Millers.

157. CAMPELOMA OBESA Lewis.

White River and Canal at Indianapolis.

158. LIOPLAX SUBCARINATA Say.

Wabash River, Grand Chain, Posey County; White, Ohio and Blue rivers (Call).

Family SPHÆRIIDÆ.

159. SPHÆRIUM VERMONTANUM Prime.

Lake Michigan, Millers.

160. SPHÆRIUM SOLIDULUM Prime.

Muscatatuck River, North Vernon.

161. SPHÆRIUM STAMINEUM Con.

White River, Indianapolis; Muscatatuck River, North Vernon; Lake Michigan, Michigan City; Tippecanoe and Turkey lakes, Kosciusko County.

162. SPHÆRIUM STRIATINUM Lam.

Tippecanoe Lake, Kosciusko County; Muscatatuck River, North Vernon; Corydon.

163. SPHÆRIUM SIMILE Say. (*Sphærium sulcatum* Lam.).

Turkey Lake, Kosciusko County; Lake Maxinkuckee, Marshall County; Wabash River, New Harmony.

164. SPHÆRIUM FABALE Prime.

Lake Michigan, Michigan City; Wabash River, New Harmony.

165. SPHÆRIUM OCCIDENTALE Prime.

Kankakee River, Laporte County; cypress swamps, Knox County; Tippecanoe Lake and pond at Vawter Park, Kosciusko County.

166. SPHÆRIUM RHOMBOIDEUM Say.

Turkey Lake, Kosciusko County; Lake Michigan at Millers.

167. SPHÆRIUM FLAVUM Prime.

Turkey Lake, Kosciusko County; variety from Lake Michigan at Millers.

168 CALYCULINA TRANSVERSA Say. (*Sphærium transversum* Say.)

Big Creek, Posey County; Wabash River, New Harmony.

169. CALYCULINA TRUNCATA Linsley.

Turkey and Tippecanoe lakes, Kosciusko County.

170. CALYCULINA SECURIS Prime.

Grassy Creek, Tippecanoe and Turkey lakes, Kosciusko County.

171. CALYCULINA PARTUMEIA Say. (*Sphærium partumeium* Say).

Grassy Creek, Kosciusko County.

172. CALYCULINA ROSACEA Prime.

Grassy Creek and Turkey Lake, Kosciusko County.

173. PISIDIUM ABDITUM Hald.

Berry Lake and Millers (Baker); Ohio and Wabash rivers, Brookville (Call).

174. PISIDIUM VIRGINICUM Bourg.

English Lake, Kankakee River.

175. PISIDIUM ROTUNDATUM Prime.

Grassy Creek, Tippecanoe and Turkey lakes, Kosciusko County.

176. PISIDIUM COMPRESSUM Prime.

Grassy Creek and Turkey Lake, Kosciusko County; Bass Lake, Starke County; Lake Maxinkuckee, Marshall County; Kankakee River and Danville.

177. PISIDIUM DANIELSI Sterki (Ms.).

Spring near Lake James, Steuben County.

178. PISIDIUM OBTUSALE C. Pfr.

Spring near Lake James, Steuben County.

179. PISIDIUM NOV-EBORACENSE Prime.

Grassy Creek and Turkey Lake, Kosciusko County; Bass Lake, Starke County.

180. PISIDIUM VARIABILE Prime.

Bass Lake, Starke County; Turkey Lake, Kosciusko County; Lake Maxinkuckee, Marshall County; English Lake, Kankakee River.

181. PISIDIUM IDAHOENSE Roper.

Lake Michigan, Millers.

182. PISIDIUM POLITUM Sterki.

Grassy Creek, Kosciusko County.

183. PISIDIUM VESICULARE Sterki.

Bass Lake, Starke County.

184. PISIDIUM PAUPERCULUM Sterki.

Lake Maxinkuckee, Marshall County; Bass Lake, Starke County; Turkey Lake, Kosciusko County.

185. PISIDIUM SCUTELLATUM Sterki.

Lost Lake, Marshall County.

186. PISIDIUM SPLENDIDULUM Sterki.

Grassy Creek and Turkey Lake, Kosciusko County; Bass Lake, Starke County.

187. PISIDIUM ROPERI Sterki.

Grassy Creek and Tippecanoe Lake, Kosciusko County; Danville (Sterki).

188. PISIDIUM MEDIANUM Sterki.

Bass Lake, Starke County.

189. PISIDIUM TENUISSIMUM Sterki.

Bass Lake, Starke County; Lake Maxinkuckee, Marshall County.

190. PISIDIUM AFFINE Sterki.

Turkey Lake, Kosciusko County.

191. PISIDIUM SARGENTI Sterki.

Bass Lake, Starke County.

192. PISIDIUM STRENGI Sterki.

Bass Lake, Starke County.

