MT. RIFENBURG.
A sand dune north of Miller's, Lake County, Indiana.

INDIANA.

DEPARTMENT

—OF—

Geology and Natural Resources.

TWENTY-SECOND ANNUAL REPORT.

W. S. BLATCHLEY,
STATE GEOLOGIST.

1897.

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1898.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
January 21, 1898.

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

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, January 21, 1898.

The within report, so far as the same relates to moneys drawn from the State Treasury, has been examined and found correct.

A. C. DAILY,
Auditor of State.

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

CHAS. E. WILSON,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana, January 21, 1898.

W. D. OWEN,
Secretary of State.

Received the within report and delivered to the printer this 21st day of January, 1898.

THOS. J. CARTER,
Clerk of Printing Bureau.

State of Indiana,
Department of Geology and Natural Resources.

INDIANAPOLIS, IND., January 21, 1898.

HON. JAMES A. MOUNT, *Governor of Indiana:*

DEAR SIR—I have the honor to submit to you herewith the Twenty-second Annual Report of the Department of Geology and Natural Resources. This report embraces, in part, the results of the work accomplished by the different divisions of the Department during the calendar year, 1897. A large proportion of the energies of the Department were employed during that year in gathering data for a detailed report on the coal area of the State, which is now in course of preparation, and which, it is hoped, will be completed within a year. The present report includes papers of economic importance relating to the petroleum, stone and clay resources of the State, the reports of the chiefs of the divisions pertaining to Mines, Natural Gas and Illuminating Oils, together with an extended paper on the Birds of Indiana, which is something that has long been needed for use in our public schools.

Very respectfully,

W. S. BLATCHLEY,
State Geologist.

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TABLE OF CONTENTS.

INTRODUCTORY. BY W. S. BLATCHLEY.

GEOLOGICAL SCALE OF INDIANA. BY W. S. BLATCHLEY AND GEORGE H. ASHLEY.

THE GEOLOGY OF LAKE AND PORTER COUNTIES.
BY W. S. BLATCHLEY.

THE CLAYS AND CLAY INDUSTRIES OF NORTHWESTERN INDIANA. BY W. S. BLATCHLEY.

THE PETROLEUM INDUSTRY IN INDIANA IN 1897. BY W. S. BLATCHLEY.

A REPORT ON THE NIAGARA LIMESTONE QUARRIES OF DECATUR, FRANKLIN AND FAYETTE COUNTIES, WITH REMARKS ON THE GEOLOGY OF THE MIDDLE AND UPPER SILURIAN ROCKS OF THESE AND NEIGHBORING (RIPLEY, JENNINGS, BARTHOLOMEW AND SHELBY) COUNTIES. BY AUGUST F. FOERSTE.

REPORT OF THE STATE NATURAL GAS SUPERVISOR. BY J. C. LEACH.

REPORT OF THE STATE INSPECTOR OF MINES FOR 1897. BY ROBERT FISHER.

REPORT OF THE STATE SUPERVISOR OF OIL INSPECTION. BY C. F. HALL.

SEPTEMBER DRAGON FLIES OF ROUND AND SHRINER LAKES, INDIANA. BY E. B. WILLIAMSON.

A CATALOGUE OF THE FOSSILS OF INDIANA. BY EDWARD M. KINDLE.

THE BIRDS OF INDIANA. BY AMOS W. BUTLER.

LIST OF PLATES.

LIST OF LITHOGRAPH MAPS.

INTRODUCTORY.

The Natural Resources of Indiana, while not including among their number any of the precious or even useful metals, are, nevertheless, as varied in character and as valuable as those possessed by any State in the Union. In each of the last two reports issued by this Department there has been given in an introductory paper a resume of all of the State's mineral resources, while of several of the more important ones, as the sandstones, oölitic stone, petroleum, etc., detailed reports with accompanying maps and results of tests have been published.

The value of each of the five leading mineral resources of the State as produced in 1896 was as follows:

Natural Gas	$5,043,635
Coal	3,946,081
Petroleum	2,954,411
Building Stone	1,691,341
Clay Products	2,674,325
Total	$16,309,793

When, to the value of those mentioned, there be added that of the cement rock, marl, whetstone and lime rocks, curbing and flagging, molding and glass sands, and other minor mineral resources, the total will easily foot up twenty or more millions of dollars. With the exception of petroleum, the value of each of the resources produced in 1897 was increased over that of the previous year, though as yet the exact figures of all are not available to show the amount of gain.

No State in the Union, unless it be Pennsylvania, possesses at present a better and cheaper supply of fuels than does Indiana. Among the other States she ranks second in the production of natural gas, fourth in the production of petroleum and seventh in the production of coal. These three fuels are all stored products which have been formed in ages past and are not now being produced beneath the surface of our State. The citizens of Indiana are drawing upon them with a lavish hand. They not only waste them in their furnaces, their grates and their stoves by burning them at all hours and in over-abundance, but they also allow twenty millions or more cubic feet of gas to escape daily because they are too indolent to plug or cap the wells which have been bored for oil. Indiana supplies, at ridiculously low prices, two millions of the citizens of Chicago with the greater part of the coal, gas and petroleum which they use. Individually those consumers may pay high enough for their fuels, but the producer who secures the fuels from the bowels of our noble State—or rather the middle-man who buys from the producer, pays less than one-fifth their real value. He gets his coal for 80 cents to $1.05 per ton; his oil at 41 cents per barrel; his gas at 2 cents per thousand cubic feet. His only additional expense is for transportation, which, in the case of the oil and gas, is but a nominal sum. Those citizens of Indiana who, by right of ownership of the surface, claim the fuels which lie beneath that surface, are content to take these meagre sums because they do not know the real value of that which they are selling. Since they have not produced these fuels by the sweat of their brows, as they have their corn, oats and wheat, they do not realize their value. Surrounded as they are by the plenty of the present, it is difficult for them to realize that the time will come, and that before many years, when the stored reservoirs of at least two of these fuels within the borders of our State, will have been drained, and only the dregs be left as a reminder of the plenty that has been.

Report of Progress on Coal Survey.—The principal work of the Department of Geology during the year 1897 was done upon the coal survey which was started the previous year and which, it is hoped, will be finished in 1898. During the field season, from the middle of April until the first of November, 1897, the following counties were surveyed: Warren, Fountain, Vermillion, Parke, Vigo, Clay, Sullivan and Greene, and those parts of Benton, Montgomery, Putnam and Owen included in the coal fields—a total of about 3,200 square miles. The field party included Messrs. G. H. Ashley, in charge, C. E. Siebenthal, E. M. Kindle and J. T. Scovell, the latter two being in the field only part of the season. Each member of the party had definite areas to work up, and will be responsible for the details of those areas. This, with the work of last season in Knox, Daviess and Martin counties, completes the field work north of the East Fork of White River, or a total area surveyed of 4,500 square miles. Two weeks were also spent in Pike County, during which most of the mines were visited and much information obtained which will not be available in the Spring when the survey of the county will be completed.

In that portion of the area which has been finished every mine has been visited, and, as far as time would allow, every known outcrop, in order to obtain records of all the prospect bores, well sections, etc., possible, and especially to make a systematic topographic survey from point to point along the outcrop of the principal coal beds. The information sought has been for two purposes; first:

General, to obtain the salient topographic features of each part of the area; to obtain typical columnar sections, especially with regard to the coal, with the variations from place to place; to obtain the characteristic features of each principal coal bed, as regards stratigraphic details and thickness, quality, quality of roof, of under-clay, workability, adaptability for different purposes, etc.; to obtain the distribution of each workable coal bed, both vertically and horizontally, etc., etc.

Secondly, from the data thus obtained, combined with the data obtainable at any point, to be able to tell at that point what coals underlie that region, their depth below drainage, thickness and details concerning quality, accompanying strata, characteristics by which each bed may be recognized, probable condition of roof and under-clay and other factors affecting workability.

There yet remain to be surveyed, Gibson, Pike (in part), Dubois, Warrick, Vanderburgh and Spencer counties, and parts of Posey, Orange, Crawford and Perry counties. It is planned to push the work on these counties the coming year with the hope of completing them fairly early in the season so as to allow the completion of the report as a whole by November 1st, 1898.

In the report the following subjects will be treated:

I. General geology of Coal.
II. General geology of Indiana coal field.
III. Mining methods, etc.
IV. Details of coal distribution in Indiana.
V. Summary of coal and mining. (Tables and statistics.)

In addition, there are contemplated 7 colored geological maps on the scale of two miles to the inch; page or double page maps on the scale of one mile to the inch of all the more important coal areas; drawings illustrating typical columnar sections, detailed coal sections, cross sections, besides numerous figures illustrating geological features of the coal, and mining methods, together with some half-tone plates, showing mines, processes, etc. In preparing the report it is planned to group similar matter as far as possible, making comparisons easy and revealing relations and facts that otherwise would not be observed.

In the matter of progress, it may be stated that four of the colored maps are nearing completion; 12 double-page and 16 single-page maps are completed or in progress; nearly 30 cross sections have been prepared; also between 75 and 100 columnar sections, near 300 coal sections, and about 50 figures, from page size down, of mining and geological subjects. Part I. of the report is ready for the press. Parts II. and III. are well under way, and 300 pages of Part IV. are finished.

When this report on Indiana coal is completed, any one wishing to know the area, average thickness or quality of the coal belonging to any one of the seven workable veins of the State can have access to a work which will furnish him the information desired.

MINE INSPECTOR'S REPORT.—The report of the State Mine Inspector, Mr. Robert Fisher, will be found, in the present volume. It shows that the output of coal in Indiana in 1897 was 4,228,085 tons, or 159,961 tons more than in 1896. When it is remembered that an extended strike among the miners began July 4th and continued until September 14th, the output for the year is a very creditable one.

In those mines of the State operating ten or more men, 7,636 miners are employed. In the smaller mines nearly 900 additional men are at work, making a total of 8,500 miners in the State. The report shows also a large decrease in 1897, in the number of accidents in the mines, there being but 16 fatal, 24 serious and 74 minor accidents, as against 28 fatal, 66 serious and 94 minor in 1896. Such a decrease is excellent proof of the efficiency of the work done by the Mine Inspector, and his deputy, Mr. James Epperson, in seeing to it that many of the former elements of danger about the mines have been removed or modified.

While the State Inspector and his assistant visit many of the mines employing less than ten men, and make recommendations, the law gives them no power to enforce better conditions of ventilation and measures of protection. A bill was introduced into the last Legislature giving them such power, but it failed of passage. Such a statute is one of the most needed additions to the mining laws of the State, since the life of a miner working in a small mine is just as valuable as that of a man working in any of the larger ones.

The report of Mr. Fisher will be found to contain much statistical and other information differing in nature from that compiled for former reports, and to it the reader is referred for additional details concerning the mining industry of the State.

PETROLEUM.—For the first time since the discovery of petroleum in Indiana, the annual production has fallen below that of the preceding year, the total production for 1897 being 4,353,138* barrels, as against 4,680,732 in 1896—or a decrease of 327,594 barrels. The

*This does not include the amount used for fuel and other purposes in the field.

prevailing low price of Indiana petroleum, which averaged for the year but 43 cents per barrel, or 20 cents less than in 1896, prevented the sinking of many new bores in the main petroleum field, and the old wells in that field decreased on an average about 40 per cent. in output.

New developments of importance were made near Alexandria, Madison County; Peru, Miami County, and Broad Ripple, Marion County. The Alexandria field very probably has an unbroken connection with the main field to the northeast, and tends to prove the belief advanced in both of my former reports that the entire gas field of the State will, in the near future, yield petroleum in greater or less quantities. The Peru and Broad Ripple productions are more probably from isolated areas of porous Trenton limestone. Such areas are very liable to be found on the slope of the main gas field anywhere within 15 to 25 miles of its margin. A paper, giving in detail the developments made in the new fields during the past year, and accompanied by maps of the Peru and Broad Ripple fields, will be found in the present volume.

The petroleum produced in Indiana is piped and shipped from the productive areas by three companies. The largest of these, the Indiana Pipe Line Company, with headquarters at Lima, Ohio, handles more than three-fourths of the production, and kindly furnished me with statistics showing the amount handled by them each month. The other two companies—The Indiana Pipe Line and Refining Company, controlled by the Cudahy Bros., of Chicago, and the Manhattan Oil Company, of Lima, Ohio, refused to furnish statistics showing the number of barrels handled. Since petroleum is one of the more important mineral resources of Indiana, and since accurate statistics relative to the State's production are of value in showing the mineral wealth of our State, and thereby attracting capital and population within her bounds, I would advise the passage of a law by the next General Assembly, compelling all companies or individuals shipping or piping crude petroleum from the receiving tanks at the wells, to furnish to the Department of Geology monthly statements showing the number of producing wells and the number of barrels so piped or shipped. Such monthly statements must, according to law, be furnished the Department by all operators of coal mines, and there is no reason why the oil companies should not be compelled to do likewise.

The total amount of oil produced in Indiana since 1889, when the first wells were sunk, has been 20,386,231 barrels,* valued at $10,816,-

* Not including the amount used for fuel and other purposes in the field.

326. The real value of a barrel of crude petroleum is much greater than 43 cents, the average market price in 1897. When the market price rises more nearly to the true value there is little doubt but that the industry will take new life, and bores sufficient in number will be sunk to bring the production up to or above that of 1896. The oil has been stored for thousands of years in the porous reservoirs, from which it is now being obtained, and the operators are content to let it remain there as long as prices are kept at a figure which gives but little profit above the actual cost of production. Unlike the gas, there is little danger of its dissipation and loss during the wait for a rise in the price.

REPORT OF THE STATE SUPERVISOR OF NATURAL GAS.—No unbiased person can read carefully the report of Mr. J. C. Leach, State Supervisor of Natural Gas, printed in this volume, and not conclude that we are nearing the end of the supply of this valuable fuel in Indiana. This report but affirms what has been written in the previous reports of this Department, even as far back as 1890.

The natural gas field of the State originally embraced almost 3,000 square miles. To-day the productive area is less than half that size. The average rock pressure was in the beginning 325 pounds; to-day it is less than 200 pounds. Mr. Leach reports that in the heart of the field, an area of 250 square miles, located in Grant, Madison, Blackford and Delaware counties, the pressure decreased 30 pounds in 1897, and now averages but 215 pounds; while in these four counties, which are the most productive of the entire field, the average pressure is but 200 pounds. This decrease in rock pressure, added to that of an exhaustion of one-half of the original productive area and the constant encroachment of salt water towards the center of the field, all point to the final exhaustion of the supply.

In the face of these facts there are many men in the gas field who are either so foolish, so woefully ignorant, or so dishonest as to decry constantly the idea that the supply of natural gas is failing. They assert, in spite of the evidence of the best scientists in America to the contrary, that the gas is being generated as fast as it is used. They continue to attempt to boom, on every occasion, the gas field. They still offer "free gas and free lands" to all factories that will locate near their towns. They condemn the reports issued by this Department. They have even told the Supervisor that the truth ought not be told; that it was not necessary to proclaim to the world the fact that gas is failing.

Such men evidently forget that this Department was organized to advertise the resources of Indiana as they are, not as boomers would have them. If the supply of a resource is failing, or if its quality is defective, it is as much the duty of this Department to make known such facts as it is to publish an account of those resources which are increasing in quantity or possess some newly discovered excellence of quality. The vast majority of the people of the State expect the truth in the reports of this Department, and the truth must be told as nearly as it can be ascertained by careful investigation.

The chief duty of the State Supervisor of Natural Gas is to prevent, wherever possible, the waste of the fuel. This duty Mr. Leach has performed to the best of his ability with the means at his command. As an assistant in this Department, he was directed to enforce the flambeau law, and by his efforts the burning of such lights has been practically abandoned. When the waste of gas began last May in the vicinity of Alexandria, I directed him to use the full limit of his powers to stop such waste, and he immediately began the enforcement of such laws as were on the statute books. He was condemned by many for not stopping the waste at once, and additional directions were given him by the Chief Executive of the State, but it was soon found that he was already doing all that he could under the existing laws, which are defective in that they do not give the Supervisor the power to cap any well whose owner insists on allowing the escape of gas. At first his efforts were condemned by many of the citizens of Alexandria, who saw a prospective oil boom in their midst. However, the rapid decrease of the rock pressure, consequent upon the wanton waste of the gas, soon brought those citizens to a proper realization of their best interests, and led them to add their efforts to those of the Supervisor in trying to stop the waste. As a result, several cases have been pushed, and are now before the Supreme Court of the State, which will soon decide whether a party in search of a few hundred barrels of oil can jeopardize the interests of thousands of citizens by allowing a waste which will soon deprive those citizens of a most valuable necessity.

The manufacturers of the gas field have, for the most part, done all that they could to stop the waste. Their association has advanced means and furnished help to assist in shutting off all unnecessary flow of gas. They realize that the future life of the field, as compared with the past, is of short duration, and they desire to prolong it as much as possible.

No one can say with certainty how long the supply of gas for manufacturing purposes will last in Indiana. It may be for one year; it may be for five. When it fails, the factories now in the field will not of necessity have to move therefrom. Petroleum can and will be used as a fuel in many of the factories. Improved methods of separating the gas from coal are constantly coming to the front, and the time may come when artificial gas from this fuel will be made in quantity and piped to the factories in the gas field. Again, their situation within 70 miles of the center of a great coal basin will give them advantages which, though far inferior to those they now possess, will still enable them to compete with many of the factories of the East, where fuel has to be transported a much greater distance.

Every one will admit that the highest use to which this gaseous fuel can be put is that of household consumption. With no kindling, no replenishing, no ashes, no soot, the duties of the housewife are decreased many fold. For this reason every effort should be made to husband the present supply by stopping at once all unnecessary use or wanton waste. Any attempt to evade the law relative to the waste of gas should be promptly reported to the proper officers. Instances were cited during the past season of persons who piped the gas into a pile of brick and burned it, hoping thereby to keep themselves within the pale of the law. All such persons are wholly lacking in public spirit, and devoid of every feeling which tends to advance the interests of humanity. All future attempts to locate large factories within the field by promising them free gas should be decried. Such factories can but shorten the present fuel supply of those in existence, and diminish the amount which will in the future be available for household purposes.

THE GEOLOGY OF LAKE AND PORTER COUNTIES.—In the law creating the Department of Geology it was specified that one of the duties of the State Geologist shall be the continuation "of the geological survey of the State by counties or districts, and the completion and revision of the same as may be practicable." My predecessors in charge of the Department followed this law literally, and in the annual reports previous to the Twentieth, dealt with all the counties except Adams, Blackford, Fulton, Hendricks, Kosciusko, Lake, Porter, Tipton and Wells. All of these counties are included in the drift-covered area of the State, and but few outcrops of rock are found within their bounds.

Since the civil boundaries of a county have little or nothing to do with the limits or boundaries of a natural resource or geological formation, the work of the Department for the past three years has, in the main, been devoted to the preparation of monographs on each of the leading natural resources of the State. The worthy citizens of Lake and Porter counties, occupying, as they do, that region of the State lying nearest the great city of Chicago, have felt that the Department of Geology had not done them justice in the bestowal of its favors in the past. It was thought best, therefore, to continue, for a time, the work based on the county boundary system, and several months of the summer and autumn of 1897 were spent by the writer in gathering data for a paper entitled "The Geology of Lake and Porter Counties, Indiana," which appears as a part of the present volume.

The paper is, in the main, devoted to the physiography or surface features of the two counties, since not a single outcrop of rock is located within their bounds. Lying, as they do, adjacent to the southern shore of Lake Michigan, much of their northern portion is covered with sand. Unfortunately, the more important railways which pass through the counties traverse this sandy region, and the traveler bears away with him wrong ideas concerning their fertility and general prosperity.

No one who spends a considerable period in the study of the surface of these two counties can deny that a large percentage of their area ranks among the most fertile lands of the State. In the production of hay, Lake stands second and Porter third among the 92 counties of Indiana; while in the production of milk, Lake ranks third and Porter fifth. Much of the sand-covered area is admirably adapted to the raising of small fruits and vegetables; and the thousands of acres of marsh-land in the valley of the Kankakee is being rapidly drained, and in time that section will be known as the garden spot of northwestern Indiana.

While no ledges of stratified rock were available for study, interesting problems were presented relative to the glacial deposits, the formation of sand dunes and prairies, the former extent southward of Lake Michigan, etc., and a discussion of these and many other features is given in the paper which follows. It is also accompanied by a map showing the more salient physiographic features of the area under consideration.

The Clays and Clay Industries of Northwestern Indiana.—Since the publication of the paper on the "Clays of the Coal-Bearing Counties of Indiana," in the report of this Department for 1895, the interest in Indiana clays and their possibilities for manufacturing purposes has largely increased. Scarcely a day passes but that inquiry by letter or person is made at the office of the Department concerning the clay resources of the State. Large factories have been recently erected near Mecca and Montezuma, Parke County; Brazil, Clay County, and Martinsville, Morgan County, for the purpose of utilizing the deposits described in detail in the report cited, and additional factories will be erected in 1898 west of Terre Haute and north of Brazil.

After the completion of the work in Lake and Porter counties, all the available time of the writer for the remainder of the season of 1897 was spent in an examination of the clays and clay factories of eight of the northwestern counties of the State, and the results of that examination are incorporated in a paper entitled "The Clays and Clay Industries of Northwestern Indiana," which is published in the present volume.

While no material suitable for the best grades of vitrified ware or pottery was discovered in the area visited, much which could be utilized in the making of pressed front brick, hollow brick, terra cotta lumber, and many fire-proof products was found. The largest pressed-brick factory in the State is located at Porter, Porter County, while at Hobart, Lake County, another, of almost equal capacity, is in course of construction. One factory at Hobart has been making terra cotta lumber for ten years, and the owner claimed to have the only deposit of clay in the State suitable for such material. The investigations and chemical analyses made and given in the paper cited prove the presence of a similar clay in a number of other localities in Lake, Porter, Laporte and St. Joseph counties. Capital invested in the making of porous fire-proof products at any or all of the points mentioned will, without doubt, return handsome revenues, since such products are coming into rapid use in the larger structures of all the leading cities of the United States.

The Knobstone shales which come to the surface over a large area in Jackson, Morgan and adjoining counties north and south, have, as yet, been practically unutilized for manufacturing purposes. In July, 1897, a careful study was made of a number of deposits of these shales in Jackson County, and an exhaustive chemical analysis shows their especial adaptation to the making of vitrified brick and sewer pipe. A plant erected by the side of the B. & O. S. W. Railway six miles west of Seymour can hardly fail in furnishing southeastern Indiana with the best grade of such products for a score of years to come.

The practical experience of the past ten years has proven that no more durable material for the making of pavements can be used than vitrified brick, provided sufficient care be taken in the structure of the foundation upon which the brick are placed. Such a pavement comes nearer than any other to a typically perfect pavement; i. e., one which is reasonable in first cost; low in cost of maintenance and easy to repair; durable under heavy traffic, with reasonable freedom from noise and dust; free from decay, water proof and non-absorptive; of low tractive resistance and furnishing a good foothold for horses.

The city of Chicago has recently let the contract for 66 miles of vitrified brick pavements, and a number of miles of brick roadway were constructed in 1897 in the country near Monmouth, Illinois. The making of paving brick is an industry yet in its infancy in Indiana, for the time will come, and that before many years, when not only the streets of every town of two thousand inhabitants within our State will be paved with brick, but also many of our country roadways in those regions devoid of gravel and other road material.

UTILIZATION OF CONVICT LABOR IN MAKING ROAD MATERIAL.—The question of good roads is at present one of the most vital with which the farming community of Indiana has to deal. Many of the better counties of the State long ago realized the importance of this question, and, where road material was conveniently located, constructed gravel or macadam roads radiating in all directions from their county towns. In other counties, possessing a plentiful supply of road material, the importance of the question has not yet been realized, and for six months of the year the farmers are practically isolated from market, or, if they manage to reach it once a week, can only haul thereto a fraction of a load. Such counties are readily recognized as far below the average in wealth, prosperity, and the public spirit of their citizens.

Prof. Latta, of Purdue University, has for some time been making a careful study of the good roads question in the State, and has received reports from hundreds of farmers, some of whom live on good roads once bad, and others on roads still bad. From these reports he has computed statistics showing that the difference between good and bad roads amounts to 78 cents an acre annually on the farms. Applying this amount to the entire State—36,350 square miles, or 23,264,000 acres—we have the sum of $18,145,920. Of this amount, fully two-thirds is wasted every year in the State in the loss of time, and in the loss of opportunity in securing the best market for the produce of the farm.

Moreover, our vehicles for rapid country travel are more numerous and of an entirely different style from what they were twenty years ago. Almost every farmer now owns his own buggy and carriage. The bicycle by countless thousands has come to stay, and the horseless carriage and motocycle will ere long make their appearance upon the scene. The owners of all these lighter forms of vehicles are demanding, and will continue to demand, better roads, and the legislator must soon learn that the question is one of the most important which he has to face.

Through all the panic and depression of the last four years, the farmers in the good road districts of Indiana, have gone on making money and improving their farms, and have not troubled themselves to any extent about politics or finance. On the other hand, those living in the bad road districts have, for more than a third of their time, endured an enforced idleness which has made them poorer, and caused them to cry out against the financial policy of the government, rather than against their own short-sightedness on the road question. Indiana is rich in clay suitable for vitrified brick, rich in gravel, rich in stone for macadam roads. There is no reason, therefore, why every public road of any importance in the State should not be improved so that it can be traveled with ease any day in the year.

In the penitentiary at Michigan City there are to-day almost a thousand able-bodied men who are being marched about to furnish them exercise, because the labor organizations of our State are opposed to their competition. The industry of the honest citizens of the State pays for maintaining these criminals in idleness. Let the General Assembly authorize the purchase of an extensive bed of shale in western Indiana; and the erection on it of a modern paving brick factory. Equip this factory with convict labor, and put several hundred additional convicts to breaking stone for foundation, and cutting it for curbing. This brick and stone can then be furnished at the plant at less than one-sixth present prices to those counties devoid of other road material.

The cost of a paving-brick plant, completed for work, which has a capacity of forty thousand output per day, is about forty thousand dollars. One with double the capacity costs about $60,000. The greater amount of this expense is for buildings and kilns which could, by convict labor, be constructed of brick made on the spot, so that the cost to the State would be less than half this sum. After the plant is once in operation, with fuel and raw material both at hand, the only outlay is for labor. Where the daily output is eighty thousand brick, and the fuel is mined in connection with the shale, the number of hands necessary is about 125. These, at $1.50 each per day, would make the cost of the brick about $2.35 per thousand. With convict labor, the actual cost of the brick would be only the sum paid out for the maintenance of the prisoners. At 50 cents per capita, this would amount to about 80 cents per thousand. With a plant erected which will give employment to 375 men, 240,000 brick can be made daily. A year's output will be sufficient to pave almost one hundred miles of roadway.

The paving brick can be sold to the counties constructing the roads at $1.00 per thousand, which would require an outlay of but $760 per mile. The crushed stone prepared by convict labor can be furnished at 30 cents per cubic yard, and the curbing at a correspondingly low price. A road of vitrified brick, which will last a quarter of a century or longer with little expense for maintenance, can then be built and need cost but little if any over $2,500 a mile, the most of which would be for grading and the laying of the brick. For, understand, the plan proposed does not consider that the convicts be employed except in the preparation of the material, the latter to be furnished at cost to the counties. All grading, teaming, bricklaying, etc., should be done by free labor, as it is at present. The day of the chain gang at work on the roadside, subjected to the gaze and jeers of the passer-by, is, rightfully, a thing of the past.

Five years ago California was in the same situation as Indiana is to-day. Her convicts were idle in deference to the wishes of her labor organizations. Her legislators passed a law authorizing the employment of the convicts in the breaking of stone for road material. To-day that State is supplying the prepared stone to the counties at 28 cents a cubic yard, on board the cars, which is less than one-third the ordinary market price; yet sufficient to pay for the maintenance of the convicts. The railroads of the State are carrying the material at the bare cost of hauling, for they realize that the improved country roads will bring to them in the future a great increase in farm products for shipment.

Many objections to the plan proposed will doubtless arise, for the questions to be solved are important ones, and for that reason no plan can or will be presented but what will have its weak points. The most serious of these objections is the cost of a new prison which would necessarily have to be constructed at the plant. This, however, would be much less than is generally supposed, since the shale can be burned into ordinary and pressed front brick of the finest quality. The brick could, therefore, be made and the prison constructed by the convicts themselves for a very reasonable cost. Moreover, fine building and pressed front brick could be made and furnished the other institutions of the State, at cost, whenever needed, thus reducing materially the amounts necessary to be appropriated from the public funds for new buildings and repairs. It seems, therefore, that given an ever-growing demand for better roads; an abundance of nature's products which can be made into the best of road material, and 850 convicts able and willing to work, that we have a combination which, under the proper management, would give us the improved roads, furnish employment for our convict labor, and yet give no offense to that army of honest workingmen whose interests and welfare are ever to be upheld.

REPORT ON THE NIAGARA LIMESTONE QUARRIES.—The Niagara limestones of southeastern Indiana have, for a number of years, been extensively quarried, especially in Decatur, Franklin and Fayette counties. As yet, however, no detailed report upon the properties and uses of the stone, or the leading features of the deposits has been published. During the past season, Dr. August Foerste was engaged in collecting information for such a report, which he has prepared for the present volume.

The most valuable variety of the Niagara stone quarried is typically exposed in the vicinity of Laurel, Franklin County, and so to all stone of that variety the name "Laurel limestone" has been applied by Dr. Foerste.

This stone can be quarried more easily and at less expense than any other stone of a similar nature in the State; the natural seams and even bedding doing away largely with the necessity for drilling and blasting. The stone occurs in natural slabs of a uniform thickness—two to twenty inches—and with the upper and lower surfaces very even, so that for many purposes tool dressing after quarrying is not necessary. It is of a handsome color, very hard and durable, and is used extensively for flagging and curbing, and to a less extent for window sills, window caps, range stone, ashlar, door-steps, foundations, street crossings, gutter stone, pier footings, bridge abutments, etc. For many of these uses it is better suited, and can be furnished more cheaply, than either the Bedford oölitic limestone or the Berea (Ohio) sandstone, the two materials with which it comes in closest competition. The railway facilities of the region about Laurel and other localities, where the best deposits are found, are, as yet, very poor, the stone from most of the quarries being hauled on wagons to the cars. With several good switches to the leading deposits, this stone could be put on the market for a lower price, and yet with a greater profit, than is now secured; and its superior quality would soon lead to its extensive adoption for those purposes for which it is so well fitted.

CATALOGUE OF THE FOSSILS OF INDIANA.—The subject of paleontology has, during the past three years, received but little attention in the reports of this Department. That subject had been quite fully treated by my predecessors, and the economic resources of the State, which have been constantly growing in importance, demanded the time and energies of the force at my command. That the paleontology of the State be wholly neglected was not intentional, however, and Mr. E. M. Kindle has, therefore, prepared for the present volume a list of all the fossils known to occur in the State. This list shows also the geological formation in which each species is found, and is accompanied by a bibliography of Indiana paleontology, making a paper which will doubtless be of much value to all collectors and students of the remnants of that rich fauna and flora which once existed in or near the waters in which the rocks of our State were laid down.

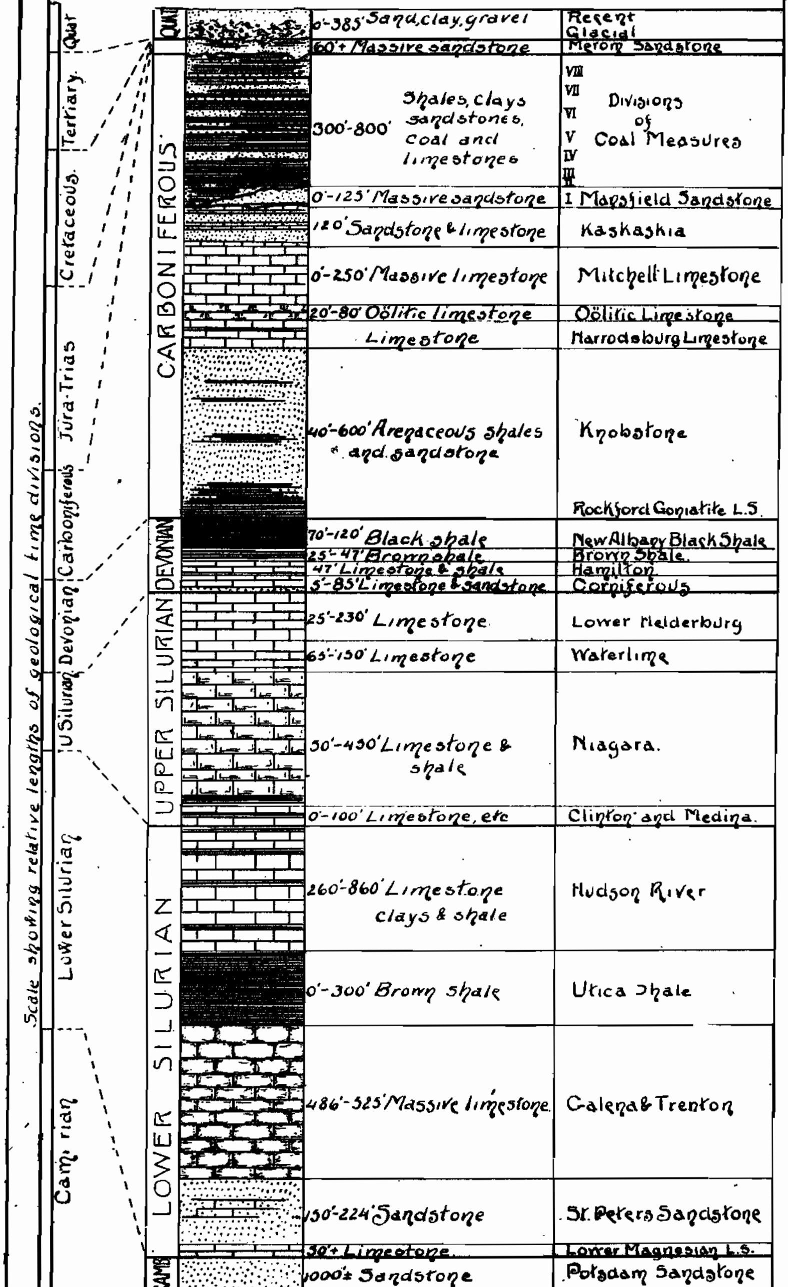
THE BIRDS OF INDIANA.—Students of Natural History throughout the State have long felt the need of a descriptive work on the birds of Indiana, which would enable them to readily recognize any species which might come into their hands. Such a work, I am pleased to say, has been prepared for the present volume by Mr. A. W. Butler, formerly of Brookville, Indiana, now Secretary of the Board of State Charities. Mr. Butler has devoted many years to the study of Indiana birds, and no man in the State knows more of their habits and distribution than he. For twenty-two years he has been gathering the data for such a report, and for that reason it can be relied upon as accurate and comprehensive.

In the paper will be found a description of each of the 321 species of birds which have been identified within the bounds of Indiana in the past; together with a description of the nest and eggs, and a statement of the geographical range of each species. An artificial key to the species is also given which will enable any one, after a little practice, to bring about their ready identification.

An account of the food habits and song of each species is also added, together with a statement of its abundance or scarcity, the season of the year in which it occurs within the State, and the time of its arrival therein and departure therefrom. A bibliography of the literature pertaining to Indiana birds and a list of those species which, by reason of their reported occurrence in adjacent States, may also occur within Indiana, is also given.

The work has been prepared with as few technical terms as possible in order that it may be readily used by boys and girls of the farm who come daily in direct contact with the birds, and by the pupils of our schools, who should have a more general knowledge of the names, songs and beneficial habits of our feathered friends throughout the State.

GEOLOGICAL SCALE OF INDIANA.



GEOLOGICAL SCALE OF INDIANA.

BY W. S. BLATCHLEY AND GEO. H. ASHLEY.

At my suggestion, Mr. Geo. H. Ashley has prepared for the present volume the accompanying table* (Plate II.), showing a columnar section of all the rocks of the State, the time period during which each group was laid down, a statement of the character of the dominating rocks of each group, and in the last column the names given to the more important subdivisions.

THE POTSDAM SANDSTONE.—In most instances in which bores for gas or oil have pierced the full thickness of the Trenton limestone, the underlying sandstone has been recorded as Potsdam sandstone. It is probable, however, that Potsdam sandstone has been reached only in the deep wells at Hammond, Crown Point and LaPorte at a depth of about 600 feet below the bottom of the Trenton. At Crown Point it was pierced about 1,000 feet without reaching its base. It does not outcrop in the State.

THE LOWER MAGNESIAN LIMESTONE.—According to Phinney, (loc. cit. p. 625) this stratum is represented by the last 50 feet pierced by the drill at Bloomington, and probably also by the boring at Greenwood, Johnson County. It is a grayish, sandy limestone, and outcrops near Utica, Illinois, but nowhere in this State.

THE ST. PETER'S SANDSTONE.—This formation has been penetrated by a number of bores which have passed through the Trenton limestone, and has usually been recorded as Potsdam sandstone. It varies from a pure sandstone to a sandy limestone, and is usually of a light color. It outcrops near Utica, Oregon and Polo, Illinois, and also in Wisconsin, but not in Indiana. It is a very porous rock, well

*In the preparation of this table and text Mr. Ashley and myself have drawn largely on the details given by Mr. A. J. Phinney in his paper on the "Natural Gas Field of Indiana," published in the Eleventh Annual Report of the U. S. Geol. Survey; and also upon the recent papers of Messrs. Hopkins, Siebenthal and Kindle in the last two reports of this Department; while upon Mr. Ashley's work in the field is based that portion of the table pertaining to the coal measures and overlying beds.

adapted for transmitting water, and is a common source of much of the water in many of the deep artesian wells of northern Illinois and Indiana.

THE TRENTON AND GALENA LIMESTONES.—This formation has become popularly known as the reservoir of most of the natural gas and oil found in the State. It is a massive stratum of limestone with a very little shale in places. Where containing gas and oil it is dolomitic in nature, and much more porous than where devoid of those bitumens. It probably underlies the entire State, with an average thickness of about 500 feet. It does not outcrop within the State, and its known closest proximity to the surface is near Lawrenceburg, where it is 348 feet below.

The upper and later portions of the Trenton are lead-bearing in Illinois and other States, and to them the name Galena limestone has been applied. These portions are darker than the typical oil-bearing Trenton, and have been struck in a number of the deep wells in northern Indiana.

THE UTICA SHALE.—This formation is a persistent, fine grained, dark brown or black shale, which immediately overlies the Trenton and forms the necessary impervious cover above the oil and gas-bearing portions of that limestone. In the eastern half of the State the Utica has a recorded thickness of nearly 400 feet, but grows thinner to the northwest, and seems to be wholly absent in the bores in Lake and Porter counties. It does not outcrop in Indiana, but probably underlies the greater portion of the State.

THE HUDSON RIVER LIMESTONES AND SHALES.—These are the oldest rocks which come to the surface in Indiana. They outcrop only in the southeastern corner of the State; forming the surface rocks over all or a portion of the counties of Switzerland, Ohio, Dearborn, Franklin, Union, Wayne, Fayette and Ripley. In several of the adjoining counties to the west they are also exposed in the ravines and deep cuts. This formation consists of bluish-green shale, bluish limestone and clays; the limestone being most prominent in the upper part of the series. The greatest recorded thickness of the formation is 860 feet. It thins to the northwest, being represented in the bores at Crown Point by only 122 feet of bluish-green shale. The upper part of the series is very fossiliferous, and has been long and extensively studied.

THE CLINTON LIMESTONES.—This formation, which is represented by thick deposits in some of the Eastern States, is known in Indiana only as a thin stratum of salmon brown or reddish, rather coarse-grained limestone. It outcrops over small areas in several counties of the southeastern corner of the State,* and has been pierced by a number of bores in the northern portions.

THE NIAGARA LIMESTONE.—In the stratigraphy of Indiana, this subdivision comprises the greater portion of the Upper Silurian period, forming the surface rocks in a number of counties in the eastern and northern portions of the State. The base of the formation consists of a characteristic bed of bluish-green shale ranging in thickness from 2 to 40 feet. Overlying this is a heavy stratum of limestone varying from 100 feet in thickness along the Ohio River to 440 feet in the northern and northwestern portions of the State. This limestone ranges from a sub-crystalline buff, through a bluish crypto-crystalline to a bluish-green shaly limestone. In Decatur, Franklin and Wabash counties, it is largely quarried for flagging, curbing and similar uses; and near Huntington and Delphi it is used extensively for lime.

THE WATERLIME AND LOWER HELDERBURG.—These are closely related limestones, whose known thickness in the State varies from 15 to 150 feet, and 25 to 250 feet, respectively. The Lower Helderburg is a buff to gray cherty limestone, which, when exposed by erosion, is often irregular and uneven in its bedding. It outcrops along the Wabash River near Logansport and farther northwest near Monon and Rensselaer. The Waterlime is chiefly represented in northern Indiana, outcropping near Kokomo, where it is extensively quarried for building material, and also near Logansport. Farther north it so merges into the Lower Helderburg that the two are difficult to distinguish.

THE CORNIFEROUS.—This formation is represented in Indiana by sandstones 15 to 20 feet thick, thought to correlate with the Schoharie group of New York, and by limestones 5 to 65 feet thick, correlated with the Upper Helderburg. The petroleum at Terre Haute probably has its origin in the limestone of this subdivision.

THE HAMILTON.—Dr. Phinney ascribes to this group a 20-foot stratum of brown calcareous shale and an overlying bed of dark gray limestone, 27 feet in thickness, which were penetrated by a bore at Goshen. The formation has not yet been recognized in southern Indiana.

THE NEW ALBANY OR GENESEE SHALE.—This shale, and a persistent underlying brown shale, forms the top of the Devonian system in Indiana, and has been recognized in all the deep bores

*See paper by August Foerste, 21st Rep. Ind. Geol. Surv., 226; also paper by same author in this volume.

drilled west of its eastern outcrop. This outcrop extends from the Ohio near New Albany in a northeasterly direction through Floyd, Clark, Scott, Jefferson and Jennings counties, then northwestwardly through Bartholomew, Johnson, Marion, Boone, Clinton, Carroll and White counties. The shale forms the surface rock of an area eight to fifteen miles wide in these counties or those adjacent on the west. It is also known to be the formation immediately underlying the drift over quite a large area of the two northern tiers of counties in the State.

This shale is rich in bitumens, and when kindled will burn until they are consumed. These bitumens are, by natural processes, often separated from the shale, and in the form of gas or petroleum, are collected in reservoirs in it or underlying strata. Such reservoirs form the source of the gas and oil hitherto developed in Washington, Harrison and Pike counties. As a rule the quantity so collected is not large and the supply is, therefore, soon exhausted.

THE KNOBSTONE.—Overlying the Rockford Goniatite Limestone, which is a thin bed of limestone and calcareous shale forming the base of the Subcarboniferous, is the Knobstone. This formation consists of a series of alternating shales and sandstones, which, in places, reach a thickness of 600 feet. It can probably be correlated with the Waverly group of Ohio and Michigan. The Knobstone comes to the surface in a strip five to forty miles in width, extending over a portion or all of Clark, Washington, Jackson, Brown, Morgan, Hendricks, Boone and Montgomery counties. In some places the shales of this horizon will be found to be excellently adapted to the making of vitrified wares, as paving brick, sewer pipe, etc.,.though, as yet, their possibilities of service in this way have been ignored.

THE HARRODSBURGH LIMESTONE. — This subdivision, sometimes called the Keokuk, consists of limestones and shales with a total thickness of 60 to 90 feet. It forms the surface of a belt four or five miles in width between the Knobstone and the oölitic limestone. Where found it is accompanied by great numbers of geodes or "mutton heads."

THE OÖLITIC LIMESTONE.—This subdivision is the source of the "Bedford Oölitic limestone," so widely and favorably known as a building and ornamental material. The stone is a calcareous sandstone or freestone, differing from other sandstones in having the grains composed of practically pure carbonate of lime instead of quartz: and from other limestones in its granular texture and freestone grain. It usually appears as a massive bed, varying in thickness from 25 to 100 feet, and in color from buff to blue. It comes close to the surface in a belt two to fourteen miles in width, which extends from Greencastle, Putnam County, to the Ohio River, through Owen, Monroe, Lawrence, Washington, Perry and Crawford counties.

THE MITCHELL LIMESTONE.—The name was applied by Messrs. Hopkins and Siebenthal to the series of impure limestones and calcareous shales, aggregating nearly 250 feet in thickness, which overlies the oölitic limestone. It is in this formation that the many sinkhole and caves of southern Indiana occur. Lithographic stone of good quality has also been found to be a member of the series, but as yet has not been discovered in commercial quantities.

THE CHESTER OR KASKASKIA.—This group, recognized by E. M. Kindle, occurs in the counties bordering the coal measures on the east from Putnam County southward. It consists of three limestones separated from each other by sandstones,* the total thickness of the series being about 120 feet. It contains some stone suitable for building purposes.

THE MANSFIELD SANDSTONE.—This, the basal member of the coal measures, corresponds to the "Millstone Grit" of adjoining States. It consists of a medium to coarse-grained massive sandstone, associated with isolated deposits of conglomerate shaly sandstone, shale, coal and fire clay, the whole approximating 125 feet in thickness. It forms the surface rock over a strip of two to twelve miles in width, extending from the north part of Warren County in an east-of-south direction to the Ohio River, a distance of 175 miles. In a number of localities, notably at Attica, Williamsport and St. Anthony, the sandstone is quarried; while at Portland Mills and Mansfield, Parke County, and near Bloomfield, Greene County, are excellent deposits of a brown variety of the stone which is especially adapted for a finishing material for buildings whose fronts are composed of pressed brick. The whetstone and grindstone rocks of Orange and Martin counties are also members of this group. The kaolin of Lawrence and Martin counties also occurs near the base of this division.

THE COAL MEASURES.—The coal measures, including the Mansfield sandstone, occupy all of fifteen counties from Vermillion and Parke southward, and most or part of 11 additional counties extending from Benton southeast to Perry County. The rocks consist of shales, sandstones, clays, coal and limestone. Of these, the first greatly predominates. In thickness the coal measures vary from 300 to 800 feet. Measurements across the outcrop show an average of about 400 feet, but a number of deep drillings in Daviess and Knox counties indicate

*See 20th Rep. Ind. Dep. Geol. and Nat. Res., 1895, 331.

that the lower part of the measures have been overlapped, and increase the thickness in that region to 800 feet.

The shales of the coal measures are in many places very suitable for the manufacture of paving brick, sewer pipe and allied products, and with the clays underlying the coals, are being extensively developed. The coal occurs in basins ranging from a part of an acre up to hundreds of square miles, the coal veins and accompanying strata increasing in persistency and in size of coal basins from the bottom to the top. About 30 horizons have been noted at which coal is found, though only a few of these show coal persistently. The most of the coal is obtained from five horizons, though locally, coal of good, workable thickness occurs at, at least, five other horizons. Most of the coal is of the caking bituminous variety, though much of that occurring in small basins near the bottom of the measures is either non-caking or splint (the so-called "block coal"), or semi-caking. Good cannel coal occurs locally. In thickness the beds vary up to 10 feet, the "block coal" having an average in the mines of 3 feet 1 inch, the caking coals where extensively mined, will probably average four and one-half or five feet. The "semi-block" coals will average between the others. The total thickness of coal at any given point will range up to 32 feet, but over much of the field will range between 10 and 15 feet, not more than one-third or one-half of which is workable under present trade conditions.