193. PISIDIUM KIRKLANDI Sterki.

Berry Lake, Lake County (Baker).

Family UNIONIDÆ.

194. TRUNCILLA TRIQUETRA Raf. (*Unio triangularis* Barnes).

Tippecanoe, Wabash, Blue, White, Muscatatuck and Eel rivers.

195. TRUNCILLA SULCATA Lea. (*Unio sulcatus* Lea).

Wabash River, Lafayette; White River, Marion County, Ohio River (Stein).

196. TRUNCILLA FOLIATA Hild. (*Unio foliatus* Hild.).

Ohio and Wabash rivers (Stein).

197. TRUNCILLA PERSONATA Say. (*Unio personatus* Say).

Wabash River, New Harmony. Authentic specimen in State Museum.

198. TRUNCILLA PERPLEXA Lea. (*Unio perplexus* Lea).

Wabash River, New Harmony; Ohio River (Stein).

198a. T. PERPLEXA RANGIANA Lea.

Wabash River, Lafayette; Tippecanoe River, Monticello; White River (Stein).

199. TRUNCILLA SAMPSONII Lea.

Wabash River; Grand Chain, Posey County.

200. MICROMYA FABALIS Lea. (*Unio fabalis* Lea).

White, Wabash and Tippecanoe rivers; Tippecanoe Lake, Kosciusko County.

201. LAMPSILIS VENTRICOSUS Barnes. (*Unio ventricosus* Barnes; *Unio subovatus* Say).

Common all over the State.

202. LAMPSILIS CAPAX Green. (*Unio capax* Green).

Wabash River, New Harmony and Grand Chain; Ohio River.

203. LAMPSILIS OVATUS Say.

Wabash River, Terre Haute, Lafayette; Ohio River.

204. LAMPSILIS MULTIRADIATUS Lea. (*Unio multiradiatus* Lea).

Wabash, Tippecanoe, Blue, White, Eel and Ohio rivers; Tippecanoe Lake. Common.

205. LAMPSILIS LUTEOLUS Lam. (*Unio luteolus* Lam.).

Common all over the State.

206. LAMPSILIS LIGAMENTINUS Lam. (*Unio ligamentinus* Lam.).

Common all over the State.

207. LAMPSILIS ORBICULATUS Hild. (*Unio orbiculatus* Hild.).

Wabash River, Terre Haute; Ohio River.

208. LAMPSILIS ANODONTOIDES Lea. (*Unio teres* Raf.).

Kankakee, Eel, Tippecanoe, White, Wabash and Ohio rivers.

209. LAMPSILIS FALLACIOSUS Simpson.

Wabash River, Lafayette; Tippecanoe River, Carroll County.

210. LAMPSILIS RECTUS Lam. (*Unio rectus* Lam.).

Common in all the rivers of the State.

211. LAMPSILIS SUBROSTRATUS Say. (*Unio subrostratus* Say).

Wabash, Eel and Ohio rivers; Foote's Pond, Gibson County; Tippecanoe Lake, Kosciusko County; Lake Maxinkuckee, Marshall County; Manitou Lake, Fulton County.

212. LAMPSILIS LIENOSUS Con.

White River and canal at Indianapolis. Abundant.

213. LAMPSILIS NIGERRIMUS Lea.

White River, Rockford.

214. LAMPSILIS IRIS Lea. (*Unio iris* Lea).

All over the State.

215. LAMPSILIS ELLIPSIFORMIS Con. (*Unio spatulatus* Lea).

Salt Creek, Porter County; Ohio, Wabash and Eel rivers (Call).

216. LAMPSILIS PARVUS Barnes. (*Unio parvus* Barnes).

White River, Indianapolis; Wabash River, New Harmony; Big Indian Creek, Corydon.

217. LAMPSILIS GLANS Lea. (*Unio glans* Lea).

White River, Rockford; Tippecanoe Lake, Kosciusko County; Wabash River, New Harmony.

218. LAMPSILIS ALATUS Say. (*Unio alatus* Say).

Wabash, Ohio, Kankakee and White rivers. Common.

219. LAMPSILIS GRACILIS Barnes. (*Unio gracilis* Barnes).

Ohio, Wabash, White and Tippecanoe rivers. Common.

220. LAMPSILIS LÆVISSIMUS Lea. (*Unio lævissimus* Lea).

Wabash River, Terre Haute, Lafayette and New Harmony; Ohio River.

221. LAMPSILIS LEPTODON Raf. (*Unio tenuissimus* Lea).

Wabash River, New Harmony, Lafayette and Terre Haute.

222. LAMPSILIS BLATCHLEYI Daniels.

Wabash River, Grand Chain, Posey County.

223. OBOVARIA RETUSA Lam. (*Unio retusus* Lam.).

White River, Indianapolis, Rockford; Wabash River, Lafayette, Terre Haute, New Harmony.