The coal measure sandstones, though often of considerable thickness, are seldom of desirable quality, though locally very desirable stone is found. The limestones, though thin, are usually quite persistent. Some gas has been obtained from the bituminous shales which often accompany the coal.

THE MEROM SANDSTONE.—This is a massive, coarse-grained sandstone, some 60 to 200 feet thick, lying unconformably on the coal measures. Its age is in doubt, being probably either Permian or Triassic. With some doubt the sandstone filling deep and broad erosion channels in the north part of the coal area has been thought to correlate with the Merom sandstone of Sullivan County. In that case this sandstone furnishes the glass sand of Coxville, the building sandstone of Silver Island, Fountain County, and elsewhere.

TRIASSIC TO TERTIARY, INCLUSIVE.—The only deposits of these ages known (with the possible exception of the Merom sandstone as noted) are some gravels found on certain high ridges in Martin and Perry* counties, and possibly elsewhere. These are outside of the drift area, and above any known stream deposits of

*See Cox, E. T.—Geol. Surv. Ind., 1872, 138.

gravel. Taken in connection with the uniformity of elevation reached by the highest hills, in the Mansfield sandstone area, the Knobstone area and the Silurian area in the southern part of the State, it has been suggested by Mr. Frank Leverett, of the United States Survey, that at least southern Indiana was reduced to base level in Tertiary time. In that case the present and preglacial topography of Indiana would date from some time in the Tertiary. This Tertiary erosion might also account for the absence of Cretaceous deposits, if any such were ever laid down in Indiana. Until more study shall have been given these gravels and their interpretation, the matter of this paragraph must be considered more as a suggestion than as a demonstrated fact.

Recent and Glacial. — The present surface of Indiana is a gently sloping plain, whose extremes of level are 313 and 1,285 feet above tide. More than three-fourths of the area of the State is covered with glacial drift deposited by several successive invasions of the great Laurentide glacier. The known thickness of this drift ranges from 0 to 485 feet. Its materials are, for the most part, foreign and derived from the vast area of crystalline rocks which occupy the region in which the glacier had its source. The sedimentary rocks of the northern part of Indiana were, of course, ground down by the overriding ice, the shales being reduced to clays, the sandstones to fine sand and the limestones to drift marl. These resulting materials were thoroughly mingled, not only together, but with those from the north, and spread out in a gradually thinning mass to the southward. The soils of this glaciated area of the State are, therefore, rich in the various elements which comprise the food of plants, and require a much less outlay for artificial fertilizers than the residual soils of the unglaciated portion of southern Indiana.

This driftless area comprises all or a large portion of each of the following counties: Posey, Vanderburgh, Warrick, Dubois, Spencer, Perry, Crawford, Orange, Martin, Lawrence, Monroe, Brown, Jackson, Washington, Floyd and Harrison. In addition, small portions of Gibson, Greene, Morgan, Bartholomew and Clark are included in its bounds. The greater portion of the driftless area "and the southeastern part of the drift plain is a region of deep, narrow valleys, bounded by precipitous bluffs, and separated by sharp, irregular divides. Isolated knobs and buttes are numerous; their crests and summits being from 300 to 500 feet above the valley bottoms. The streams are rapid and broken by frequent cataracts. All open into the Ohio Valley, a trench from one to six miles wide, 400 feet deep and bounded by steep bluffs."*

*Dryer.—Stud. in Ind. Geog., 1897, 19.

THE GEOLOGY OF LAKE AND PORTER COUNTIES, INDIANA.

BY W. S. BLATCHLEY.

Occupying the extreme northwestern corner of Indiana are the two counties of Porter and Lake, together comprising 920 square miles of territory. This territory is bounded on the east by Laporte County, Indiana, on the south by the Kankakee River, on the west by Cook, Will and Kankakee counties, Illinois, and on the north by Lake Michigan.

Location and Area. According to the United States Survey, the area comprising these two counties lies in Townships 31 to 38, inclusive, north of the base line of Indiana, and in Ranges 5 to 10, inclusive, west of the Second principal meridian. Valparaiso, the county seat of Porter County, and located near its center, is in latitude 41 deg., 28 min., north, and in longitude 87 deg., .04 min., west, while Crown Point, the county seat of Lake county, is in latitude 41 deg., 25 min., .07 sec., north, and in longitude 87 deg., 22 min., 30 sec., west of Greenwich.

The two counties were at first united, but by an act of the Legislature approved January 18, 1837, that portion of their territory lying west of the center of Range 7, west, was organized as Lake County, and was declared to be independent after the 15th day of February, 1837. This division gave to Lake County an area of 500 square miles and left in Porter County 420 square miles. With its northwestern corner lying within 12 miles of the Court-house of Chicago, the area comprised in these two counties is destined to become as valuable as any of equal size in the State of Indiana.

GENERAL PHYSIOGRAPHY.

In the present paper we have to deal principally with the physiography or surface features of the area under consideration since not a single outcrop of paleozoic rock is known to occur in the two counties. Their 920 square miles is a *plain of accumulation*, being everywhere covered with a sheet of glacial drift ranging in known thickness from 90 to 141 feet.

If a person could rise in a balloon so as to get a bird's eye view of this plain, or if he would traverse it from north to south at intervals of a few miles, he would see that it comprises three distinct belts or regions, each with well-marked surface characteristics. The region on the north and the one on the south would each be seen to be lower, and comparatively much more level than the one intervening. Along the upper margin of the northern region would be noted, however, a narrow strip covered with numerous hills and ridges of sand. The surface of the middle region, comprising more than half of the entire area, would in some parts be seen to be high and undulatory, in others more even and regular, but on the whole much more rugged and broken than either of the other two. To these regions the following names may be applied:

1. THE CALUMET OR NORTHERN REGION, so called because the Calumet River flows east and west through its full width, comprises approximately 250 square miles, 162 of which are in Lake County and 88 in Porter. On the western border of Lake this belt is 15 miles wide, but it narrows as it passes to the northeast until it is but eight miles in width, where it passes into Porter County, and but seven miles where it leaves that county at the northeastern corner. This region, as we shall see, owes its surface configuration partly to a former extension of Lake Michigan southward, and partly to the action of the wind on the sand thrown up by the present lake.

2. THE MORAINIC OR MIDDLE REGION. Four hundred and eighty-five square miles of the surface of the two counties are comprised in this belt, about 250 of which lie in Lake and the remainder in Porter. The higher altitude and more rugged surface of this area is due to its being covered with a much thicker mass of glacial debris which was dropped where it now lies by a lobe of the great Laurentian ice-sheet. Since its deposition its surface has been modified only by wind, frost and erosion by small streams. On the western border of Lake County this belt of drift is 17 miles in width. Where it passes into Porter County its width is approximately the same. In that county it trends to the northeast and gradually narrows until at the point where it leaves the county it is but about seven miles in width.

3. THE KANKAKEE BASIN OR SOUTHERN REGION. The remaining 185 square miles of the two counties are comprised in this region, 80 of them lying in Lake County and 105 in Porter. In the former county most of this area is marsh land, which up to the present has not been drained sufficiently for thorough cultivation. In Porter County the marsh area is much less, a large part of the Kankakee basin, being composed of rich, and at present, well drained prairie lands. A more detailed account of each of these regions will follow hereafter.

THE UNDERLYING ROCKS.

If through the great sheet of drift which covers the surface of Lake and Porter counties a bore be driven, as has been done in a number of places, solid or bed rock will be struck at varying depths. In Porter County and in the eastern two-thirds of Lake County this rock has been found to be the black Genesee shale of the Devonian age. In the south half of the western third of Lake County it is the Lower Helderburg limestone, while in the north half of the same area it is the Niagara limestone, both of the Upper Silurian age. Whatever its nature the formation immediately underlying the drift was, at one time, laid down as sedimentary rock in the bottom of a shallow sea, and several millions of years ago, was raised into dry land.

The Black or Genesee Shale.

The black shale, which, during a very long period, formed the surface over the greater portion of this area, when first brought up from the deep bores in Porter and Lake counties, has a black to bluish gray color, but an exposure to air soon changes to a light gray or drab. It is a soft material, easily pierced by the drill, and is composed mainly of very fine grains of sand (silica) and alumina cemented together by iron (ferric) sulphide and thoroughly saturated with bitumens. The proportions of these constituents are shown in the following chemical analysis of a sample of the shale from New Albany, Indiana:*

ANALYSIS OF GENESEE SHALE.

Water expelled at 100°C	0.50
Volatile organic matter (bitumen)	14.16
Fixed carbon (bitumen)	9.30
Silica	50.53
Pyritic iron and alumina	25.30
Calcium oxide	0.09
Magnesium oxide	0.12
Total	100.00

The bitumens doubtless owe their presence in the shale to the slow decomposition of a vast number of marine plants and animals which were deposited with the sand and iron sulphide by the turbid waters of the old Devonian seas. Once so deposited these organisms did not decay as do animals on land, since by the waters above and the mud and ooze about them they were shut off from the free oxygen of the air which is the principal agent in decay. They underwent, instead, a process of slow decomposition, the products or residue of which are

*See article by Hans Duden, in 21st Annual Report, Department of Geology and Natural Resources of Indiana, 1896, 108-119, entitled "Some Notes on the Black Slate or Genesee Shale of New Albany, Ind."

known as bitumens. These bitumens in time saturated the surrounding sediment and gave to it its distinctive black color. They have since remained closely associated with this sediment, which, by great pressure, has been compressed into shale or laminated clayey rock.

The bitumens, when separated by distillation or otherwise, will burn readily with a bright flame and without leaving a residue.* On account of their presence the shale itself may be set on fire and will burn until the bitumens are consumed. The sand, alumina and iron sulphide being non-combustible, the shale retains its shape after the bitumens are burned out, but is changed in color to a reddish brown. On account of this property of partial combustibility, the black shale is often mistaken for coal by persons who are unacquainted with its true nature.

This Genesee shale is known to be the formation immediately underlying the drift over quite a large area of the two northern tiers of counties in Indiana. In a strip eight to fifteen miles wide, extending from Jasper County in a southeasterly direction to the Ohio River at New Albany, it also lies next below the drift or forms the surface rock. West of this strip it lies at greater depths beneath the Subcarboniferous and Carboniferous limestones and shales which comprise the surface rocks of Southwestern Indiana. Its thickness as noted at a number of points in the State is as follows:

New Albany	104 feet.
Salem	103 feet.
Seymour	115 feet.
Bridgeport	124 feet.
Goshen	140 feet.
South Bend	95 feet.
Valparaiso	65 feet.
Crown Point	112 feet.

This shale undoubtedly once covered a much larger area south and east of the ones above mentioned; but during the long interval between its rise above sea level and its burial beneath the drift, that area was reduced by extensive erosion.

The Lower Helderberg Limestone.

The Lower Helderberg, which lies next to the drift in the southern half of the western third of Lake County, is a buff or gray cherty limestone. Where it is exposed by erosion it is often irregular and uneven in its bedding. The best exposure of this formation in Indiana is along the Wabash River above and below the City of Logansport. Further northwest it comes near the surface at Monon and Rensselaer, in Indiana, and in Kankakee and Iroquois counties, Illinois.

*Mr. Duden, by a process of distillation, obtained from 8.5 pounds of the shale 65 gallons of 22 candle-power gas. He also states that in Scotland, in 1890, 62,500,000 gallons of crude petroleum and 25,000 tons of sulphate of ammonia, the latter a valuable fertilizer, were made from a similar shale.—*Loc. Cit.*, pp. 113-114.

The Niagara has been found by borings to underlie the drift in the vicinity of Hammond, Lake County, and between there and Chicago. Over a large portion of the eastern half of Indiana it also forms the surface rock. It is a bluish or buff, sub-crystalline limestone, usually rich in the fossil remains of those marine animals common to the epoch of its formation. Near Chicago this limestone contains much petroleum, but in such a minutely diffused state as to be wholly without value.

The Niagara Limestone.

Could all the drift be removed from the surface of Lake and Porter counties the elevations of the different portions of the exposed surface would be found to vary but little, and the three formations—Genesee Shale, Lower Helderberg and Niagara limestones—would be exposed as the surface rock, each occupying its respective area above mentioned. If the black shale could in turn be stripped from the area which it covers, beneath it would be found the Lower Helderberg, and beneath that the Niagara.*

GLACIERS AND GLACIAL DEPOSITS.

In the surface rocks below the drift which covers Lake and Porter counties there doubtless exist many shallow valleys and perhaps some deep ones, remnants of those of pre-glacial days. For, be it remembered that during thousands—aye, millions—of years, these surface rocks were once dry land. Decay and erosion were in action then as they are to-day. 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, probably, that of to-day 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 soil—formed from decaying rocks and vegetation—poorer, perhaps, than much of that which at present covers the surface of the two counties—resembling closely, perhaps, that now found in Scott, Jennings and Floyd counties, where the black shale has 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

*Between the Genesee shale and the Lower Helderberg might be found the Upper Helderberg, and between the Lower Helderberg and Niagara the Waterlime. But in Indiana the Upper Helderberg is often very thin or altogether wanting, while in the northern counties of the State the Waterlime is so similar to the Lower Helderberg that the two are difficult to distinguish.

the regions to the east and south of Hudson's Bay became similar to that of Greenland to-day, 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 and 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 exponents of the direction in which the glacier moved.

Origin of Glaciers.

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 a straight line, but in lobes or long, gradual curves. Mr. B. F. Taylor has given the following graphic description of the ice sheet at the time of its greatest advance into the regions now comprising Indiana:*

Glacial Epochs.

"When the glacier covered most of Indiana 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

*Studies in Indiana Geography, 1897, 102.

ice front extending south towards Kentucky, while to the west it would have been seen in the distance stretching away towards 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 to-day."

A Terminal Moraine.

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 bowlders, which have been dropped on the surface in more or less regular concentric lines. Such bowlders 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 bowlders 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. It is usually between them and occupying depressions caused by their divergence that most of the larger lakes embraced in the moraine are found......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.

As already noted, a large area of the present surface of Lake and Porter counties is covered by a portion of a terminal moraine possessing many of the characters above described. The city of Valparaiso is located near the crest of the main ridge, and for that reason the name "Valparaiso moraine" has been ascribed to it. According to Frank Leverett,† who has made a special study of a portion of this moraine, it begins near the Illinois and Wisconsin line and extends southward through portions of Lake, McHenry, Cook, Dupage and

* Chamberlain, T. C.—Third Ann. Report, U. S. Geol. Surv., 1883, 311.
† See Bull. Chic. Acad. Science, No. 2, 1897, p. 26.

Will counties, Illinois. In Will and southern Cook counties it turns to the southeast and enters Lake County, Indiana, from the southeastern portion of Will County. Throughout this course it ranges from ten to fifteen miles in width, and its inner border lies nearly parallel to the shores of Lake Michigan and distant from it about 12 miles. Its leading features in Lake and Porter counties will be described more in detail hereafter.

The Valparaiso Moraine.

From Porter County it extends northeasterly across Laporte County, the town of Otis lying near its inner margin. Still pursuing a northeasterly course, it extends through portions of Berrien, Cass, Kalamazoo, Barry, Kent, Ionia and Montcalm counties, Michigan, beyond which it has not been definitely traced. In the words of Dr. Chamberlain:* "It may be likened in a general manner to an immense U, embracing the great lake between its arms. This gigantic loop is over 200 miles in length and from 90 to 150 miles in width. The parallelism of this moraine to the lake shore is one of its most striking features."

Each of the great divisions or lobes of the main glacier has been given a special name by those geologists who have studied the limits of its advance. The division which once partly covered the area now comprising Lake and Porter counties is known as the Michigan lobe—its outline having roughly corresponded to the area at present occupied by Lake Michigan. Over the area now covered by the Valparaiso moraine other ice sheets had, no doubt, previously advanced and receded, but that moraine, as now limited, is due to the last advance of the great Michigan lobe. The final retreat of this lobe was towards the northeast.

As it slowly receded it left between the border of the inner slope of the Valparaiso moraine and the edge of the retreating ice a low area, which was soon covered with water from the melting glacier and from rainfall. A lake was thus formed whose waters were dammed up on the north and northeast by the ice of the retreating glacier, and on all other sides by the moraine which this glacier had left behind it. This lake continued to rise until it overflowed the moraine at its lowest point, which happened to be to the southwestward, near the present city of Chicago. At this point a channel was eroded, through which, for a long period, the waters of the glacial lake found their way to the Des Plaines River, and thence by way of the Illinois to the Mississippi. To this channel has been given the name "Chicago Outlet," and the glacial lake which formed it is known in geological literature as "Lake Chicago."

Formation of Lake Chicago.

* Third Ann. Report U. S. Geol. Surv., 1883, 322.

The area of this lake was necessarily a variable one; since the ice dam on the north was all the time slowly receding. However, the name Lake Chicago is applied to all its stages* from the time of the first opening of the Chicago outlet until its final closing on account of the overflow of the Great Lakes, finding for itself a new channel through the Niagara River.

Area of Lake Chicago.

On the south, Lake Chicago, during its first stage, extended into Lake County as far as the high sandy ridge passing east from Dyer through Schererville. East of this ridge the southern border of the lake lay south of Turkey Creek and Deep River, in the northern part of Ross Township. In Porter County it turned sharply to the northeastward, following the border of the moraine to near the center of section 18, Portage Township, then southeast up the valley of Salt Creek to section 32, where it again turned to the northeast. According to Leverett, who has studied carefully the limit of the lake in this region, the sand ridges which lead northeast from Crissman mark the southern limit of the lake proper in Porter County, so that the plain along Salt Creek and east from there to Chesterton and a narrow strip northeast of Chesterton along the Calumet River to near the line of Porter and Laporte counties was covered by a nearly enclosed shallow bay. This bay apparently opened into the lake proper at the Little Calumet, in section 31 (37 north, 6 west). There was probably a similar bay east of Deep River and south of the village of Lake, which opened into Lake Chicago at the head of Turkey Creek, south of Griffith.

I. THE CALUMET OR NORTHERN REGION.

The high ridge which was mentioned above as being the limit of Lake Chicago near Dyer, is but one of three prominent ridges or beaches which mark in part the old shore line of that lake in Lake and Porter counties.

The Upper or Glenwood Beach.

The one at Dyer is the upper beach thrown up by the first stage of the lake. To it the name of Glenwood Beach has been given by Mr. Leverett,† since the beach is well exposed near the town of that name, a few miles south of Chicago. In Illinois it has been traced by Leverett from the Illinois-Wisconsin line. North of South Waukegon it lies but one or two miles from the present shore of Lake Michigan. Between Waukegon and Winnetka the beach has been cut away by the encroachment of the waters of Lake Michigan. Below Winnetka it extends a little south of west through Oak Park, Maywood, and La Grange, to near

* Leverett—Bull. Chic. Acad. Science, No. 2, 1897, 65.

† See Bull. Chic. Acad. Nat. Science, No. 2, 1897, 66, *et seq.*

Willow Springs, where it turns to the southeast. Between Willow Springs and Glenwood it is not prominent, the old shore line being "carved on the inner face of the Valparaiso moraine, with banks 5 to 20 feet or more in height, but with only occasional deposits of gravel and sand." Near Glenwood, in the northwest quarter of section 25, (36 north, 13 east), the beach line diverges from the moraine and from this point to Dyer lies from one to two miles to the north of its border. Throughout this distance the beach is composed mainly of deposits of sand and gravel thrown up to a height of 6 to 15 feet above the surrounding surface. In many places these deposits are spread out over an area a half mile or more wide, in the form of small parallel ridges with numerous depressions or sags intervening.

At Dyer, 15 miles due south of the Illinois-Indiana cornerstone, the beach enters Indiana. Here the small ridges have combined into one prominent one, composed mainly of fine sand, whose crest rises rather abruptly 25 to 40 feet above the lowlands of Cady Marsh to the north. The level of the base of the ridge, where crossed by the Monon Railway at Dyer, is 636 feet above tide, so that the crest of the ridge is 80 to 95 feet above the present level of Lake Michigan. The width of the crest itself is but 40 to 70 feet, this distance being practically level. On the south side the slope is much more gradual than on the north, the entire width of the base being 40 to 60 rods. This ridge continues unbroken due east from Dyer about two and a half miles. Small trees of the black oak, *Quercus velutina* Lam., and thickets of crab-apple and other shrubs cover its slopes and crest throughout this distance and have prevented the moving of the sand by the wind. A mile west of Schererville the continuity of the ridge is broken. Sand hills or dunes begin, some of which are 25 to 30 feet in height. These extend two miles east of Schererville, where they end in section 12 (35 north, 9 west).

From this point the shore of the first stage of the glacial Lake Chicago no longer coincides with the beaches which owe their origin to it. The former, as already mentioned, passes to the eastward south of Turkey Creek, while Glenwood Beach sets in again near Griffith, and extends in a northeasterly direction through Ross. A mile and a quarter beyond this station, in section 29 (36 north, 8 west), it joins the Middle or Calumet Beach. Between Griffith and this junction the Glenwood Beach is a half mile or more wide and is composed of several broken ridges of dunes, covered with small black oak timber. Beyond the junction the two beaches—Glenwood and Calumet—lie side by side and trend northeastward to near the Calumet River, two miles northeast of Crissman, Porter County, where they suddenly terminate. Between the station of Lake and this terminal point these two beaches

Calumet Beach near Highland, Lake County, Indiana.

Hart Ditch, cut through Calumet Beach, 1¼ miles west of Highland, Lake County, Indiana.

VIEWS OF CALUMET BEACH.

consist of two or more parallel ridges, each 20 to 30 feet above the depression between them. Several smaller ridges lie also parallel to and north of them.

North of the Calumet River, in Westchester and Pine townships, Porter County, the two beaches are in places separated by a narrow marsh lying just north of the Michigan Central Railway. East of Furnessville the Glenwood Beach lies mainly south of the Michigan Central Railway, while the Calumet Beach lies north of it as far eastward as the vicinity of the Northern Indiana Penitentiary, in Laporte County. Over most of this distance their combined width is about three-fourths of a mile. Between their northern limit and the Lower or Tolleston Beach, lying to the northward, is a great marsh, eight miles long by one-half mile wide, which extends from Michigan City westward to old City West. (See map.)

For some reason, probably that of a great recession of the ice dam to the north of the glacial Lake Chicago, accompanied, perhaps, by a lowering of elevation far to the northeast and the cutting of an outlet in that direction, the waters of Lake Chicago ceased for a time to flow through the Chicago Outlet. They withdrew wholly from the area which they covered in Lake and Porter counties—and even a large part of the southern end of the present Lake Michigan is supposed to have been dry land.

After a long period, by another glacial advance, or an elevation of the territory embracing the northeastward outlet, perhaps both, the waters of Lake Chicago again advanced southward and began to flow through the southwestward outlet. A new beach was thrown up north of the old Glenwood Beach. Since it lies close to the Calumet River throughout much of its course the name "Calumet Beach" has been ascribed to it.

In Illinois, according to Leverett, it is difficult to distinguish from the upper beach until the Chicago River is reached. Between the Chicago and Des Plaines rivers it lies from one and one-half to three miles distant from the Upper beach, but follows the same general direction. At Summit it turns to the southeastward and follows that direction to the north end of Blue Island ridge, where it turns southward and passes by Washington Heights to the Calumet River east of Blue Island. Then ensues a break due to the location of the old Sag Outlet, through which Lake Chicago discharged. East of this break, near the Illinois Central Railway, the beach again appears, and, passing eastward through Lansing, crosses the State line into Indiana about one and a half miles south of the Little Calumet River. Continuing eastward along the north border of Cady Marsh, it passes through Highland,

The Middle or Calumet Beach.

and, as already noted, joins the Upper or Glenwood Beach northeast of Ross. Beyond this point its course through Lake and Porter counties practically parallels that of Glenwood Beach and has been traced in connection with it.

Between the State line and the junction above noted the Calumet Beach consists of a single prominent ridge of sand, possessing practically the same characteristics as the Glenwood Beach east of Dyer. Its north slope is much more abrupt than the south one, and the crest ranges from 25 to 35 feet above the Calumet Plain to the northward. Just west of Highland this crest is 150 yards wide. Where excavations have been made by burrowing mammals many coarse pebbles and pieces of limestone an inch or more square have been thrown out, suggesting a mixture of gravel with the sand some distance below the surface.

At the crossing of the Hart ditch, one and a fourth miles farther west, a cut is made 45 feet deep through sand alone. The crest is here about 140 yards wide, and the base probably as wide again. This ridge, with its wooded crest standing so high above the great treeless Cady Marsh on the south and the Calumet Plain on the north, is a prominent feature of this section of Lake County. The elevation of its crest at Highland is 55 feet above Lake Michigan.

Once again the waters of Lake Chicago receded and for a time stopped flowing through the Chicago Outlet. When they again advanced they threw up the third of these prominent sand ridges, called the Lower or Tolleston Beach, since it passes through the Indiana town of that name. It has been traced by Leverett from Evanston, Illinois, south through Rose Hill Cemetery to Lincoln Park, Chicago, beyond which it is obliterated for quite a distance. From Englewood it passes southeasterly to Hyde Park, and then south near Pullman, Kensington and Riverdale. Near Dolton, south of the Calumet River, it turns more to the eastward and enters Indiana in section 12 (36 north, 10 west), less than two miles south of Hammond. Trending eastward, it passes through the villages of Hessville, Tolleston and Miller's, in a line about midway between the Little and Grand Calumet rivers. East of Miller's it deflects slightly to the northward and through Porter County lies parallel to the present shore of Lake Michigan, and distant from it nowhere more than a mile. It has here, however, been largely covered by the dunes of the present lake so that it is difficult to distinguish from these later deposits. In its extent through Lake County this beach is composed of a broken ridge of sand dunes varying in height from 20 to 30 feet, and covered with dwarf black oak and other trees and shrubs peculiar to a sandy soil.

The Lower or Tolleston Beach.

CALUMET BEACH.

Showing cut of Hart Ditch and wagon bridge, Lake County, Indiana.

In both Lake and Porter counties all that interval lying between Tolleston Beach and Lake Michigan is covered with sand, there being no such broad, level plains as occur along the Little Calumet, between the Calumet and Tolleston beaches, and along Cady Marsh between the Upper and Middle beaches. In Porter County, as already noted, this interval is covered with high sand dunes. North of Miller's such dunes also cover most of the area, but west of that station a series of low beaches or sand ridges appear which lie parallel to Tolleston Beach and cover the whole interval between it and the present lake. These beachlets, for the most part, rise but 8 to 15 feet above the level of Lake Michigan and are 6 to 10 rods in width, with narrow swamps or swales intervening, which become dry in summer. Leverett has counted 32 of them on the line running north from Hessville. They were evidently formed after the waters had ceased to flow through the Chicago Outlet and hence were thrown up by the waters of Lake Michigan rather than those of Lake Chicago.

Low Beaches.

Similar low beaches are found in the vicinity of Jackson Park and Englewood, Illinois. Between their southern ends and the western ends of the beaches in Lake County a low sandy plain intervenes whose surface is nowhere more than 10 feet above the present level of Lake Michigan. This is supposed to have been an open bay at the time the beachlets were forming, but has since been partially filled with sand, leaving Lakes George and Wolf, in Indiana, and Calumet, in Illinois, as remnants of its waters.

West of Hobart, and included within the area supposed to have been covered with the waters of Lake Chicago, is a morainic ridge about four miles long by one mile wide. Its surface is higher than that of the surrounding country and covered with glacial till. This ridge was evidently an island whose surface lay above the waters of Lake Chicago at the time of its highest stage.

Beneath the sand north of Tolleston Beach occasional layers of gravel are struck at varying depths, and mingled with these, as well as with the sand, are numerous remains of fresh water mollusks, both univalve and bivalve. But little data was available concerning the thickness of the sand. Well sections at Liverpool show it to extend to a depth of 10 to 16 feet; at Lake 20 to 22 feet, and at the powder works, near Miller's, 40 feet. At Hammond, where it ranges from 23 to 30 feet, it overlies a blue pebbly clay, 60 to 85 feet in thickness. This clay appears more homogeneous and finer-grained, and less tough and compacted, than that found underlying the Valparaiso moraine, farther south. These qualities are probably due to its deposition by the waters of Lake Chicago, the finer particles as they settled down from suspension in water having been distributed more uniformly than if dropped by a melting glacier. Beneath this clay lies the Niagara limestone or surface rock of preglacial age. Aside from the dunes the sand will probably vary from 20 to 40 feet in depth and will be found to overlie the subaqueous clay above mentioned throughout most of the area north of the Lower Beach.

Silt Deposits.

Within the area covered by the bays of Lake Chicago mentioned on page 33 there are large deposits of a very fine-grained silt or marly clay. Of these the one near Hobart is best known, having been exposed in a large pit to a depth of 25 feet, and pierced by a bore 132 feet without reaching its base. It is a dark drab in color, becoming lighter by exposure. As is customary with such deposits, it lies in thin layers, two to nine inches thick, separated by a slight coating of sand. It contains quite a percentage of lime disseminated evenly through it, and for this reason burns to a whitish or cream color. It is wholly free from pebbles or impurities of any kind, and is extensively used at Hobart for the making of pressed front brick and terra cotta lumber.* This silt is exposed at Garden City, on the county line two miles southeast of Hobart, also at several points north of Porter and Chesterton along the Calumet River. It has also been found in a number of wells in the western part of Portage Township, Porter County.

The Present Beach.

The northern limit of Lake and Porter counties comprises 33 linear miles of the southern beach line of Lake Michigan, one of the grandest bodies of fresh water on the globe. Along this beach was for years the only public road in the area now comprising the two counties, all overland communication between Ft. Dearborn—Chicago—and Detroit in the early part of the present century having been along its sands.

The limits of this beach line are ever changing. Water and wind are, every second, tearing from it in one place and adding to it in another. From Michigan City southwest for ten or more miles the removal is probably greater than the accumulation, but along the remainder of the Indiana shore the beach line is being widened. In the latter portion a person walking along the margin of the water can see that each wave throws up a minute ridge of sand, so minute, in fact, that it is scarcely visible. Perhaps the next succeeding wave carries it away. But if it be thrown high enough to remain unmolested until it has time to dry, its particles are caught up by the wind and carried farther inward. In most cases they are piled up for a

* For analyses of this clay and a more detailed account of its uses see the article entitled "The Clays and Clay Industries of Northwestern Indiana" in the present volume.

time along the foot of a ridge or dune, which is found from 50 feet to 100 yards back from the water. If a stiff breeze be blowing, the traveler over this beach is bombarded by the fine, sharp-edged particles of sand, many of which strike against his face and produce a stinging sensation. These grains are composed of small angular pieces of quartz and have a light-brownish tint.

The amount of this sand which has been thrown by the waves of Lake Michigan on to the shores of Porter and Lake counties has been computed by Dr. Edmund Andrews,* as follows: "For 25 miles west from Michigan City the beach maintains an average cross section of about 6,000 square yards, and its contents are 264,000,000 cubic yards. In this division the beach is in the form of a lofty belt of sand dunes, about one-third of a mile wide and in places 160 to 200 feet in height. In the next eight miles west (extending to the Indiana line) the beach spreads out into a broad belt of low parallel ridges, about two miles in extreme width. This division has a cross section of about 16,000 square yards, after deducting the sand which was deposited by Lake Chicago. Its contents amount to 225,280,000 cubic yards." It will thus be seen that at a low estimate half a billion cubic yards of material have been added to the surface of these two counties by the waters of the present lake.

The Sand Dunes.

The dunes constitute the most striking and characteristic feature of the shore line. They are great sand ridges, sometimes continuous for a mile or more, but more often broken or cut by "blow-outs" into isolated rounded hills. The highest of these hills in Porter County is Mt. Tom, in section 12 (37 north, 6 west), northwest of old City West. Its crest is 190 feet above Lake Michigan. Northeast of Miller's, Lake County, are a number reaching a height of 150 feet above the lake. In some places, notably about Dune Park, Porter County, the ridges are for long distances wholly destitute of vegetation. Their bared surface, 50 to 100 feet in height, with the sand piled just as steeply as it will lie, gleams and glistens in the sunlight and reflects the summer's heat with unwonted force. Other ridges and rounded hills, especially those back some distance from the lake, are often covered with black oak, northern scrub pine (*Pinus banksiana* Lambert), stunted white pine (*Pinus strobus* L.), and many shrubs and herbs peculiar to a soil of sand. The roots of this vegetation form a network about the sand grains and prevent the leveling of the dunes. In time, however, a tree is uprooted, or a forest fire burns off the vegetation. The protecting network of rootlets is destroyed. A bare spot results over which the winds freely play. A great storm from the north or northwest scoops out a small

*Quoted by Leverett in Bull. Chic. Acad. Sci., No. 2, 1897, 80.

bowl-shaped cavity, and, carrying the sand either south or southeastward, drops it over the hillside. The cavity is cut deeper and wider by succeeding storms, and a great "blow-out" in time results. Where a few years before stood a high hill or unbroken ridge now exists a valley, or a cavity in the hillside, acres, perhaps, in extent, and reaching nearly to the level of the lake. The sands which once were there now constitute new hills or ridges which have traveled, as it were, a greater distance inland. In many places the drifting sands have wholly or partly covered a tall pine or oak tree. Where but partly covered, its dead (sometimes living) top projects for a few feet above the crest of hill or ridge. One may rest in its shade and not realize that he is sheltered by the *upper* limbs of a large tree whose trunk and main branches lie far beneath him embedded in the sands.

But few forms of animal life dwell among these dunes. Vegetation is not plentiful enough to furnish sustenance. A lizard scampering rapidly along will sometimes be seen, but even they are scarce. The twitter and chirp of bird is seldom heard. Insect life is less abundant than in any area of equal size in the State. Back, away from the sound of the breaking waves, a peaceful quiet pervades. There may one sit and literally watch the growing of the hills. There will he come to realize, as never before, how the slow, unceasing action of some of nature's milder forces have modified to so great an extent the surface of the earth. Around him on every side is matter—sand. Coming in from over the lake is the force—wind. Slowly but surely building up about him is the result of the action of the force on matter—hills. Thus have dunes been formed, here or elsewhere, for ten thousand times ten million years.

Where the gravel road from Hobart strikes the lake north of Miller's is a portion of the beach which is destined to become a noted resort. It is 150 yards or more wide, with a gradual slope from the foot of the first ridge to the water. The bathing is excellent. The scenery about the Calumet, the mouth of which is but a short distance away, is very fine, while from the tops of near-by dunes one can obtain some magnificent views over Lake Michigan, or over the rugged surface to the south and east.

Another portion of the beach which affords fine bathing and some excellent scenery lies north of Furnessville, but the facilities for reaching it are, at present, not of the best.

Between the station of Pine, Lake County, and the State line no dunes occur, and the present beach, i. e., the one washed by the waves of storms, is, in general, much narrower than that to the eastward. Along most of this distance the water line is closely paralleled by three

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1. Down the Calumet, north of Miller's, Ind.
2. A sand ridge northwest of Dune Park, Ind.
3. The shore of Lake Michigan, east of Whiting, Ind.
4. A sand flat, with swamp and hill in distance.
5. Bridge across the Calumet, north of Miller's, Ind.
6. Down the Kankakee, from the Monon Railway, Lake Co., Ind.

VIEWS IN LAKE AND PORTER COUNTIES.

railways, whose artificial roadways are in places protected by piling. In places east and west of Whiting large amounts of refuse slag from the furnaces of the Illinois Steel Company at South Chicago have been dumped to prevent erosion. The presence of this slag and piling detracts greatly from the natural beauty of the lake front.

The Sand Supply.

Near the shore the bottom of Lake Michigan is uniformly covered with sand. At the shore line this sand is about ten feet deep and it extends out to where the water reaches a depth of about 35 feet. Beyond this depth of water the lake bottom is composed of a stiff, tenacious blue clay, which is said to contain partings or pockets of sand, from whence, in part, comes the supply which is constantly being carried shoreward by the waves. Much of the sand is doubtless blown from the dunes by south winds back over the lake, and, falling on its surface, is again brought to land. Moreover, by storms and by ice jams in the spring, all projecting points along the lake are slowly worn down and the material composing them is carried out to be again returned and built up in a new place. Thus much of the sand is in constant circulation, and the necessary new supply is not so great as it appears to be.

Much gravel, consisting of pebbles ranging in size between a hen's egg and a small marble, is washed up by the waves to within a foot or two of the water margin. In many places it is raked out by hand and carted beyond the reach of the high storm waves, and afterwards loaded and shipped by rail to Chicago, where it is used in roofing and concrete pavements. The immediate source of this gravel is doubtless the blue glacial till which forms the greater part of the floor of the lake, since the composition of the pebbles plainly show that they came originally from formations which lie far to the northward.

Thousands of trainloads of sand are annually shipped to Chicago from the dunes of the present lake, as well as from the ridges near Tolleston and Griffith. It is mainly used in elevating the beds of railways and in filling lots. Much money has been realized from its sale by parties who, years ago, had the foresight to purchase large areas of the dune land, then considered almost worthless.

The Calumet River.

This northern region of the two counties is drained by the Calumet River, a stream peculiar for the direction of its flow, its low banks and the sluggish motion of its waters. Except near its source it resembles more a great artificial ditch than a natural waterway. Its banks, where present, are seldom more than 10 feet above the water level. Its head waters are in Laporte County, but close to the Porter County line. Entering the latter county in the southeast corner of section 25 (37 north, 5 west), about one-half mile north of the northern border of the morainic region, it flows westward across the two counties and leaves the State at the southwest corner of section 12 (36 north, 10 west), but three miles south of the line of its entry into Porter County. From this point its direction is northwesterly for about seven miles to the bluff at the southeastern corner of Blue Island, Cook County, Illinois. Here, turning on a sharp curve, it flows first northeast, then southeast, and, crossing once again into Lake County, continues for 14 miles almost due eastward until it empties into Lake Michigan at the northeastern corner of section 31 (37 north, 7 west), but two miles north and two west of where it first entered Lake County. About a half mile above its mouth, where crossed by the road leading from Miller's to the lake beach, it is about 300 feet in width, and runs between some lofty sand ridges. In August, 1897, its waters at this point were shallow and almost filled with aquatic vegetation.

To distinguish the two parallel portions crossing Lake County, the southern has received the name Little Calumet and the northern, Grand Calumet. The former lies between the Calumet and the Tolleston beaches of the glacial Lake Chicago, while the Grand Calumet lies north of, but parallel to, the Tolleston Beach until the latter comes so close to the present lake shore as to head off the stream and force it to flow into the lake. The singular course of the Calumet through the two counties is wholly determined, therefore, by the presence and trend of these ancient sand ridges, and by a morainic ridge lying north of the greater part of its length in Porter County.

One other peculiarity of the Calumet is its apparent possession of two mouths. It is a double-headed monster. The Indiana mouth above mentioned is the original one. The other empties into (or receives from) Lake Michigan at South Chicago, and a channel from that point passes between Calumet and Wolf Lakes and connects with the river proper near the south line of section 31 (37 north, 15 east), about four miles northwest of the center of the city of Hammond. This channel is said to be artificial and to have been opened by Indians about 90 years ago. They pushed their canoes on one line through the marshes until a permanent channel was worn, through which the water freely flowed. This, as well as the main stream between the junction and Hammond, has, within recent years, been dredged, and small steamers now daily ply between Chicago and Hammond.

Throughout the full length of its course in Lake County and in Porter County west of Chesterton, the waters of this strange stream have, in the summer season, but little perceptible flow. In places they spread out a half mile or more wide, and the channel is so clogged with the leaves of the water lily and other aquatic plants that a boat can scarcely be forced along. "But in the late winter or early spring-time, when the melting snow and heavy rainfalls fill to the brim the low banks, the overflow covers a large amount of surface, justifying the expression of the early geographers that 'the country around the extreme south bay of Lake Michigan has the appearance of the sea marshes of Louisiana.' "* It is then that the marshes of the Calumet become the temporary home of thousands of water-fowl and the paradise of sportsmen.

II. THE MORAINIC OR MIDDLE REGION.

This region comprises, approximately, 485 square miles lying across the center of the two counties. It is covered by a sheet of drift which at Crown Point is 141 feet and at Valparaiso 125 feet in thickness. The upper portion of this drift is, as already noted, a part of the great Valparaiso moraine, the origin and general trend of which has been given. Where this moraine crosses the State line and enters Lake County it is about 17 miles in width, extending from near Dyer to a point opposite Sherburnville, Illinois. The greatest height or main crest on this line is southwest of the town of Brunswick, in section 36 (34 north, 10 west.) A weaker crest line which forms the watershed in western Lake County runs parallel with the inner border of the moraine from near Orland, in Cook County, Illinois, southeastward, entering the State of Indiana about six miles north of the main crest line, section 36 (35 north, 10 west.) The surface in this vicinity and for some miles north and northeast of St. John's is more broken and irregular than farther southward. The soil immediately overlies a thick bed of clay, in which are mingled many pebbles and small bowlders. In northern Hanover Township the surface is undulatory, but not broken by deep ravines. Farther south a high, rolling prairie region sets in, which covers the southern part of Hanover and the northern two-thirds of West Creek townships. The soil of this prairie, as that of several to the eastward, is a rich, black loam, which covers to a depth of from one to three feet the clay till of the moraine. This clay varies in thickness from 40 to 65 feet. Beneath it is a sand stratum from 20 to 70 feet thick, which furnishes plentiful water.

The Moraine in Lake County.

The main crest of the moraine passes along a wooded ridge about a quarter of a mile north of Cedar Lake and thence along a low, curving ridge to the fair ground south of Crown Point. Between this city and Cedar Lake and extending southward almost to Lowell is a wooded table-land, in places quite broken, where the clay of the mo-

*Ball, Rev. T. H.—Lake County, 1884, 178.

raine comes close to the surface. East of this wooded belt the rich rolling prairies again set in and cover the greater portion of the morainic area embraced in the eastern third of Cedar Creek and the western half of Eagle Creek townships.

North of Le Roy, in sections 1 and 12 (34 north, 8 west), the crest of the moraine is cut by a branch of Deep River flowing northward. In this region the Lake Michigan watershed extends farther southward than at any other point in Indiana. According to the report of the United States Deep Waterways Commission for 1896, the crest of the moraine at the lowest point near the head waters of Deep River and Eagle Creek is 747 feet above tide, or 165 feet above the waters of Lake Michigan. Just south of the divide, in Le Roy, is a flowing well which furnishes a plentiful supply of good water. The bore was sunk through clay to a depth of 65 feet, when a water-bearing stratum of sand was encountered.

In the Court House yard at Crown Point the surface is 714 feet above tide. At this level a bore was begun in 1889 and put down to a depth of 3,100 feet in search of gas. No accurate record of the formations passed through was kept, but, from a partial record and samples of drillings shown me by Mr. W. A. Clark, the following section was made:

SECTION OF DEEP BORE AT CROWN POINT.

1. Drift.	Soil and clay	15 feet.
	Sand	100 feet.
	Blue clay	25 feet.
2.	Genesee shale	112 feet.
3.	Lower Helderberg and Niagara limestones	433 feet.
4.	Niagara shale—bluish green	55 feet.
5.	Clinton limestone	57 feet.
6.	Hudson River shale—bluish green	122 feet.
7.	Trenton limestone	556 feet.
8.	Sandstone, alternating from brown to white	1,625 feet.
	Total	3,100 feet.

The upper two-thirds of the Trenton limestone, struck at 919 feet, was darker brown than the lower third, the latter being whitish, with streaks of pure white sand scattered through it. The bore filled with salt water from the Trenton to within 100 feet of the top.

The water supply of Crown Point is derived from the stratum of sand which immediately underlies the surface clay. At the water works, in the north part of the city, are two eight-inch wells located but 12 feet apart, which furnish an average supply of 200 gallons a minute, and can furnish 400 gallons in an emergency. The soil and clay at this point are 40 feet thick and the wells penetrated the underlying sand to a depth of 20 feet. The water is "hard," containing lime and iron salts, and has a tendency to encrust the pipes through which it flows. For drinking purposes and household use its quality is excellent.

The northern slope of the morainic region is in Lake County much more narrow and abrupt than the southern. It contains several small prairies, and in the eastern portions of Winfield and Ross townships a number of low ridges or gently undulating swells, with intervening sags. In general, especially on the prairie, the soil is a rich black loam, but on some of the ridges mentioned it is a whitish clay.

On the whole, it may be said that the surface of the moraine in Lake County is much less rugged and irregular than in Porter. The large bowlders, usually accompanying such a moraine, are far less numerous in the former county. But one or two were seen which were more than 18 inches in diameter. Even the smaller ones were scarce and in most places have been carefully gathered for use in the foundations of buildings.

The Moraine in Porter County.

The general trend of the morainic belt in Porter County is to the northeast. Where it enters the county it is about 15 miles in width, extending from section 10 (35 north, 7 west), about two miles north of the town of Woodvale, to the southwest corner of section 22 (33 north, 7 west), two miles southwest of Hebron. At the latter town its surface is about 48 feet above that of the Kankakee marsh lands, three miles to the southward. The crest of the moraine crosses the county line a little south of the common corner of the four townships of Ross, Winfield, Porter and Union. Thence it extends a little north of east to a point about a mile east of Valparaiso, where it is cut by Salt Creek flowing northward. Beyond this stream it extends from Emmettsburg in a northerly direction to Liberty Township, where it trends to the east and passing across the southern tier of sections of Jackson Township enters Laporte County.

North of Emmettsburg, in section 11 (35 north, 6 west), the height of the moraine, as determined by Leverett, is approximately 840 feet, and near the center of section 30 (36 north, 5 west), Mr. Henry Rankin has run a level which showed the surface to be 306 feet above Lake Michigan, or 888 feet above tide. This latter point is probably the extreme height to which it reaches in the two counties.

The topography of the morainic belt of Porter County is much more varied than in Lake. Immediately north and west of Hebron are a number of high wooded ridges composed of clay and covered for the most part with timber. Horse Prairie, a higher undulatory region, then sets in and covers the greater portion of the south half of Porter Township. Bowlders of large size begin to appear. The following section of an open well sunk on the land of Hon. Geo. C. Gregg, east half of section 34 (34 north, 7 west), two miles north of Hebron, was furnished by Mr. Gregg, and will give an idea of the morainic material in that vicinity:

SECTION OF WELL NORTH OF HEBRON.

1.	Soil and stiff yellowish clay	12 feet.
2.	Blue clay—comparatively free from pebbles	17 feet.
3.	Sand, similar to that in ridges to the northward	18 feet.
4.	Hard, sticky blue clay with flint pebbles	20 feet.
5.	Coarse blackish sand	4 feet.
	Total	71 feet.