224. OBOVARIA CIRCULUS Lea. (*Unio circulus* Lea).

Ohio, Wabash, Tippecanoe, White and Eel rivers.

225. OBOVARIA LENS Lea.

Ohio, Wabash, Tippecanoe, White and Eel rivers.

226. OBOVARIA ELLIPSIS Lea. (*Unio ellipsis* Lea).

Wabash River, Lafayette, Terre Haute, New Harmony; Ohio River, New Albany.

227. PLAGIOLA SECURIS Lea. (*Unio lineolatus* Raf.).

Wabash River, Lafayette, Terre Haute, New Harmony, Grand Chain; Ohio River, New Albany.

228. PLAGIOLA ELEGANS Lea. (*Unio elegans* Lea).

Ohio, Wabash, Tippecanoe, White and Kankakee rivers.

229. PLAGIOLA DONACIFORMIS Lea. (*Unio donaciformis* Lea).

Ohio, Wabash, White and Tippecanoe rivers.

230. TRITOGONIA TUBERCULATUS Barnes. (*Unio tuberculatus* Barnes).

Common in the Ohio and lower Wabash rivers; White River, Rockford; Blue River, Crawford County.

231. CYPROGENIA IRRORATA Lea. (*Unio irroratus* Lea).

Ohio, Wabash and White rivers. Common.

232. OBLIQUARIA REFLEXA Raf. (*Unio cornutus* Raf.).

Common in the Ohio, Wabash and White rivers.

233. PTYCHOBRANCHUS PHASEOLUS Hild. (*Unio phaseolus* Hild.).

Ohio, Wabash, Tippecanoe and White rivers; Tippecanoe Lake, Kosciusko County.

234. STROPHITUS EDENTULUS Say. (*Anodonta edentula* Say; *A. wardiana* Lea).

Common in all the larger streams in the State; Tippecanoe Lake, Kosciusko County.

234a. S. EDENTULUS PAVONIUS Lea.

Wabash, Tippecanoe and White rivers; Big Indian River, Corydon.

235. ANODONTA IMBECILLIS Say.

Ohio, Wabash and White rivers; Lily Lake, Laporte.

236. ANODONTA SUBORBICULATA Say.

Dan's Pond, Knox County; Foote's Pond, Gibson County, rare; Wier's Lake, Posey County, common; White River, Rockford.

237. ANODONTA GRANDIS Say. (*Anodonta salmonia* Lea).

Rivers and ponds throughout the State.

237a. A. GRANDIS FOOTIANA Lea.

Turkey Lake, Kosciusko County; Manitou Lake, Fulton County.

238. ANODONTA CORPULENTA Cooper.

Clear Lake, Laporte.

239. ANODONTA KENNICOTTII Lea.

Turkey Lake, Kosciusko County.

240. LASTENA LATA Raf. (*Anodonta dehiscens* Say).

Ohio, Wabash and Tippecanoe rivers.

241. ANODONTOIDES FERUSSACIANUS Lea.

Lake Michigan, Millers.

241a. A. FERUSSACIANUS SUBCYLINDRACEUS Lea. (*Anodonta subcylindracea* Lea).

Wabash River; Berry Lake, Lake County (Baker).

242. ARCIDENS CONFRAGOSUS Say. (*Margaritana confragosa* Say).

Wabash River, Lafayette, Terre Haute and New Harmony; ponds in Posey County.

243. SYMPHYNOTA COMPRESSA Lea. (*Unio pressus* Lea).

Wabash, White and Tippecanoe rivers.

244. SYMPHYNOTA COSTATA Raf. (*Margaritana rugosa* Barnes).

Wabash, Ohio, White, Tippecanoe, Blue, Kankakee and Eel rivers.

245. SYMPHYNOTA COMPLANATA Barnes. (*Margaritana complanata* Barnes).

Common in all the rivers of the State.

246. ALASMIDONTA CALCEOLA Lea. (*Margaritana deltoidea* Lea).

Lake Maxinkuckee, Marshall County; Moots Creek, White County; Big Indian River, Harrison County; Salt Creek, Porter County; Wolf Lake (Baker).

247. ALASMIDONTA TRUNCATA B. H. Wright. (*Margaritana marginata* Say).

In nearly all of the rivers and several of the lakes and ponds.

248. HEMILASTENA AMBIGUA Say. (*Margaritana hildrethiana* Lea).

Wabash River, Grand Chain, Posey County; White River, Rockford.

249. MARGARITANA MONODONTA Say.

Grand Chain, Posey County; Falls of the Ohio near New Albany (Call).

250. UNIO GIBBOSUS Barnes.

Common in the larger streams of the State; Turkey and Tippecanoe lakes, Kosciusko County; Lake Maxinkuckee, Marshall County.