Plenty of good water was found in the blackish sand. It was necessary to curb the upper stratum of sand, No. 3 of the section, as it caved in very badly. The total thickness of the drift at Hebron, on a level, probably 30 feet below this point, was found to be 108 feet.

North of Horse Prairie, in sections 13, 14 and 15 (34 north, 7 west), a stiff, clayey subsoil comes near the surface, and a timbered area begins which covers the northern half of Porter and the southern half of Union townships. This area is much broken, especially along the crest of the moraine. The soil over much of it is a whitish clay, which produces fair timothy hay, but poor crops otherwise.

The northern half of Union Township is in part covered with a sandy soil. This starts in about sections 23 and 24 (35 north, 7 west), and extends to the Grand Trunk Railway or to the border of the moraine. A spur of the moraine about two miles wide extends into Portage Township to the southeastern corner of section 13, and embraces a portion of Twenty Mile Prairie.

In the western half of Center Township the moraine begins to show more prominently, there being many high ridges which intersect one another at various angles. Their component materials, where exposed, are mainly a stiff yellow clay, with many limestone pebbles which are angular and but little water-worn. In several places occur deposits of gravel a few feet in thickness, but in general it is too fine to make good road material. The city of Valparaiso is located on the slope of one of these subordinate ridges southeast of the main crest of the moraine. The level at the station of the Grand Trunk Railway, in the northern part of the city, is 820 feet; that of the Court House yard 803 feet, and that of the Pennsylvania road, in the southern part of the city, 736 feet above tide.

At a still lower level—718 feet—in the southwestern part of the city, a deep bore was put down for gas in 1889. From data and specimens of drillings kindly shown the writer by Mr. C. W. Dickover, the following strata were shown to have been pierced:

SECTION OF DEEP BORE AT VALPARAISO.

1.	Soil and drift	125 feet.
2.	Genesee shale	65 feet.
3.	Corniferous and Lower Helderberg	230 feet.
4.	Niagara limestone	270 feet.
5.	Niagara shale	5 feet.
6.	Clinton limestone—white to steel gray	55 feet.
7.	Hudson River limestone	110 feet.
8.	Hudson River shale—bluish green	160 feet.
9.	Trenton limestone*	330 feet.
	Total	1,350 feet.

At a depth of 1,290 feet salt water was struck, which rose to the top of the well.

In Liberty Township the northern slope of the moraine is much more narrow and abrupt than in any part of its course in the two counties. From the road a mile or two east of Gosset's mill one gets, looking across a branch of Salt Creek to the south and southwest, a fine view of the morainic hills, since they are from 100 to 150 feet above the level of the observer. To the northeastward the irregularities of the surface become more pronounced, and in Jackson Township, especially in sections 13, 14 and 15, many of the features of a typical, unmodified terminal moraine are present. Here is found an intricate series of subordinate ridges putting out in every direction from the main one. Bowlders are very plentiful and in several places were noted to be sole material used in the construction of fences. The largest ones seen in the two counties were in this vicinity. There are also numerous large rounded depressions, some of them embracing an acre or more in extent, which recall vividly the sinkholes of southern Indiana. Alternating with these are corresponding rounded knobs or knolls, the crests of which, in a number of instances, are 80 feet or more above the bottom of the depressions. These "knobs and basins," as they are called, owe their peculiar formation to the irregular deposition of the glacial debris, there probably having been a great isolated mass of ice imbedded in the debris where each basin

*The upper 280 feet of this stratum was somewhat darker colored than the lower 50 feet, and had been called by Mr. Dickover "Galena limestone." This is only a synonym for the upper or later portions of the Trenton formation, which in Illinois and Wisconsin are lead bearing.

now exists. By its melting a cavity was left which was separated by a mass of drift material from a somewhat similar cavity where another ice mass had been imbedded. The shape and size of each cavity or basin depends upon the shape and size of the ice block and the amount of drift originally covering it. Where an impervious bed of clay was left or has accumulated in the bottom of the "basin," the latter often fills with water and a small lake results. Such was doubtless the origin of Bull's Eye Lake, two miles north of Valparaiso, whose area is but one-half acre, and whose waters are 45 feet in depth.

The northern border of the morainic belt extends diagonally across Liberty Township from its southwestern to its northeastern corners. Thence it passes through sections 6 and 5 in the southeastern corner of Westchester Township. Bending to the east, then south and again east, it follows closely the border line between Pine and Jackson townships. Turning north along the county line, it finally leaves the county from the east side of section 36 (37 north, 5 west.)

Just within the borders of the moraine, on the southeast quarter of section 1 (36 north, 5 west), is a flowing well which was put down in June, 1897. Its section, as furnished by the owner, Edward Stevens, shows the following strata:

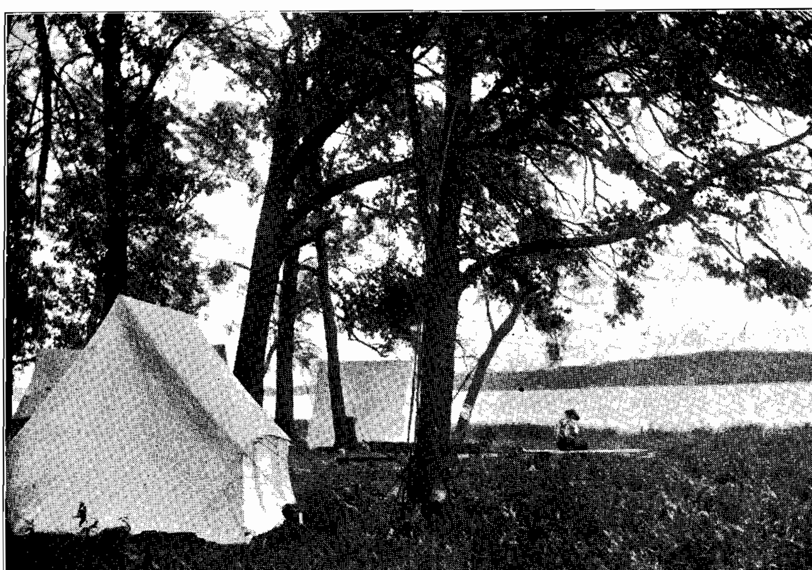
1.	Soil and gravel	3 feet.
2.	Blue clay	60 feet.
3.	Sand	21 feet.

On September 10th the water was rising through a two-inch pipe to a height of four feet above the surface. Through a three-quarter-inch pipe it had risen 25 feet above the surface, but had failed to rise to the top of an additional pipe 18 feet in length and of the same diameter. The rate of flow was about six gallons per minute. The source of this water is probably on the slope of the moraine to the southward.

North of the border of the morainic region proper, as traced above, there exists in Porter County a long, narrow ridge, whose surface is a till of clay. This ridge lies north of the Calumet River and extends east and west through Westchester and Pine townships. Its average width is about a mile. The surface is quite regular except where cut by erosion. The soil is a whitish clay, well adapted to the production of timothy hay, but producing poor crops of the cereals. This ridge, like the one west of Hobart, was an island whose surface lay above the waters of the shallow bay of Lake Chicago, which covered and modified the area between it and the morainic region to the south.

The southern margin of the morainic belt in Porter County extends from a point almost a mile south of Hebron in a northeasterly direc-

Looking west across the lake. Ice houses on opposite shore.



A camp on the west shore.

VIEWS OF CEDAR LAKE.

tion, crossing the southeastern corner of Porter Township and passing diagonally across Morgan and the southeastern corner of Washington townships. The southern slope is much more subdued or less broken and irregular than the northern. The soil is usually a whitish clay and far less rich and productive than that of Morgan Prairie, which borders a large portion of this region on the east.

With the exception of Lakes Wolf and George, in the northwestern corner of Lake County, which, as already noted,* are but remnants of a once shallow bay of Lake Michigan, the lakes of the two counties are of morainic origin and should be treated in this connection. Those which the citizens have esteemed large enough to be worthy of names are Cedar Lake and Fancher Lake, in Lake County, and Eliza, Quinn, Flint, Long, Bull's Eye and Clear lakes, in Porter County. It is a noteworthy fact that each of these lies very close to the summit of the main crest of the moraine.

Morainic Lakes.

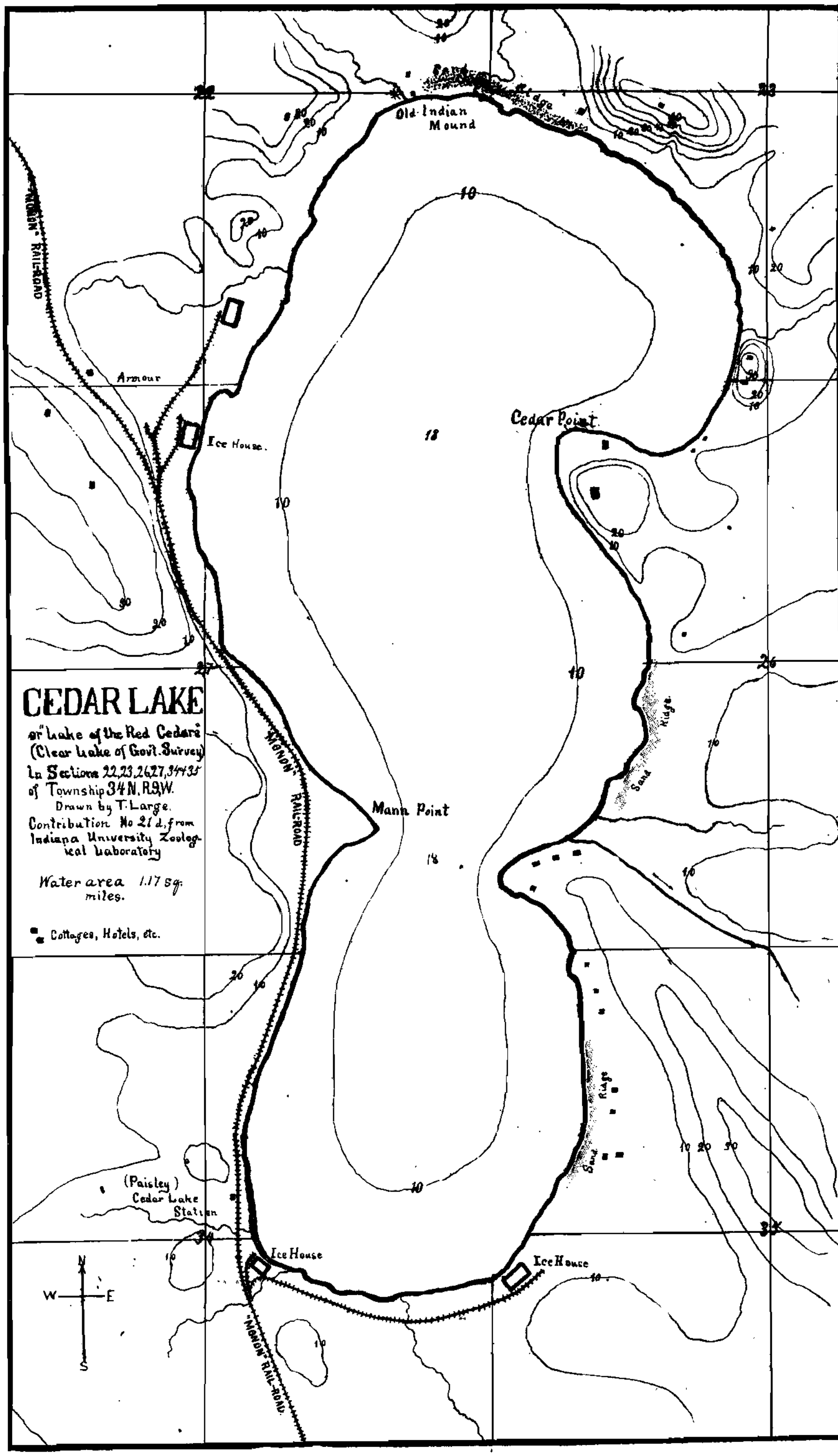
The largest, most handsome and best known of these lakes is Cedar Lake, or "Lake of the Red Cedars," located in parts of sections 22, 23, 26, 27, 34 and 35 (34 north, 9 west), on the line between Center and Hanover townships, about four miles southwest of Crown Point. Its general outline somewhat resembles that of a kidney. Its length is about two and one-eighth miles and its greatest breadth a little more than three-quarters of a mile. Its water area, as computed by Thomas Large,† is at present about 1.17 square miles.

Cedar Lake.

Cedar Lake owes its origin to the irregular deposition of the surrounding drift. On all sides, except the south, it is embraced by wooded ridges of sand or clay, those to the north rising 60 feet above the level of its waters. Between these ridges, on the southern slope of the moraine, a long, low valley was left by the retreating ice sheet. The bottom of this valley was covered with an impervious stratum of clay. In its depression collected the waters of the melting glacier and the lake resulted. Its waters once covered all the low, marshy land to the southward and overflowed the lowest part of the rim of its basin toward the Kankakee. At that time they covered the present shores as far as the foot of the ridges on the east and north and were probably 40 feet deep in places. Now they nowhere exceed 20 feet in depth. Within the memory of man they have receded from 50 to 90 feet from the former margins. This recession and consequent lowering of depth is mainly due to three causes, viz.:

*P. 37. Fish Lake, in the extreme northeastern corner of Porter County, is a wet weather lake which is practically dry in summer.

†See Proc. Ind. Acad. Sci., 1896, 299 and 301. The accompanying map of Cedar Lake was also drawn by Mr. Large and published in the Proc. of the Academy, *loc. cit.* By permission it is reproduced in this connection.


CEDAR LAKE
or "Lake of the Red Cedars"
(Clear Lake of Govt. Survey)
In Sections 22,23,26,27,34 & 35
of Township 34 N. R.9 W.
Drawn by T. Large.
Contribution No 21 d, from
Indiana University Zoological Laboratory
Water area 1.17 sq. miles.
Cottages, Hotels, etc.
Old Indian Mound
Sand Ridge
Cedar Point
Mann Point
Armour
Ice House.
Ice House
Ice House
"MONON" RAIL-ROAD
"MONON" RAIL-ROAD
"MONON" RAIL-ROAD
(Paisley) Cedar Lake Station
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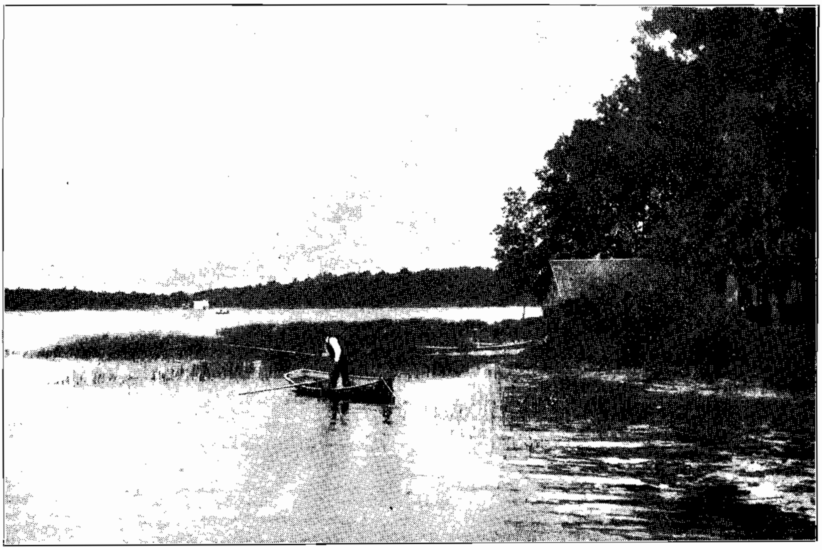

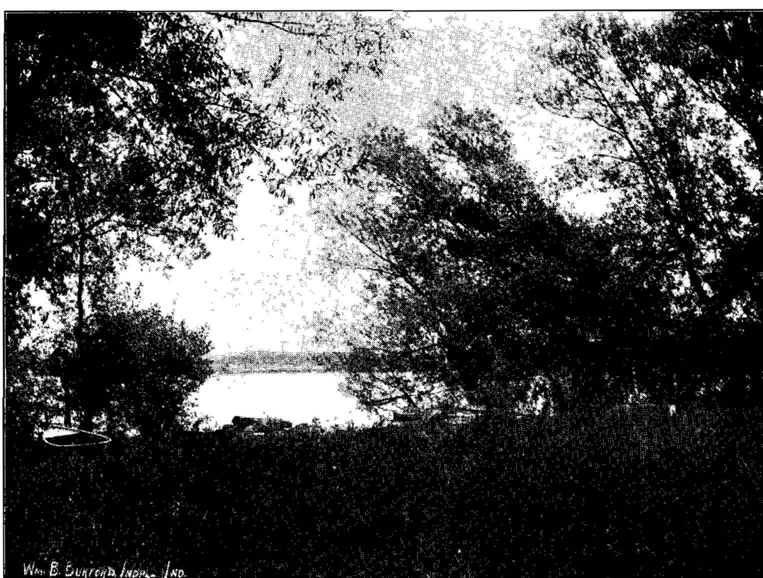

GLIMPSES OF CEDAR LAKE.

a. Artificial Drainage. To reclaim 200 acres of comparatively worthless marsh land—at its southern end—a ditch was cut on its eastern side which lowered the level of the water from 8 to 12 feet. This outlet is the present source of Cedar Creek, which flows southward through the town of Lowell and empties into the Singleton ditch.

b. The Growth and Decay of Aquatic Vegetation. Beneath the shallow water along its western and southern margins there are thick beds of muck and black mud. In these beds grow luxuriantly spatter-dock, rushes, ditch moss, algae and many other aquatic plants. These die down and the matter which they have withdrawn from the air and solidified within their stems is added to the surface of the muck. The latter is, therefore, ever thickening and encroaching upon the water area.

c. Decrease of Water Supply. Situated, as it is, so near the crest of the moraine, the area from which the lake draws its supply of water is very limited, being but a few square miles in extent. This supply comes wholly from the rain of the season, which, soaking into the earth, finds its way through springs into the immediate basin of the lake. Since the settlement of the surrounding region much timber has been cut away and the land so drained that the water flows rapidly away instead of soaking into the ground and finding its way into the lake as formerly. At present the season's evaporation is, probably, almost as great as the supply. For these causes the area and depth of the lake have for years been slowly diminishing and will continue to diminish until it wholly disappears.

Within the past ten years many cottages have been erected on the wooded ridges about Cedar Lake. The Monon Railway, which runs along its western border, has possessed itself of the high wooded ridge on that side and has transformed it into a so-called park. Thousands of visitors are each season brought from Chicago and from the cities to the southward. The quiet beauty and repose which for centuries existed along the margins of the lake have forever disappeared. In their stead have sprung up those artificial surroundings which the ever-increasing wants of the Nineteenth Century seeker after pleasure demand and eventually secure.

Fancher Lake is located in the Lake County fair grounds, northwest quarter of section 17 (34 north, 8 west), one mile south of Crown Point. It covers about 20 acres and in places is said to be 35 feet in depth. Lying on the very crest of the moraine, it doubtless occupies a kettle hole or basin formed by the melting of an imbedded ice mass. Its waters flow northward, finding their way into Lake Michigan by the way of Deep River and the Calumet.

Lakes Quinn and Eliza are located about a mile apart, in sections 12 and 1, respectively (34 north, 7 west), near the northern line of Porter Township, Porter County. The former covers an area of about 12 and the latter 40 acres. Eliza is but one-half mile south of the divide and is much the more handsome, being surrounded on all sides by oak groves. Wolf Creek is the outlet of both lakes, flowing southward from Eliza through Quinn, and then southeasterly into Sandy Hook Creek.

Lying three and one-quarter miles a little east of north of Valparaiso and about a mile east of the crest of the moraine is Flint Lake. Its waters cover an area of 95 acres and have an average depth of about forty feet. It is surrounded by high ridges, those on the east and north being wooded. Its western and a portion of its southern margins, like those of Cedar Lake, have mucky banks, while those of the east and north are sandy, a condition due to the prevailing westerly and southerly winds, which create a breaking of the waves along the eastern and northern shores, and so prevent the formation of muck.

The waters of Flint Lake have receded more than 50 feet from the edges of their former margins. This recession is due to the same causes as have brought about that of Cedar Lake. Flint Lake, however, is the source of the water supply for the city of Valparaiso, 600,000 gallons being at present drawn from it each day. Its artificial drainage is, therefore, somewhat excusable. It lies 243 feet above Lake Michigan and 14 feet above the Court House yard at Valparaiso, its waters being brought to that city by both gravity and direct pressure. If the lake continues to recede at the present rate it is only a question of a few years until the city will have to seek another water supply.

Long Lake occupies a narrow morainic valley a short distance northwest of Flint Lake. It is about three-fourths of a mile in length by 40 rods in greatest breadth, and is connected with Flint Lake by a small drain. The natural outlet of both is one of the branches of Crooked Creek, a tributary of the Kankakee.

Clear Lake is located partly in section 24, Jackson Township, and is cut by the line between Porter and Laporte counties. It has no outlet and its waters are 25 feet in average depth, and cover an area of about 30 acres. In the words of Dr Chas. R. Dryer,* all of these morainic lakes in Indiana "are geologically young, being confined to the very latest moraines of the glacial period. They are mere babes born yesterday and destined to die to-morrow. The present dominant race of men may pass away and leave these lakes still lying like bright jewels among the hills: but every one is doomed to final extinction.

*Stud. in Ind. Geog., 1897, 59.

'The hills are shadows and they flow
From form to form, and nothing stands:
They melt like mist, the solid lands,
Like clouds they shape themselves and go.'

But of all features of the landscape, lakes are the most ephemeral. As long as they remain they will continue to contribute to the service and delight of man. They fed the savage with fish, but they feed the more highly developed man with beauty, and afford means for that relaxation and healthful pleasure which the conditions of modern life demand."

The Water Shed.

The drainage system of Lake and Porter counties is governed almost entirely by the topography of the surface of the morainic region. The watershed or divide separating the basin of Lake Michigan from that of the Mississippi corresponds very closely to the crest line of the moraine already traced. With two exceptions, all streams which start south of that crest line find their way into the Kankakee, while all but one of those starting north of it flow into Lake Michigan. The exceptions noted are the branch of Deep River rising near Le Roy, which has been mentioned as cutting the crest east of Crown Point; and a branch of Salt Creek, which has its source in Bull's Eye Lake, north of Valparaiso, and flowing southward and then westward around that city, unites with another branch which rises in the northern part of Morgan Township, and cuts the crest south of Emmettsburg. West Creek, rising near St. John's, flows southward, cutting the main crest between Hanover and Brunswick.

Just north of Cedar Lake, in section 23 (34 north, 9 west), is one of the best marked portions of the watershed in the two counties. A narrow ridge, not over three rods wide and six to eight feet in height, separates for a distance of 150 feet a marsh on the north from the head of a shallow ravine on the south. The waters of the marsh, which is fed by springs, flow, eventually, into Lake Michigan, while those from the ravine find their way, after many wanderings, into the Gulf of Mexico. The divide is also very narrow in Union Township, Porter County, just north of Lake Eliza, and again in section 34, in the south half of Jackson Township, between the head waters of Coffee and Crooked creeks.

Drainage.

Aside from the Calumet and Kankakee rivers, all the principal streams which drain the two counties have their sources on or near the crest of the divide. These are, in Lake County, West Creek, rising near St. John's and flowing southward through Hanover and West Creek townships; Cedar Creek, the outlet of Cedar Lake, flowing southward through Cedar Creek Township, and

Eagle Creek, the outlet of a small lake northeast of Le Roy and flowing south. The waters of these three are collected by the Singleton ditch in the Kankakee basin.

On the north of the divide one of the branches of Deep River has its sources in Fancher's Lake and in a marsh two miles northwest of Crown Point. This unites in the northeastern corner of Center Township with the branch from near Le Roy, and flows northeasterly to the county line about a mile southeast of Woodvale. Thence it bears northwest to the mouth of Turkey Creek, in section 1 (35 north, 8 west); thence northeasterly through Hobart to near the station of Lake, where it again turns west and empties into the Calumet, in section 14 (36 north, 8 west). Throughout its course from Woodvale northward it is a slow flowing, sluggish stream, with its bottom of clay or mud. In its waters the fresh water mussel, *Anodonta grandis* Say, and allied mud-burrowing species exist in enormous numbers, while in the mill ponds at Woodvale and Hobart great masses of aquatic vegetation spring up and during the hot days of August and September decay and throw off a disagreeable odor. Since 1883 the amount of water at Woodvale has been sufficient only to run a corn mill, and all wheat has been ground by steam.

In Porter County the streams south of the divide are Sandy Hook and Crooked creeks, both of which are of small size and sluggish in flow. The former has for its tributaries Wolf Creek, the outlet of Eliza and Quinn lakes, and the West Branch of Sandy Hook. These drain Porter and the west half of Morgan townships. Two branches of Crooked Creek rise near the divide in the south part of Jackson Township, and a third is the outlet of Flint Lake. This stream drains Washington and the east half of Morgan townships and empties into Reeve's ditch in the Kankakee marshland.

North of the divide are Salt Creek and Coffee Creek, the former being the larger and more important of the two, draining eastern Union and Portage, a part of northern Morgan, all of Center and most of Liberty townships, and emptying into the Calumet, in section 31 (37 north, 6 west). Its waters are sufficient in amount to furnish power for three mills, one just south of Valparaiso, another (Pierce's) in section 16 (35 north, 6 west), and a third (Gossett's) in section 21 (36 north, 6 west). Above each of these the stream widens into a large mill pond, that at Gossett's being a mile long and a quarter of a mile wide. Coffee Creek rises on the crest of the divide in the south half of Jackson Township, and, flowing west of north, drains southwestern Jackson, northeastern Liberty and a part of Westchester townships, emptying into the Calumet a little north of Chesterton. Its current in Jackson Township is more rapid than that of any other stream in the counties, and at Long's mill, in section 20 (36 north, 5 west) the supply of water is sufficient to turn a large turbine wheel the year round. Several small tributaries of the Calumet drain the northern half of Jackson Township.

III. KANKAKEE OR SOUTHERN REGION.

All that area of the two counties lying south and southeast of the southern border of the Valparaiso moraine is comprised in this region. In Lake County this morainic border extends to the old northern shore line of the Kankakee Marsh and the area south of that line was, at one time, all overflowed or swamp land. In Porter County, about 65 square miles of swamp land proper and 40 square miles of prairie are included within the region under consideration. The prairie portion lies 10 to 40 feet above the level of the main marsh and slopes gently down to it. Along Sandy Hook and Crooked creeks a strip of marsh land, in places two miles in width, extends a number of miles northward into the prairie region, and the difference in level between the two is more abrupt.

The Kankakee River.

The Kankakee River, which forms the southern boundary of the two counties, is noted for its low banks, its sluggish current and the crookedness of its channel. From its source in a large marsh about three miles southwest of South Bend, St. Joseph County, section 16 (37 north, 2 east), it flows in a southwesterly direction through that county to the Laporte County line, from which point it forms the boundary between the counties of Laporte, Porter and Lake on the north and St. Joseph, Starke, Jasper and Newton on the south. Crossing the State line near the southwestern corner of section 1 (31 north, 10 west), it flows a little south of west to Kankakee, Illinois, where it receives the Iroquois River from the south. Thence it flows almost due northwesterly to near the northeastern corner of Grundy County, where it unites with the Des Plaines, the two forming the Illinois River.

Between its source and the point where it crosses the State line, in the extreme southwestern corner of Lake County, the distance is about 75 miles. Within this distance the stream is said to make 2,000 bends and to flow over a total length of 240 miles. According to the survey made by Dr. J. L. Campbell, in 1882, the difference in level between the source and the State line is but 97.3 feet, showing a fall of but 1.3 feet to the mile. For this reason its waters, above the crossing of the Monon Railway, section 33 (32 north, 8 west), have an almost imperceptible flow, and in many places wild rice, rushes, lily pads and aquatic grasses so choke the channel as to cause the flooding of the marshes during a summer freshet. Between the Monon Railway and the State line the velocity of the flow is greater, owing to a slightly increased slope and fewer bends.

In Indiana the bed of the Kankakee is composed mainly of sand and fine gravel. But in a few places, as just west of Dunn's bridge, in the southeastern corner of Porter County, it contains rather extensive beds of coarse gravel. Only at one point, where visited by the writer, was stone seen in its bed. This was just across the State line in Illinois, where, in front of the residence of Daniel Parmlee, the current is more rapid than elsewhere noted, and a number of large bowlders are located near the middle of the channel.

The amount of water which the river now discharges varies with the season much more than formerly. According to measurements made by Dr. Campbell* in August, 1882: "The sectional area at the State line was 543 square feet, the mean hydraulic depth 4.5 feet, the calculated mean velocity 2.35 feet per second, and the volume of discharge 1,271 cubic feet per second." This was during an average low-water stage of the river. The least flow is during extreme cold weather, when the great marsh, which borders the river, and which acts as a sort of reservoir or feeder, is frozen solid. In 1882 there were almost 500,000 acres of this marsh land within the valley of the Kankakee. It resembled an immense sponge, slowly absorbing the water during the wet season and as slowly oozing it forth during the dry, so that the flow throughout the year was quite regular and uniform in amount. At present, on account of the drainage of a large portion of this marsh, especially in St. Joseph, Starke and Laporte counties, the water flows off much sooner after it falls and consequently the river is higher during the autumn and spring floods and lower at other seasons than formerly. From careful measurements made for a series of 12 years at Wilmington, Illinois, it was found that the average volume carried by the Kankakee during the extreme high water was 30,000 cubic feet per second.† Since the partial drainage of the upper portion of the marsh there is little doubt but that during the spring floods the discharge across the State line is fully 25,000 cubic feet per second.

In 1872 Rev. T. H. Ball, of Crown Point, wrote of that portion of the Kankakee bordering on Lake County: "A river is known to be there. The blue line of trees marking its course can be discerned from the prairie heights; but only occasionally in midwinter or in a

*Rep. Upon Improv. Kank. River, 1882, 16.

†See Leverett.—Ann. Rep. U. S. Geol. Surv., XVII, 1896, 740.

time of great drought can one come near its water channel. So far as any ordinary access to it from this county is concerned, it is like a fabulous river, or one the existence of which we take on trust."* Now, within Lake County, five north and south roads reach its borders through the marshes, while three wagon and two railway bridges span its waters. In Porter County six roads lead to it, and one railway and three wagon bridges cross it.

The Kankakee Marshes.

The Kankakee marshes comprise the most extensive body of swamp land in Indiana. The original area of this marsh land in the seven counties drained by the Kankakee was, as already noted, almost a half million acres. For many years schemes of various kinds have been proposed, and hundreds of thousands of dollars have been spent, in endeavoring to reclaim a portion or all of these lands. State aid has been invoked and a large sum appropriated and expended in removing a rock ledge at Momence, Illinois, but this was only a beginning, and, as yet, the end is not in sight. In Lake County there exists, at the present time, 50,000, and in Porter County about 40,000 acres, which, for at least four months of the year, are covered with from one to five feet of water; and during four of the remaining months this area is an immense bog or quagmire.

In these two counties the marshes occupy a broad valley between the border of the moraine and the channel of the river. The mean elevation of this valley is 90 feet above the level of Lake Michigan and 160 feet above the waters of the Wabash River at Lafayette, Indiana. The surface of this marsh land is, for the most part, a great treeless plain, with an average slope of about 1.2 feet to the mile in a westerly direction. On the immediate border of the river there is a strip ranging in width from a fourth to one and one-half miles, which is heavily timbered. In the southeastern corner of Lake and on adjacent territory in Porter County this timbered area widens and comprises about ten square miles. The only other timber is found on the so-called "islands" or "groves," whose surfaces rise 10 to 20 feet above the general level of the marsh. The largest of these in Lake County is Fuller's Grove, in sections 4 and 5 (32 north, 8 west), between the Griesel and Singleton ditches. It is one and a half miles long by one-third of a mile in width. Others are Oak Grove, south half of section 16 (32 north, 9 west), and South Island, in sections 13 and 24 (32 north, 8 west), each of which are about one by one-quarter miles in area; Beech Ridge, section 9 (32 north, 7 west); Ridge Island, sections 10 and 11 (32 north, 8 west); Crab-Apple Grove, section 19

*Lake County, 1834—1872, 16.

(32 north, 9 west), and others, are smaller. All were once covered with a heavy growth of oak, hickory, black gum and other timber, the best of which was long ago removed by the early settlers along the northern border of the marsh. The surface of these islands, when cleared, becomes fair grazing lands, but the soil is in general too sandy for cultivation. On the majority of the "islands" are houses, in which dwell the owners or renters of the surrounding marsh lands.

Vegetation of the Marshes.

The open marsh is covered with a rank growth of wild grasses, bullrushes, sedges, reeds, wild rice and other semi-aquatic vegetation. Over a large area which has been sufficiently drained much of this growth is annually cut, either for bedding or marsh hay. In other places the surface is either too rough, being cut up with sloughs and bogs, or never drys sufficiently to allow teams to pass over it. Oftentimes, after a long drouth, thousands of acres are burned over by a fire which sweeps along with great rapidity, consuming everything in its path.

Between the woodland bordering the river bank and the marsh, as well as around the margin of most of the islands, there are dense thickets of elbow brush, *Cephalanthus occidentalis* L., willows, swamp dogwoods, soft and red maples and other swamp-loving shrubs. These grow so densely that a person has no little difficulty in forcing his way among them. In some places, as at Stowell's ranch in southeastern Porter, sections 1 and 2 (32 north, 5 west), and at Gales, in southern Lake, section 26 (32 north, 9 west), large areas of land whose soil is a rich sandy loam rise above the surrounding swamps. These areas were less heavily timbered than the islands above mentioned, and comprise valuable farming lands.

Soil of the Marshes.

In general the soil of the marsh is a dark, sandy loam, very rich in organic matter. For century upon century a thick mass of vegetation has fallen and decayed, and mingled with its remains have been the particles of sand and clay brought down as sediment by the overflowing waters. No richer soil occurs in the State, and its depth in many places is from three to five and even six feet. Like all soils composed of similar materials, it is very porous and has the power of taking up and retaining large quantities of water. Beneath the soil is a sand, darker colored and containing a greater mixture of calcareous and earthy matter than that found near the shores of Lake Michigan. When thrown up by the dredge it packs and becomes hard, forming excellent roadbeds wherever it has been put to that use. Below the sand are layers of fine gravel and below that the omnipresent blue clay of the older glacial tills lies next above the surface rock.

All of the materials lying between the blue clay and the soil are the sedimentary deposits of a great post-glacial river, for the valley itself doubtless owes its origin to the flow of waters which followed the melting of one of the later retreating ice sheets. This flow was at first sufficient in volume and velocity to erode the present valley to quite a depth through the underlying clay. Later, on account of a diminution in the supply of water, as well as the gentleness of the slope, the current became too sluggish to erode much deeper or to carry coarse material, and only the finer sediment was brought down. From a still farther diminution in the water supply, as well as by the building up of a sedimentary dam near the western end of the valley, the water for a long period ceased to flow, and a lake of shallow depth resulted. Where the waves or currents of this lake washed against the higher portions of its bed, or its shores, accumulations of sand and mud were thrown up from its bottom. These increased in size, and, rising above the water, became covered with trees. The surface of these "sand islands" has ever since remained above the flow of waters and, as a consequence, their soil lacks those rich organic constituents, formed by the decay of aquatic plants, which are possessed by the soils of the surrounding marsh.

Origin of Kankakee Valley.

Again, by a new accession of water from the northwest, the barrier at the foot of the valley was washed away and the river of the present had its beginning.* At first its waters flowed the full width of the valley, but in time their volume decreased and a portion of the river's bed became bare in summer. Over this a vegetation sprang up and decayed. A soil was started above the sands and was added to each year by the decay of the summer's vegetation and the sediment brought down by the overflow in spring. The main current of the stream was thus gradually narrowed until it reached its present size. The annual overflow is yet sufficient to cover the porous soil and to fill its every interstice with water, which, on account of the gentle slope, cannot flow rapidly away after the subsidence of the flood. Thus the valley remains a marsh, and will so remain until a complete system of drainage furnishes a more rapid outlet for the waters which are absorbed during the annual overflow.

Quite a percentage of the marsh land in the two counties has been already partially reclaimed by large ditches either dredged by private enterprise or by assessment against the adjacent lands. In Porter County the largest of these is Reeve's ditch, beginning on the county

*This alternate increase and decrease in the volume of the water may have corresponded in time with the increase and decrease in the waters of Lake Chicago, already noted.

line, in the southeast quarter of section 24 (33 north, 5 west.) Thence it runs southwestward across section 25 and then due west to Grand Junction, east half of section 36 (32 north, 6 west), where the old mouth of Crooked Creek unites with the Kankakee. A mistake was made in the construction of this, as in several other of the large ditches, in that the sides were left almost perpendicular instead of with at least a 45 deg. slope. As a result, freezing has caused the sides to slough off and partially fill the ditch, so that it only serves as a drain in wet weather.

Drainage of the Marshes.

In Lake County the Singleton ditch is the main one, the others being tributary to it. This ditch extends from Eagle Creek, in section 29 (33 north, 7 west), in a generally southwesterly direction to the river, crossing the State line near the southwest quarter of section 25 (32 north, 10 west). It was begun in 1882 and completed in 1886; being constructed under the general ditching laws, with an average assessment of about $2.00 per acre on all lands between the river and the north margin of the marsh. It was 20 feet in width by 5½ feet to 7 feet in depth, but its sides were too abrupt, and it now needs re-dredging throughout its full length. By its construction a large acreage of the marsh was reclaimed sufficiently for the cutting of wild hay. Along the northern border minor secondary ditches soon allowed the raising of cereals on a strip a mile or two wide.

The Brown ditch was constructed in 1888, mainly as a shore ditch to prevent the spreading of water from the river northward. Through it the water flows in all seasons, even in great drouths. In length it is about 14 miles, extending from section 4 (32 north, 7 west), to the Singleton ditch, near the west end of Ash Grove, section 29 (32 north, 9 west). Other subordinate ditches are Griesel's and Ackerman's, shown on the accompanying map.

The report of Dr. J. L. Campbell on the drainage of the Kankakee marshes, published in 1882, has become very scarce. It is thought best, therefore, to incorporate in this connection the conclusions and recommendations of Dr. Campbell relative to the draining of those portions of the marsh lands lying in Porter and Lake counties. These conclusions were based on an accurate survey of the entire region, made by authority of an act of the Legislature, approved April 11, 1881. Under the head of "General Improvement," Dr. Campbell says:* "The drainage and recovery of the Kankakee marshes will in-

*"Report Upon the Improvement of the Kankakee River and the Drainage of the Marsh Lands in Indiana," 1882, 15.

Campbell's Report on the Drainage of the Kankakee Marshes.

clude: First, the construction of a better main channel than now exists, for the flow of the river; second, the straightening and deepening of the beds of the streams which empty into the main stream; and third, the digging of a large number of lateral ditches through the swamps to the improved channels.

"The portion of the work which seems properly to belong to State and National supervision is the improvement of the main channel of the river. The other parts of the work may be left to the owners of the land, to be executed under our general drainage laws."

For convenience in describing the necessary improvements, the river and marsh lands were divided into seven divisions. Of these, the conclusions regarding divisions III., V. and VI. are those which are quoted, since they deal with the drainage of the lands in Porter and Lake counties.*

"DIVISION III. extends from the terminus of Division II. at the mouth of Mill Creek, section 7 (34 north, 2 west), *by a new channel*, to Grand Junction, at the mouth of Crooked Creek, section 36 (33 north, 6 west).

"The Kankakee River below the mouth of Mill Creek has a belt of timber along its banks, which would make the cost of straightening the river very great.

"The great deflection of the river from the general direction of the valley makes it important to shorten the distance by a new channel.

"The line proposed for the improvement lies in a remarkable part of the valley. The line will be clear from timber obstruction, except about one and a half miles at the lower end, where it passes through the belt of river-bank timber into the old channel. The line lies for the most part in a series of deep marshes, now impassable, and well known in the neighborhood as a deep slough, sand channel, etc...... The new channel will take the greater part of the water of the improved river above Mill Creek, and all the surface drainage on the north side in Laporte and part of Porter counties. The length of the division will be 21.5 miles.

"The proposed dimensions for the new channel for this division are at the upper end—width of bottom 27 feet, width at top 51 feet, depth 8 feet, area of cross section 312 square feet. At the lower end—width at bottom 33 feet, width at top 57 feet, depth 8 feet, area of cross sec-

*Division IV. was subordinate to III., and included the improvement of Yellow River and the present channel of the Kankakee along the line of Division III., for the purpose of draining the territory south of that river. The estimated cost of this division was $80,000.

tion 360 square feet. The mean measure will be—width at bottom 30 feet, width at top 54 feet, depth 8 feet, area of cross section 336 square feet.

"These dimensions will give—mean hydraulic depth 5.23 feet, calculated mean velocity 2.405 feet per second, mean volume of discharge 808.4 cubic feet per second. The volume of discharge at the lower end will be 878.4 cubic feet per second.

"The mean dimensions will give—for each linear yard 37 1-3 cubic yards, for each mile 65,707 cubic yards, for the division 21.5 miles, 1,412,700 cubic yards; the cost of which, at 7 cents per yard, will be $98,889; or, at 10 cents per yard, $141,270." But 6.75 miles, or 443,522 cubic yards, of this division lie in Porter County. This, at 7 cents per yard, would cost $31,046, or, at 10 cents per yard, $44,352.

"DIVISION V. extends from Grand Junction, section 36 (33 north, 6 west), *by a new channel*, to a point in the river in section 33 (32 north, 8 west), near the bridge on the line of the Indianapolis & Chicago (Monon) Railway.

"At Grand Junction, the new channel or the Upper Kankakee, the old channel or the Yellow River section, and Crooked Creek, unite their waters and form the enlarged lower river.

"From Grand Junction to the State line, and to Momence, Illinois, there is plenty of water for the purposes of navigation, and it is desirable that the improvement below Grand Junction should be made with reference both to drainage and navigation. The route proposed for the new channel will be through the open marsh, entirely free from timber obstruction, except one mile of river-bank timber on the west end, and is admirably located with reference to the drainage of some of the deepest marshes in the entire valley.

"Another route may be adopted, nearly, if not quite, as good as the one proposed, by running the new line more directly west after it enters Newton County, and terminating in the river north of the point above mentioned; thence by the straightened river to the terminus at the State line. The cost of the two routes will be about equal. The length of the division will be 16 miles.

"The dimensions proposed for the new channel for this division are—at the upper end, width at bottom 36 feet, width at top 63 feet, depth 9 feet, area of cross section 445.5 square feet. At the lower end—width at bottom 42 feet, width at top 69 feet, depth 9 feet, area of cross section 499.5 square feet. Mean measure—width at bottom 39 feet, width at top 66 feet, depth 9 feet, area of cross section 472.5 square feet.

"These dimensions will give—mean hydraulic depth 6.06 feet, calculated mean velocity 2.7 feet per second, volume of discharge 1,275.7 cubic feet per second. The volume of discharge at the lower end station will be 1,358.6 cubic feet per second.

"The mean dimensions give for each linear yard 52.5 cubic yards, for each mile 92,400 cubic yards, for the division (16 miles) 1,478,400 cubic yards; the cost of which, at 7 cents per yard, will be $103,488, or, at 10 cents per yard, $147,840.

"The old channel of the river below Grand Junction receives no important creek, and only a small expenditure will be required to keep this channel open for its limited drainage area."

"DIVISION VI. extends from the terminus of Division V., along the general line of the river to the State line.

"The increased velocity of the river in this division, owing to its increased slope and the general direction of the stream, make the improvement desirable along the general line of its present flow.

"A new channel in section 33 (32 north, 8 west), one mile in length, and a similar one, chiefly in sections 1 and 2 (31 north, 9 west), two and a half miles long, will be required. The dimensions of these new channels are estimated the same as in Division V.—per mile, 92,400 cubic yards—3½ miles, 323,400 cubic yards; and their cost, at 7 cents per yard, will be $22,638, or, at 10 cents per yard, $32,340.

"The other improvements in this division will consist in a general straightening of the channel, the removal of timber obstruction and dredging the channel to secure an additional depth of two feet, the estimated cost of which will be $69,000.

"The estimated length of the division after the improvement has been made will be 15 miles.

"In addition to the cost of construction, the question of maintenance of the new channel requires consideration. The same causes which produced the present crooked river will, in a less degree, affect the straightened stream, and continued care will be required to preserve an unobstructed flow.

"If we assume that the river now has an approximately stable bed, the result mainly of the free action of natural forces on the sandy soil, it is evident that any increase of velocity will affect this stability and introduce a disturbing element which will require special attention.

"The banks of the new channel will likewise deliver quantities of sand into the current until they assume their proper angle of rest and are protected by grass or other vegetable growth.

"The lateral ditches will also bring down masses of sand, which will, if left uncared for, form bars where these ditches empty into the river.

"To meet these difficulties it will be necessary to keep at work one or two dredging machines until the new channel has assumed a partially stable condition.

"Grass grows most luxuriantly in all parts of the Kankakee Valley, and from this cause we may expect that the banks will be covered very rapidly. After the drainage has been once accomplished and the lands brought under cultivation, there will be a great diminution of the volume of water to be carried off.

"The absorbent power of the reclaimed land and the evaporating surface will be increased, and the quantity of surplus water will be proportionally diminished.

"The diminished volume will give a relative increased capacity, with less depth, and thus by degrees the new channel will become stable, while at the same time it fulfills all the requirements for complete drainage."

The minimum cost of the improvements for draining the Kankakee marsh lands west of the mouth of Mill Creek was thus estimated by Dr. Campbell to be $294,015, and the maximum $390,450. Subtracting from these two amounts, respectively, $67,843 and $96,918, the estimated necessary cost of that portion of the excavation lying in Laporte County, we have $226,172 and $293,532 as the estimated maximum and minimum cost of all improvements between the east line of Porter County and the State line.

From the Porter County line the new channel could be extended eastward to connect with the present river at Lougee's wagon bridge, section 24 (33 north, 4 west), a distance of three miles. Assuming Dr. Campbell's figures of the mean excavation to the mile for Division III. to apply to this extension, its cost would be $13,798, at 7 cents per cubic yard, or $19,712, at 10 cents. The total cost of draining the lands would, therefore, according to Dr. Campbell's plans, be between $239,970 and $313,244. In addition to the marsh lands north of the river, fully 70,000 acres would be reclaimed in Jasper and Newton counties on the south, so that the cost would be less than $2.00 per acre for the 160,000 acres in the four counties.

Taking into consideration their proximity to Chicago and the excellence of their soil, there is little doubt but that these lands, if permanently drained, would command from $40.00 to $60.00 per acre. It would seem, therefore, that private enterprise would have long since provided for their drainage. But in this instance private enterprise has been waiting for State aid, which has been granted only to the extent of partially removing the barrier of rock at Momence. If the State would appropriate $300,000 for straightening the river and reclaiming the lands, it would be only a loan of money; soon to be repaid, for the increase in the taxable value of those lands would soon bring back to her coffers far more than the amount expended. The principal reason why such an appropriation is not made doubtless lies in the fact that the lands are, for the most part, owned in tracts of from one to ten thousand acres, instead of by many individuals. The people of the State do not believe in increasing the wealth of these speculative owners by temporarily taxing themselves. Still, as a business enterprise, the State would, in time, be largely the gainer, and a portion of her area now practically valueless would soon be known as the garden spot of northern Indiana.