251. UNIO CRASSIDENS Lam.

Ohio, Wabash and Tippecanoe rivers.

252. UNIO TETRALASMUS Say.

Ohio and Wabash rivers (Call).

252a. U. TETRALASMUS SAYI Ward.

Montour's Pond, Knox County.

253. PLEUROBEMA CLAVA Lam. (*Unio clavus* Lam.).

Wabash River, Lafayette, Terre Haute, New Harmony; Tippecanoe River.

254. PLEUROBEMA ÆSOPUS Green. (*Unio cyphyus* Raf.).

Tippecanoe River, Monticello; Wabash River, Lafayette, Terre Haute and New Harmony; Ohio River, New Albany.

255. PLEUROBEMA CICATRICOSA Say. (*Unio varicosus* Lea).

Wabash River.

255a. QUADRULA PLICATA Say.* (*Unio plicatus* Le Sueur).

Common in the Ohio and lower Wabash rivers.

256. QUADRULA UNDULATA Barnes.

Ohio, Wabash, White, Eel, Blue and Tippecanoe rivers.

257. QUADRULA HEROS Say. (*Unio multiplicatus* Say).

Wabash River, Lafayette, Terre Haute, New Harmony; Ohio River, Mt. Vernon.

258. QUADRULA CYLINDRICUS Say. (*Unio cylindricus* Say).

Common in the Ohio, Wabash, White, Eel and Tippecanoe rivers.

259. QUADRULA METANEVRA Raf. (*Unio metanevrus* Raf.).

Ohio, Wabash, White and Blue rivers.

260. Q. METANEVRA WARDII Lea.

Wabash River.

261. QUADRULA LACHRYMOSA Lea. (*Unio lachrymosus* Lea).

Wabash River, Terre Haute and New Harmony; Ohio River.

262. QUADRULA FRAGOSA Conrad. (*Unio fragosus* Conrad).

Wabash River, Gibson County.

263. QUADRULA PUSTULOSA Lea. (*Unio pustulosus* Lea).

Common in the Ohio, Wabash, White and Tippecanoe rivers.

264. QUADRULA COOPERIANA Lea. (*Unio cooperianus* Lea).

Wabash River.

265. QUADRULA PUSTULATA Lea. (*Unio pustulatus* Lea).

Wabash River, Terre Haute and New Harmony; Ohio River, Mt. Vernon.

---

*This is not a variety of *Pleurobema cicatricosa* Say. The number was accidentally omitted in the text, and the number 255a has been given it for that reason.

266. QUADRULA RUBIGINOSA Lea. (*Unio rubiginosus* Lea).

Common in all of the streams and most of the lakes of the State.

267. QUADRULA TRIGONA Lea. (*Unio trigonus* Lea).

Tippecanoe Lake, Kosciusko County; Ohio, Wabash, Blue, Tippecanoe and White rivers.

268. QUADRULA OBLIQUA Lam. (*Unio obliquus* Lam.).

Wabash River, Terre Haute and New Harmony; Ohio River.

269. QUADRULA COCCINEA Con. (*Unio coccineus* Lea).

Common in all of the larger streams of the State; Lake Maxinkuckee, Marshall County; Tippecanoe Lake, Kosciusko County.

270. QUADRULA SOLIDA Lea. (*Unio solida* Lea).

Wabash River, Terre Haute and New Harmony; Ohio River, Mt. Vernon.

271. QUADRULA PLENA Lea.

Wabash River, Terre Haute, New Harmony and Lafayette; Tippecanoe River, Carroll County.

272. QUADRULA PYRAMIDATA Lea.

Tippecanoe River, Carroll County, common; Wabash River, Lafayette and Terre Haute.

273. QUADRULA SUBROTUNDA Lea.

Wabash River, Lafayette, Terre Haute, New Harmony; Tippecanoe River, Carroll County.

274. QUADRULA EBENUS Lea. (*Unio ebenus* Lea).

Wabash River, Terre Haute and Grand Chain, Posey County; Knox County, White River.

275. QUADRULA TUBERCULATA Raf. (*Unio verrucosus* Barnes).

Common in all the streams of the State.

276. QUADRULA GRANIFERA Lea. (*Unio graniferus* Lea).

Ohio River.

GENERAL INDEX TO 1901 REPORT.

INDEX TO MINERAL WATERS OF INDIANA.

(1901 Report.)

GENERAL INDEX TO 1902 REPORT.

INDEX TO ORTHOPTERA OF INDIANA.

(1902 Report)

(FAMILY AND SUB-FAMILY NAMES ARE IN SMALL CAPITALS; GENERIC AND SPECIFIC NAMES IN ROMAN.)

INDEX TO MOLLUSCA OF INDIANA.

(1902 Report.)

(FAMILY NAMES ARE IN SMALL CAPITALS; GENERIC AND SPECIFIC NAMES IN ROMAN.)