GENERAL FEATURES.

Although the prairies of the two counties belong, for the most part, to the morainic region, their consideration has been purposely omitted until after that of the Kankakee marsh, since that marsh is but an embryo prairie; i. e., a prairie now in the course of formation.

We have already noted the fact that the irregular deposition of drift gave rise to the basins of morainic lakes. Where these basins are deep valleys or pot holes, they still contain water. Where large areas were covered with but a shallow depth of water, those areas were first lakes, then swamps, and finally prairies. The change from one to the other was gradual, and in many places is still going on.

Prairies.

Near the close of the glacial period the surface of the morainic area of Lake and Porter counties contained a number of large shallow basins, which were covered by the melting waters of the glacier. For many, perhaps thousands of years, the waves piled up sands from the deeper portions of these basins into the "sand islands," or present wooded groves, which here and there dot the prairies. Everywhere in the shallow water aquatic plants were slowly decaying, and their organic matter, mingling with the fine sediment which was constantly settling, gave rise to that peculiar soft black mould or loam which forms the main portion of typical prairie soil. After a time, by evaporation and other causes, the water was removed from the surface of each of these shallow lakes, and a swamp resulted. This in turn gave way to a wet prairie, and this to a dry prairie with a compact sod of grasses. As long as the earth was covered with water no seeds of trees would germinate. Neither would they germinate after the water disappeared, for the soil was too full of humic acid formed by the decaying of the aquatic plants. Finally the sod became so thick and tough that if the conditions of germination had been favorable the rootlets of the sprouting seed could not have penetrated it. These reasons are responsible for the treeless condition of all typical prairies.

In passing back from the margin of the Kankakee marsh lands towards the higher prairies on the moraine, the wet and dry prairies merge by such insensible degrees that it is very difficult at times to fix a point of separation between them. The surface appearances are very much the same. The plants are all herbaceous and belong practically to the same families, differing only in that some prefer dry and others moist situations. The likeness of the soil is still more striking. The same kind of sub-soil is overlain by the same black spongy mould. The "islands" of both marsh and upland prairies are also essentially the same in composition and in the kinds of timber which cover them. No one who carefully compares the characters common to both can for an instant doubt but that the origin of the one has been similar to that of the other.

The greater irregularity of surface in the upland prairie which causes it to be termed *rolling*, is due in part to irregular deposition of drift, the deeper parts of the lakes having been over the lower portions of the present prairie, and in part to the erosion of the waters as they slowly found their way through the countless lagoons of the swamps to lower levels.

In several places in the two counties small prairies have been formed by the work of beavers. Dams were thrown up. Ponds or small lakes were formed, and the sand from the bottom of these lakes was washed out in several localities about their margins. Beaver Dam Marsh, northwest of Crown Point, in section 1 (34 north, 9 west), now in a transition stage between a swamp and a prairie, is an example which may thus be traced to the work of beavers. The sand along the road which runs across the marsh was washed up from the bottom of the lake, where it was originally deposited as a part of the Valparaiso moraine.

The principal prairies of Porter County are Twenty Mile Prairie, in Portage and Union townships; Morgan Prairie, in Morgan Township, and Horse Prairie, in Porter Township. In Lake County, Robinson's Prairie, near the center; Lake Prairie, in the southwest, and Eagle Creek Prairie, in the southeast, are the largest, most fertile and most beautiful.

When the two counties were first settled the wooded islands and the timbered uplands, with their clayey and sandy soils, were considered more valuable than the prairies. The settlers had come from well-timbered countries and had the erroneous belief that land that would not produce trees would not produce cereals. Many of the prairies, as Twenty Mile Prairie, Whippoorwill Prairie, and much of Morgan Prairie in Porter County, and those on the northern half of the morainic region in Lake County, were wet prairies, and for years yielded only swamp hay and pasture.

At present the prairie soils are considered far more valuable than those of the woodlands. The elements entering the former through the medium of decayed aquatic plants and animals have been in proper proportion and in sufficient quantity to give them extraordinary fertility. Their depth is so great that successive crops of the same kind can be cultivated year after year; the lower portions being as rich in the necessary elements of plant food as are the upper.

FARM PRODUCTS.

Especially are these prairie soils suited to the production of grass and hay. As natural meadows, they fed for centuries countless numbers of buffalo and deer. They now yield for the domestic animals of man thousands of tons of the best of timothy and wild hay.

Hay Production. In 1896 Lake County ranked second and Porter County third among the 92 counties in the State of Indiana in the production of timothy hay. The former produced 36,560 acres, yielding 49,356 tons;* the latter, 25,570 acres, yielding 34,438 tons. This does not include the upland prairie hay nor the lowland marsh hay. Probably as many or more tons of the latter are produced than of the timothy, though statistics are not available. Thousands of acres are annually cut, stacked, baled and shipped to Chicago. If the yield of timothy hay is short, good prices are realized. If timothy is plentiful, much of the marsh hay must be sold for bedding and packing at lower prices. Wild hay from upland prairies ranks next to timothy in quality, and sometimes brings even a better price. The largest hay fields in the State are in these two counties. In the northeast corner of Pleasant Township, Porter County, in 1897, were two full sections—1 and 12 (33 north, 5 west)—of raw prairie in one field, every foot of which was mowed. Another field, containing 2,000 acres, formerly in meadow, but now pastured, lies north of Fuller's Island, in Cedar Creek Township, Lake County. It has been partially reclaimed by the Griesel and Singleton ditches.

*Allen County ranked first by a very small margin, producing 36,826 acres and 49,715 tons. These figures are from the 12th Report, Indiana Dept. of Statistics, 1896, 436.

The prairie soils also yield bountiful crops of corn and oats, but wheat is not a success, especially in Lake County, where, in 1897, but 809 acres, yielding 12 bushels per acre, were produced. The freezing of the soil causes it to "heave" and throw out the roots of the plant, and the latter winter-kills. In Porter County, especially on the uplands of Washington, Jackson, Liberty and the eastern half of Center townships, a much larger acreage is sown; the average for the last three years being about 12,000 acres, with an average yield of nine bushels to the acre.

Production of Cereals.

Much of the sand-covered area of the two counties, now considered waste land, will be found to be admirably adapted to the raising of small fruits and certain vegetables. Wherever wild berries and wild grapes grow luxuriantly, there, with a little care, can tame ones be successfully cultivated. Within recent years the growing of strawberries has been carried on to quite an extent on the sandy lands in the vicinity of Furnessville. This fruit is especially suited to a sandy soil, and hundreds of acres could be grown in the Calumet region on land which now produces nothing but weeds. Where they have been planted and given proper attention they have yielded bountifully and have found a ready market in Chicago. The raising of raspberries has also proven successful in the same vicinity, as well as on the sandy lands southwest of Kouts, in Pleasant Township, Porter County.

Small Fruits and Vegetables.

On the crests and slopes of the higher sand ridges along the shores of Lake Michigan wild grapes grow abundantly, and the fruit reaches a large size. The vines spring, apparently, from a mass of pure dry sand. But a careful examination will soon show that only the surface of the sand is dry. Six or eight inches below the surface there is moisture even in the dryest of seasons. It rises, by capillary attraction, from the very base of the ridge or dune, and the surface itself would be moist were it not for the constant evaporation. Moreover, the sand is not pure silica, but contains sufficient calcareous and organic matter to furnish plentiful food for the wild grapes, wild grasses and numerous shrubs and trees which spring from its surface. That tame grapes will thrive and yield abundantly on these sands has been proven by Mr. A. Stamford White, of Chicago. In 1894 he planted in Concord grapes three acres on the southern slope of a sand ridge, in section 3, Pine Township, Porter County. On September 10th, 1897, each vine was loaded with as fine fruit as one could wish, which was just ripening. The only drawback was due to the exceptional drouth of that season, which had caused the leaves of some of the vines to shrivel and drop, and so exposed the fruit to the blistering rays of reflected sunlight. This would not happen in an ordinary season. Numerous peach and cherry trees had also been planted on the same ridge and were growing thriftily, but were yet too young to bear. Plum trees will also doubtless bear well, since many clumps of wild trees were noted on the "sand islands." Wild huckleberries grow plentifully in the Calumet region, and from Tolleston a thousand bushels a year were formerly shipped.* The huckleberry seems to be especially adapted to the sandy ridges, and is one of the most prolific and highly esteemed of the wild midsummer fruits.

The more level sandy areas, when first cultivated, produce for a few seasons excellent sweet potatoes, watermelons and pumpkins. By a careful system of fertilization a plentiful yield of all vegetables which flourish best in a sandy soil could be obtained. This has been proven in a locality along the Monon Railway, south of Hammond, where, for several seasons, hundreds of carloads of night soil have been shipped from Chicago and used as a fertilizer. As a result, an abundant yield of vegetables has been obtained from land once thought to be barren. These are in turn shipped to the Chicago market, thus furnishing a pointed example of that constant circulation of matter forever going on.

In the marshes wild cranberries grow indigenously, and when the season is not too dry excellent crops are produced. Much of the marsh land now uncultivated could be made to yield a handsome revenue if planted to this fruit. The largest, best-flavored and highest-priced berries can be readily grown on drained marsh land which has been properly prepared by cultivation so as to remove the natural growth of bushes, weeds and grass; and which can be flooded in late autumn and early spring. Where muck underlies the sod the latter should be removed and about four inches of sand mixed with the former: since the muck alone produces plentiful vines but few berries. Four years are necessary for the plant to come into full bearing, when the yield is from 100 to 150 bushels per acre, the wholesale price of the better berries being seldom less than $2.00 per bushel. Plentiful water for flooding the marshes can be readily obtained by putting down driven wells and equipping them with windmill pumps. By this means also water in unlimited quantity can be had for irrigating fruits and vegetables grown on sandy lands adjacent to the marshes. Large areas of the marsh land now uncultivated will also produce paying crops of peppermint and celery, both of which plants require rich, moist soil for their successful raising.

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*Ball, Rev. T. H.—Lake County, 1884, 159.

Next to hay, the most valuable farm product of the two counties is milk. Among Indiana counties, in 1897, Lake ranked third, and Porter fifth, in number of milk cows, there being in the former 9,832 and in the latter 8,218.*

Production of Milk.

The numerous railways passing through the counties to Chicago have each one or more daily "milk trains," which stop at platforms erected at intervals of two or three miles and gather up the liquid product for the Chicago market. The demand for milk in that city is constantly on the increase. The cash return therefor is sure, profitable and quick to reach the producer's pocket. As a result, the number of dairies in the two counties is constantly increasing, while the acreage devoted to the raising of cereals grows proportionally less.

Timber.

Fifty years ago Lake and Porter counties contained much valuable timber, but the older and larger trees have almost all been removed, and what remains is mostly "second growth." As already noted, the wooded groves or "sand islands," of both the prairie and the marshes, are thickly covered with small-sized black oak, *Quercus velutina* Lam., white oak, *Q. alba* L., bur-oak, *Q. macrocarpa* Michx., and in places the shell bark and pignut hickories, *Carya alba* Nutt., and *C. porcina* Nutt. Much underbrush exists among these trees, and about the borders of the islands, especially sassafras, hazel, crab-apple and hawthorne shrubs.

On the sand hills along the northern border, notably in Porter County, grew many large-sized white pine, and black and white oaks, but sawmills were erected in several localities on the lake shore, and the hills were soon stripped. The gray or northern scrub pine, *Pinus banksiana* Lambert, now far outnumbers the white pine in that region.

No hard or sugar maple trees and but few beech grow indigenously in Lake County, but on the clay uplands of Jackson and Pine townships, in Porter, they are found in numbers. Here, also, grow red oak, *Q. rubra* L., shingle oak, *Q. imbricaria* Michx., and the wild cherry. Sycamore, river or red birch, *Betula nigra* L., and the soft or silver maple, occur along the banks of the Kankakee and the Little Calumet, but they do not reach the size which they attain in central Indiana.

MINERAL PRODUCTIONS.

Porter and Lake are pre-eminently agricultural and manufacturing counties and contain but few mineral productions of value. No coal or building stone occur within their bounds, and neither natural gas

* Allen County was first with 11,002; Marion second, with 10,016, and St. Joseph fourth, with 8,716.

nor petroleum have as yet been found. Deposits of clay suitable for making pressed front brick, terra cotta lumber and other high-grade clay products are located near Hobart, Porter and Chesterton, on the Deep and Calumet rivers. Clay suitable for ordinary brick and drain tile occurs in a number of localities in the morainic region. These deposits are described in detail in another paper in the present volume.

Clay.

Molding sand of excellent quality occurs in abundance at several localities in the two counties. The best-known deposits are on the lands of L. H. Robbins and Theodore Swear, near McCool, Porter County, sections 7, 8 and 17 (36 north, 6 west). These deposits occur over the greater portion of the three sections, and shipments have been made from them for six years. In 1897 a carload a day was shipped from the Swear land (section 17) to the Illinois Steel Company, at South Chicago, and four cars a week from the Robbins land to foundries in Chicago. The owners haul the sand to McCool and load it on the cars, receiving from $7.50 to $10.00 per carload at that station. The principal bank on the Robbins land, one-half mile northeast of McCool, showed the following exposure:

Molding Sand.

Soil	1	foot.
Fine grained buff clay containing much silica or free sand—"loam"	2	feet.
Coarser, darker molding sand	3.5	feet.

The soil is stripped; the "loam" separated from the molding sand and sold for lining ladles and cupola furnaces, and the molding sand for making castings. Each foot in thickness yields about 70 carloads per acre.

Southeast of Valparaiso, in southwest quarter of section 34 (35 north, 5 west), and north half of section 3 (34 north, 5 west), are also deposits of molding sand, much of which has been shipped to Chicago in recent years. The main deposits are close alongside the "Nickel Plate" Railway. The sand here is a dark brown, averages from two and one-half to three and one-half feet in thickness, and is overlain by six inches of soil. On the roadside one-fourth of a mile east of the Methodist Church, near the center of section 15, Washington Township, Porter County, is also an exposure of molding sand, deeper-red in color and three feet in thickness. It underlies six inches of soil and overlies a thick deposit of ordinary sand.

In Lake County the only deposit of molding sand noted was one and a half miles southeast of Hobart, on the land of William Frank, southeast quarter of section 33 (36 north, 7 west). Where exposed, this deposit is from eight to ten feet thick and is overlain by eight inches of soil. It has been tested in Chicago and in the foundry at Hobart, and is pronounced of excellent quality. The Nickle Plate Railway runs within one-eighth of a mile of this deposit, which doubtless covers the greater portion of the quarter section. The following record of a bore put down 200 yards south of the above exposure was furnished by Mr. Frank:

Soil	1	foot.
Molding sand—heavy	4	feet.
Molding sand—lighter	4.5	feet.
Blue sand	6	feet.
Blue clay	76	feet.
Blue sand and clay mixed	96	feet.
Total	187.5	feet.

Both this deposit and the one near McCool are within the area at one time covered by the bay of Lake Chicago, mentioned on page 33, and were doubtless deposited by that sheet of water.

Peat and Bog Iron Ore.

Peat exists in quantity in many of the marshes of the two counties. In Lake it is especially abundant in the Cady Marsh, northeast of Dyer. In Porter, the marsh north of Furnessville and the one along Sandy Hook Creek, in Morgan Township, contain it in great abundance. It is formed by the partial decomposition of plants beneath the surface of the water. The gaseous constituents of the plants mostly escape, but the carbon is left behind. The decay of the plants is prevented by the water, which shuts off the free oxygen of the air, the main agent of all decay, and also by a peculiar antiseptic property which peat itself possesses. Each generation of plants takes gaseous carbon dioxide from the air, solidifies it within the plant body, and then adds it to the soil. A bog is therefore composed of the solid matter of thousands of generations of plants. The peat can be readily cut, dried and pressed into a valuable domestic fuel. At one time quite an industry of this kind was started at the Cady Marsh, but cheap coal, brought in by the many railways, has brought it to an end.

Beneath the peat bogs, especially in the Calumet region, there usually occur great quantities of limonite or bog iron ore. In the marsh north of Furnessville masses of it weighing many hundreds of pounds have been unearthed. This ore is too impure, however, to compete with the hematite and other high-grade iron ores of the Lake Superior, Missouri and Georgia mines. At one time a large blast furnace for reducing the bog ore of the Kankakee region was in operation at Mishawaka, St. Joseph County, but, like a number of others in central and southern Indiana, it has long since gone out of blast.

Gravel.

Gravel suitable for road purposes should be found in quantity in the higher ridges of the morainic region, but a careful search has not, as yet, revealed its presence. It is plentiful in the clay soil of the uplands, and seems to have been scattered through this soil and not accumulated in vast beds as in the moraines of central Indiana. The largest deposit noted in Lake County was near West Creek, in section 7 (32 north, 9 west). It was excellent in quality, but was but two and one-half feet thick, and was overlain with three feet of earth and underlain with coarse sand. It is my opinion that careful investigation will yet reveal large deposits of gravel in the higher ridges east and west of Lowell, and in some of those north and west of Hebron.

Several small deposits have been found just south and west of Valparaiso, one of which, called "Sugar Loaf," 20 feet in height and covering half an acre, was used on the streets of that city. A deposit three feet and more in thickness was noted east of Bell Marsh, on the side of the Valparaiso and Laporte road, in the southeast quarter of section 10 (35 north, 5 west). The appearance of the surrounding country is very favorable to the discovery of large deposits in this vicinity. The absence of good road material is a great drawback to the rapid development of the two counties, most of the gravel which has heretofore been used having been shipped in at great expense from Joliet, Illinois.

Stone.

In September, 1897, it was reported at Chesterton that an outcrop of rock, *in situ*, had been discovered near Gosset's mill, in the western part of Liberty Township, Porter County. A visit to the place showed that on the land of John Tratebas, northwest quarter of section 21 (36 north, 6 west), the supposed rock was being taken out from a bluff of Salt Creek. The following section was exposed:

1.	Soil and clay	2.5 feet.
2.	Sand, strongly impregnated with a solution of carbonate of lime	14 feet.
3.	Calcareous sandstone formed by the cementing action of carbonate of lime on the grains of sand	4 to 6 inches.
4.	Sand	3 feet.
5.	Gravel	6 inches.
6.	Blue clay	? ?

The sandstone, No. 3, was evidently of very recent formation, and the blocks of it were very rough, uneven and irregular in size. The owner was endeavoring to get out enough of it to strengthen the mill dam, but found it a difficult task on account of the heavy overlying deposit of sand. The cementing principle being carbonate of lime, readily soluble in rainwater, the stone, when exposed, will doubtless soon disintegrate into loose sand.

Other than bowlders, this was the only stone noted in the two counties, and the assertion was frequently made by citizens that no outcrop is known. Richard Owen, however, in his Report of a Geological Reconnaissance of Indiana, 1859, 205, makes the following statement:

"On Mr. Howell's elevated land, about three-quarters of a mile southeast of Valparaiso, on section 30 (35 north, 5 west), we were shown good gray crystalline limestone which had been quarried and burned into lime; but as the layer is only two or three feet thick, and apparently local in extent, it was soon abandoned. Unfortunately, no fossils were found, the lithographic or lithological character, however, indicates a rock of Upper Silurian age."

This statement was not observed until after my return from the field. The only information I have since been able to gain concerning the stone mentioned is from Henry Rankin, of Valparaiso, as follows: "I have interviewed Judge Wm. Johnstone about the limestone. He was raised within a mile of it. When a boy he has seen Mr. Howell burn lime on the northwest quarter of the section cited. He describes the stone as not in strata, but set up on edge, and says there were several cords of it." It is more than probable, therefore, that the stone mentioned by Dr. Owen was of drift origin, and not formed *in situ*.

Numerous springs occur throughout the counties, but the water is, in general, free from mineral constituents. At the Willow Dale Stock Farm, one-half mile north of Crown Point, are, however, several fine springs which yield a copious supply of mineral water. The owner, Mr. W. J. Davis, kindly furnished the following copy of an analysis made by Dr. T. C. Van Nuys, formerly chemist at the State University:

Mineral Water.

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

	Grains Per Gal.
Potassium sulphate—potash salts (K_2SO_4)	0079.94
Sodium sulphate—Glauber's salts (Na_2SO_4)	0011.31
Sodium carbonate—carbonate of soda (Na_2CO_3)	0139.79
Sodium chloride—common salt (NaCl)	0018.34
Aluminum sulphate—aluminum salts ($Al_2(SO_4)_3$)	0065.24
Calcium bicarbonate—salts of lime ($CaH_2(CO_3)_2$)	1929.06
Magnesium bicarbonate—salts of magnesia ($MgH_2(CO_3)_2$)	1165.08
Silicic acid ($Si(OH)_4$)	0166.39
Total	3575.15

The water is colorless and clear. Specific gravity, 1.0002. No iron or manganese was found. T. C. V.

At Hammond mineral water flows from six artesian wells, which average about 1,840 feet in depth, and at East Chicago, from one, 1,830 feet in depth. Two of those at Hammond are located on the grounds of the Western Starch Association, and the water flows from a vein which was struck at 1,850 feet.

A chemical analysis of this water, which will probably hold good for that flowing from the other wells at Hammond, showed the presence of the following mineral salts:

ANALYSIS OF ARTESIAN WATER FROM WELLS ON GROUNDS OF THE WESTERN STARCH ASSOCIATION AT HAMMOND, IND.

	Grains Per Gal.
Silica	1.022
Oxide of iron and aluminum	.058
Carbonate of lime	10.003
Carbonate of magnesia	9.283
Sulphate of soda	29.894
Chloride of sodium	20.913
Carbonate of soda	3.260
Sulphate of lime	38.308
Total	112.741

Two artesian wells, flowing water of high repute, are located in Porter County. One is the Blair well, in the extreme northeastern corner of the county, about one and one-half miles southwest of Michigan City. This well flows about 80 gallons per minute of water which a few years ago was much used for medicinal purposes. A bathhouse and sanitarium were erected, and many guests visited the place each year and were benefited by the treatment. Since the death of the owner the use of the water has been practically abandoned. The depth of this well was 840 feet, and an analysis of the water by Dr. P. S. Hayes, 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 Gal.
Chloride of sodium ($NaCl$)	360.4794
Chloride of magnesium ($MgCl_2$)	45.6550
Sulphate of potassium (K_2SO_4)	17.9968
Sulphate of magnesium ($MgSO_4$)	31.9730
Sulphate of calcium ($CaSO_4$)	84.4024
Bicarbonate of calcium ($CaH_2(CO_3)_2$)	147.8503
Silica (SiO_2)	1.7523
Total solids determined	690.1092

Hydro-sulphuric acid, total in volume at 62° F, 11.1719 cubic inches.

The second well flowing mineral water in Porter County is located on the grounds of the Chicago Hydraulic Press Brick Company, at Porter, twelve miles southwest of Michigan City. It was bored in search of gas to a depth of 860 feet, and at present flows about 75 gallons per minute of water which is highly charged with hydrogen sulphide, as well as the following mineral salts:

ANALYSIS OF THE PORTER ARTESIAN WATER.

	Grains Per Gal.
Sodium chloride—common salt ($NaCl$)	208.76
Calcium chloride—chloride of lime ($CaCl_2$)	51.93
Magnesium chloride—salts of magnesia ($MgCl_2$)	38.71
Ammonium chloride—salts of ammonia (NH_4Cl)	0.44
Potassium chloride—potash salts (KCl)	13.18
Potassium sulphate—potash salts (K_2SO_4)	17.08
Calcium carbonate—carbonate of lime ($CaCo_3$)	11.14
Silica	1.10
Total	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."

RAILWAYS.

The 920 square miles comprised in these two counties is less than one-fortieth of the area of Indiana, yet they contain more than one-fourteenth of the total miles of railway in the State. Of the $154,841,971 of railway property assessed in Indiana in 1897, $15,539,249, *or more than one tenth*, is within these counties and pays taxes into their treasuries.

Among Indiana counties, Lake easily ranks first in the number of miles of railway within her bounds. Porter stands third, being excelled only by Laporte, her much larger eastern neighbor. Nine great trunk lines cross both counties from east to west and in Lake the Monon runs almost the full length of the county from north to south. The two counties thus stand at the main door of entry into Chicago. Across their bounds all passengers to and from that city to the Eastern States must travel.

Besides these ten great systems, five belt railways, each connecting with almost all the roads entering Chicago, cross a portion or all of

Lake County, and one of them, the Elgin, Joliet & Eastern, extends nine miles into Porter. The principal business of these belt roads is the transferring of freight from the main trunk lines east of Chicago to similar lines running west from that city. Crossing and intersecting, as they do, the Calumet region, they give to that area most excellent shipping facilities. Many capitalists have, of recent years, availed themselves of these facilities, and about Hammond, East Chicago, Whiting, Hobart, Porter and Chesterton have been located some of the largest and most flourishing factories in Indiana. In fact, its many railways, its proximity to Chicago and the cheap prices at which factory sites can be secured within its bounds, now mark the once despised and little valued Calumet region as one of the future great manufacturing districts of the world.

In order to give exactly the railway statistics of the two counties, the following table from the "Proceedings of the Indiana State Board of Tax Commissioners for 1897" is inserted:

Railway Statistics of Lake and Porter Counties in 1897.

NAMES OF ROADS.	Main Track.			Second Main Track.			Side Track.			Rolling Stock.			Improvements on Right of Way.	Total of Roads.	Total of Counties.
	Miles.	Per Mile.	Total.	Miles.	Per Mile.	Total.	Miles.	Per Mile.	Total.	Miles.	Per Mile.	Total.			
LAKE COUNTY—															
Baltimore & Ohio & Chicago	17.86	$22,000	$392,920	11.42	$8,000	$91,360	11.59	$3,500	$40,565	17.86	$2,500	$44,650	$1,460	$570,955	
Chicago & Erie	24.42	25,000	610,500	......	......	......	17.16	3,500	60,060	24.42	2,500	61,050	8,350	739,960	
Chicago & Lake Shore Eastern	7.94	10,000	79,400	7.51	5,000	37,550	......	......	......	7.94	1,500	11,910	400	129,260	
Chicago & Calumet Terminal	10.93	18,000	196,740	.99	6,000	5,940	12.82	3,500	44,870	10.93	3,000	32,790	2,750	283,090	
Chicago & Grand Trunk	16.53	32,000	528,960	......	......	......	3.83	4,000	15,320	16.53	3,500	57,855	3,600	605,735	
Chicago, Hammond & Western	3.82	2,500	9,550	......	......	......	.40	1,500	600	......	......	......	100	10,250	
Elgin, Joliet & Eastern	23.70	20,000	474,000	......	......	......	7.76	3,000	23,280	23.70	2,500	59,250	2,720	559,250	
East Chicago Belt	3.04	2,000	6,080	......	......	......	......	......	......	......	......	......	......	6,080	
Lake Shore & Michigan Southern	18.25	40,500	739,125	18.25	10,000	182,500	7.45	4,000	29,800	18.25	6,000	109,500	1,750	1,062,675	
Louisville, New Albany & Chicago	33.54	16,600	556,764	......	......	......	10.88	3,500	38,080	33.54	2,500	83,850	2,295	680,989	
Michigan Central	16.40	32,500	533,000	16.40	10,000	164,000	11.41	3,500	39,935	16.40	5,000	82,000	6,170	825,105	
Montpelier & Chicago	10.81	14,000	151,340	......	......	......	3.09	3,000	9,270	10.81	3,000	32,430	800	193,840	
New York, Chicago & St. Louis	18.03	32,000	576,960	......	......	......	5.65	4,000	22,600	18.03	3,000	54,090	1,770	655,420	
P., C., C. & St. L. (Chicago Division)	22.12	34,000	752,080	......	......	......	8.37	4,500	37,665	22.12	5,000	110,600	3,885	904,230	
Pittsburgh, Ft. Wayne & Chicago	20.07	56,500	1,133,955	20.07	10,000	200,700	10.54	5,000	52,700	20.07	7,000	140,490	6,475	1,534,320	
State Line & Indiana City	7.56	7,000	52,920	......	......	......	3.16	2,000	6,320	......	......	......	2,800	62,040	
Indiana, Illinois & Iowa	11.26	15,000	168,900	......	......	......	1.02	3,000	3,060	11.26	1,500	16,890	650	189,500	
Joliet & Northern Indiana	15.51	16,000	248,160	......	......	......	2.29	3,000	6,870	15.51	2,500	38,775	2,080	295,855	
Total	281.79		$7,211,354	74.61		$682,050	122.41		$430,995	267.37		$936,130	$48,055		$9,308,584
PORTER COUNTY—															
Baltimore & Ohio & Chicago	16.59	$22,000	$361,980	......	......	......	4.11	$3,500	$14,385	16.59	$2,500	$41,475	$2,690	$423,530	
Chicago & Erie	16.62	25,000	415,560	......	......	......	3.50	3,500	12,250	16.62	2,500	41,550	1,450	470,750	
Chicago & Grand Trunk	15.28	32,000	488,960	......	......	......	4.91	4,000	19,640	15.28	3,500	53,480	12,340	574,420	
Chicago & Indiana Coal	3.22	14,000	45,080	......	......	......	.14	3,000	420	3.22	2,000	6,440	......	51,940	
Elgin, Joliet & Eastern	9.12	20,000	182,400	......	......	......	4.11	3,000	12,330	9.12	2,500	22,800	850	218,380	
Lake Shore & Michigan Southern	15.57	40,500	630,585	15.57	$10,000	$155,700	10.37	4,000	41,480	15.57	6,000	93,420	3,860	925,045	
Michigan Central	17.04	32,500	553,800	17.04	10,000	170,400	5.01	3,500	17,535	17.04	5,000	85,200	4,100	831,035	
Montpelier & Chicago	16.61	14,000	232,540	......	......	......	2.38	3,000	7,140	16.61	3,000	49,830	1,310	290,820	
New York, Chicago & St. Louis	16.97	32,000	543,040	......	......	......	1.98	4,000	7,920	16.97	3,000	50,910	1,250	603,120	
P., C., C. & St. L. (Chicago Division)	15.48	34,000	526,320	......	......	......	5.34	4,500	24,030	15.48	5,000	77,400	2,580	630,330	
Pittsburgh, Ft. Wayne & Chicago	16.47	56,500	930,555	12.57	10,000	125,700	4.51	5,000	22,550	16.47	7,000	115,290	17,200	1,211,295	
Total	158.97		$4,913,760	45.18		$451,800	46.36		$179,680	158.97		$637,795	$47,630		$6,230,665

WOLF LAKE HARBOR.

Since Indiana at present possesses but one harbor on the shore of Lake Michigan, namely, the one at Michigan City, the question of opening another at Wolf Lake, north of the city of Hammond, has been agitated for several years past.

Wolf Lake is located in the northwest corner of the State of Indiana and in the northeast corner of the State of Illinois, within 500 feet of Lake Michigan. It has an area of about five square miles and is from three to fourteen feet deep. It is surrounded and touched by ten great trunk lines of railway, viz.: Baltimore & Ohio; Lake Shore & Michigan Southern; Pennsylvania; Wabash; Chicago & West Michigan; Michigan Central; New York, Chicago & St. Louis; Chicago & Erie; Chicago, Indianapolis & Louisville, and the Pandhandle; and by five belt lines of railway, viz.: Lake Shore & Eastern; Chicago Belt Line; Chicago & Calumet Terminal; Elgin, Joliet & Eastern, and Chicago Terminal Transfer Company. These belt lines pass around the city of Chicago, crossing and connecting with the 24 great trunk lines terminating in that city. Two eight-inch pipe lines from the oil fields of Ohio and Indiana, through which is pumped crude oil for fuel and for refining in the largest oil refinery in the world, located at Whiting, just east of Wolf Lake; and two eight-inch pipe lines from the natural gas fields of Indiana also pass close to the borders of the proposed harbor.

The existing natural advantages for a harbor at Wolf Lake over those of the Chicago River and the Calumet River are many and have been summarized as follows:

First—The entrances to the Chicago and Calumet harbors are from the east; that of Wolf Lake would be from the north. The storms that wreck the vessels on the south coast of Lake Michigan are from the north. Only three years ago 23 vessels were wrecked in one storm on the shores of Lake Michigan, near Wolf Lake. Why they were unable to make the harbors at Chicago and Calumet can readily be seen. If there had been a harbor at Wolf Lake, such as is now proposed, it is believed that all of these vessels could have entered in safety. The same cause that wrecked so many vessels in this storm wrecks vessels there every year.

Second—The Chicago and Calumet rivers are narrow—200 feet wide and less—and must of necessity always remain so. A strip 300 feet wide from Lake Michigan to Wolf Lake has been dedicated to the government, and the riparian owners propose to donate all their right, title and interest in and to so much of said lake as the government may wish, to make a commodious inland harbor for commercial and naval purposes.

Third—The Chicago and Calumet rivers are filling up from sewage and other causes from eight to twelve inches per year, as shown by the engineer's report, and are continually forming bars at the end of the jetties. Such continual filling requires a constant dredging, equal in amount to that required to dredge a new river the full length, width and depth of the proposed improvement, once in every 12 to 15 years. Wolf Lake has not filled one foot since Columbus discovered America. The sand on the bottom of this lake is as clean and bright as it was 400 years ago, and, once dredged, will ever remain so.

Fourth—It is conceded by all that the bridge and tunnel nuisance of Chicago adds 25 per cent. to freight, and what is true of Chicago is to a great extent true of the Calumet, and will continually grow worse. The people of Hammond, in common with all the great Northwest, have to bear this extra freight. Wolf Lake is not and never will be bridged or tunneled.

Fifth—Narrow rivers are poor harbors of refuge. They are broader at the entrance than at any other place, and as the waves converge they grow higher and more vile; hence Chicago is asking for outer harbors. Every one of theoretical or practical knowledge must know that outer harbors are of little value compared with inland harbors, and that they are maintained at an enormous expense. To the inland harbor at Wolf Lake the vessels could go for refuge, and, while the storm was raging upon the sea, they could load and unload their cargoes in safety.

Major Marshall, the engineer in charge, says that Wolf Lake must eventually be the terminus of the Lake Michigan and Mississippi waterway. All the country, including the Little and Grand Calumet rivers and the cluster of small lakes near the southern shore of Lake Michigan, is known locally as the Calumet region. Of it Major Marshall says: "Here the manufacturer recognizes a location after his own heart. Here, converged by lake, rail and pipe lines, are iron, lumber and copper from Michigan, bituminous coal from Illinois and Indiana, anthracite and coke from Pennsylvania, and crude oil and natural gas from Indiana. Here is a large resident laboring populace. Here is the market—the great Northwest—and here are shipping facilities unrivaled in the world. Here the car or vessel can be loaded and leave without delay on any of the 24 trunk lines of railroads, or the Great Lakes, direct for almost any point in the United States or Canada. The terminal facilities, access to Lake Michigan at numerous points along the Calumet River and system of lakes connected therewith; the ample land-locked natural basin, needing only deepening by dredging for the construction of great wharves and derricks, will furnish a commodious harbor scarcely excelled in or on the Great Lakes. All these advantages point irresistibly to the Calumet region as a proper terminus of a great waterway between the Great Lakes and the Mississippi River."

Much work has already been done by private individuals which can be utilized towards the construction of a future harbor. A brief resumé of this work is as follows: 100 feet of inside work, well and substantially built, to prevent Lake Michigan from cutting behind the piers; a 600-foot pier, of the best quality of white oak, worth, according to the United States Engineer's report, $18,000, built from the water's edge 600 feet out into Lake Michigan from the northwest side of the harbor; 375,000 cubic yards of dredging in Wolf River and Lake at a cost of over $30,000. The interest of private individuals in the project keeps a dredge continually at work in Wolf Lake on the line of the proposed improvement. The sand dredged out of the proposed basin will be required to fill in around the margin of the lake outside of the dock line.

Such a harbor as is proposed would be of inestimable value to the people of Indiana as a whole. That the people outside of the immediate vicinity are interested in the project is evidenced by the fact that all the State officials, the Board of Trade of Indianapolis, and the entire delegation of Congressmen and Senators of the State, two years ago united with the people of Lake County in a petition to Congress for an appropriation. Congress appropriated $8,000 towards the work, but as there had been no plans prepared by the War Department, the Engineer in charge refused to expend the money. The committee in charge succeeded in getting the extra session to re-appropriate the same sum in the Sundry Civil Bill, and the President vetoed the entire bill.

Among Indiana cities, Hammond at present ranks next to Indianapolis as a manufacturing center. The 967 factories which were reported to the State Statistician in 1896 showed an annual productive output of $132,713,421. Of this sum the factories of Indianapolis contributed $27,770,820; those of Hammond, not including Whiting or East Chicago, $20,245,099, and those of Ft. Wayne, which ranked third, $9,509,627. The population of Hammond, East Chicago and Whiting, the towns surrounding Wolf Lake, is about 40,000. Thirty-seven large industries, with an invested capital of more than twenty millions of dollars, are located in these three cities. These factories consume annually more than 350,000 tons of fuel and ship more than three millions of tons of material. It is a well-known fact that transportation rates by water are less than one-third those by rail, yet, with the site for an excellent harbor within their very midst, the inhabitants and manufacturers of these cities must transport everything by rail. All these facts go to show that the harbor at Wolf Lake is practicable and needed. Every person in Indiana and the great Northwest who helps to pay the 25 per cent. additional freight made necessary by the defects of the other harbors at Chicago should use his energy in endeavoring to further the construction of a new Indiana harbor at Wolf Lake.

ARCHÆOLOGY.

Among the lakes, streams, prairies and dunes of the two counties the Red Man and his predecessor, the Mound Builder, found, for centuries, a dwelling-place congenial to their wants. There flesh and fur were plentiful. Fishes and mussels abounded in the streams and lakes. Wild fowl by myriads in their migrating seasons came and went, stopping to feed among the marshes. Buffalo, deer and grouse, in untold numbers, inhabited the prairies: while beaver, muskrat and otter crowded the overflowed basins of the Calumet and Kankakee. Nor was the food supply limited to flesh. Wild fruits—huckleberries, grapes, plums, cranberries, sand cherries and many others—flourished in profusion along the sand ridges. Wild rice grew by acres in the marshes, while acorns and the nut of the hazel and the hickory abounded in the groves.

Such an abundance and variety of food—ready for the taking—could but attract primitive man. The first white settlers found plentiful evidence of his former presence. On the "sand islands" and higher levels of the prairie and the marsh were his mounds and his burying grounds, and in places plots of cleared ground where had been his gardens and his fields. Many skeletons of Indians have been exhumed from the burying grounds. With them were usually found fragments of pottery, mussel shells, stone beads, flint arrowheads, bones of animals used as food, and, oftentimes, implements of iron. These remains denote that with the dead was buried food believed to be sufficient to last during the journey to the "happy hunting grounds."

South of Orchard Grove, Lake County, on a sand island now owned by John Brown, of Crown Point, northeast quarter of section 21 (32

Mounds in Lake County.

north, 8 west), is the so-called Indian Battle Ground. When first noted by the whites a low breastwork or artificial ridge enclosed on two sides about three acres of ground. Within this enclosure were some 200 holes, each about three feet in diameter and four feet deep. They resembled individual rifle pits scooped in the sand. In 1897 the outlines of the ridge were still visible, and also many depressions where the pits had been. As to when and by whom the entrenchments were made, not even tradition furnishes a knowledge. Remains of similar breastworks and pits are said to exist on Oak Grove Island, section 16 (32 north, 9 west). Numerous skeletons have been found in the immediate vicinity of both entrenchments.

Several mounds are located about the shores of Cedar Lake. From one of these, on the north side of the lake, about twenty skeletons, some pieces of lead ore and some arrow points were taken in 1880. A bur-oak tree, six feet in circumference, and containing 200 rings of annual growth, grew on the mound above some of the human remains. The largest mound is on the west side of the lake. In 1837* its surface was 12 to 15 feet above the surrounding level, but is now much lower. So far as known it has never been explored.

On the farm of J. P. Spalding, south of Orchard Grove, northwest quarter of section 33 (33 north, 8 west), are the remains of two large mounds. They have been plowed over for almost sixty years, yet portions of human skeletons, arrowheads and pottery are still at intervals unearthed by the ever-leveling plowshare.

One mile south of Hobart, on the land of William Frank, southeast quarter of section 32 (36 north, 7 west), are the sites of four mounds which have been nearly leveled by cultivation. They have never been excavated, and only a part of a stone tomahawk and a few small flints have been found in the field in which they are located.

Just north of the mill at Woodvale, in a field annually overflowed by Deep River, is a large mound, in shape resembling a flat-iron. It is 190 feet in length by 75 feet in greatest width, and its surface is 22 feet above the level of the field in which it stands. Ball states† that in 1836 there was not a tree or shrub on its surface, but many oaks and other trees, some of which are 14 inches in diameter, now grow upon its crest. Although thought by most observers to be artificial, it is my opinion that it is a natural formation cut off from the surrounding highlands by the waters of Deep River. The artificial mounds of this region are always composed of clay, but the material

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*Ball, Lake County, 1884, 333.

†Lake County, 1834—1872, 73.

thrown out by numerous woodchucks, 8 to 15 feet below its crest, shows this one to be composed largely of sand, which is the material underlying the surface clay in the highlands of the vicinity. Numerous other mounds are scattered here and there in Lake County, but, for the most part, they are small and but few of them have been systematically explored.

Among the private collections of prehistoric and other relics made in Lake County none excels that now owned by J. W. Youche, Jr., of Crown Point. It was mainly collected by W. W. Cheshire, now of Washington, D. C., while he was Clerk of the Court and County Superintendent of Lake County. It comprises several hundred stone axes, celts, hatchets, spearheads, pestles, mortars, hammers, gorgets, banner stones, etc., etc. Some fine spades, pipes, "shuttles" and chisels are also in the collection. Special mention can here be made of but six of the articles which are somewhat unique in character. First, a copper arrowhead (Fig. 1), $4\frac{3}{4}$ inches long by $1\frac{1}{4}$ inches wide, with three small notches on each side of the shaft. It was found in St. John's Township about five miles northwest of Crown Point. Second, a polished stone of whitish quartzite (Fig. 2), in shape and size somewhat like the half of an egg cut lengthwise. It has a spoon-shaped indentation on the flat side, and a lengthwise groove on the convex side. No description of such an article is found in any work on archæology at hand. It was found about five miles east of Crown Point, in Winfield Township. Third, a "shaft rubber" of fine sandstone (Fig. 3), six inches long, one-half inch thick and one inch wide, flat on both sides and edges and with a narrow groove running the full length of one side. It was found on the Kankakee Marsh, four miles southwest of Lowell. There was probably another part to correspond with the one in the collection, and the two were used in polishing the shafts of arrows. Fourth, a ceremonial stone (Fig. 4) made of compact reddish porphyry, very highly polished, double hatchet-shaped and with sharp edges. It was found in the northern part of Lake County. Fifth, a plummet or net sinker (Fig. 5), one and one-eighth inches in diameter, made of close-grained granite. It is smoothly polished and regular in shape, with a hole through one end for attachment, and was found in Lake County, near the Kankakee River. Sixth, a gorget (Fig. 6) made of fine-grained variegated slate, highly polished, and about three-sixteenths of an inch in thickness. One of its ends has 15 small notches cut in it, and it was probably used as a counting device. It was found near the central part of Lake County.

The last piece to be mentioned in this connection is more modern and is still in possession of Mr. Cheshire, who claims that "it is the

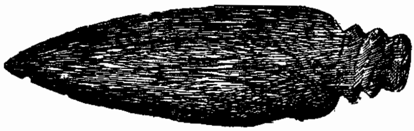

FIG. 1—$\frac{1}{2}$.

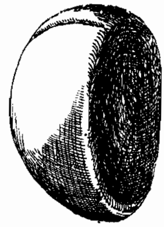

FIG. 2—$\frac{1}{3}$.

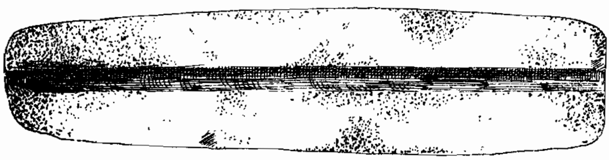

FIG. 3—$\frac{1}{2}$.

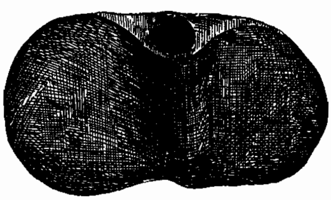

FIG. 4—$\frac{1}{3}$.

FIG. 5—$\frac{1}{3}$.

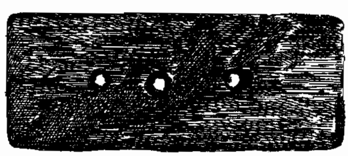

FIG. 6—$\frac{1}{2}$.

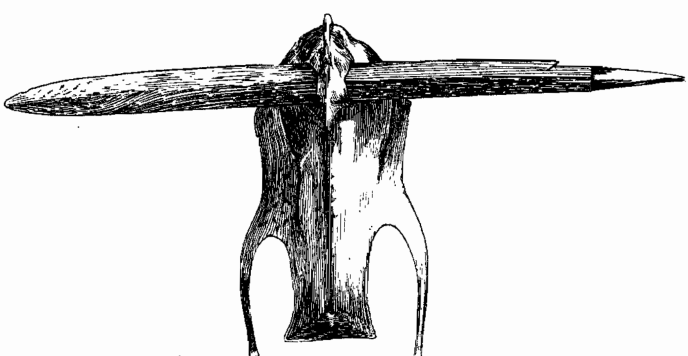

FIG. 7—$\frac{1}{3}$.

most unique specimen of its kind on earth." It consists of the breast-bone of a wild goose transfixed by a bone arrowhead (Fig. 7), 9 inches long, a half inch wide, slightly curved, and with four sides or faces. By request Mr. Cheshire kindly furnished the following information concerning it: "The goose was shot on the Kankakee Marsh south of Lowell, October 20, 1871, by H. N. Clement, a farmer living near the marsh. The very curious points about it are: (a) That the arrowhead should strike the keel of the breast-bone exactly in the middle; (b) that it should stop with its length exactly divided by the keel; (c) that the shaft to which it was evidently fastened should drop off when it struck the bone; (d) that a callous should grow around it, holding it fast; (e) that the goose should be fat and well after carrying it in that transfixed position. Prof. O. T. Mason, of the National Museum, says that no people of the world make such arrowheads except those of the Yukon Valley, Alaska; and he therefore concludes that the arrow was shot into the goose in that valley, remained there until it grew fast and the goose wore it as a breastpin down into Lake County, Indiana. The goose was going south when shot."

In the collection of Rev. T. H. Ball, of Crown Point, is a celt of hammered copper three and one-half inches long, one and one-half inches in greatest width and one-quarter of an inch thick. It was taken from a wolf's burrow just west of Cedar Lake. Nicholas Schutz, of Dyer, possesses a large collection made in that vicinity. In it are some fine "rolling pins" or cylindrical pestles and a small and very handsome granite pipe. Another collection of almost two thousand arrowheads, stone awls, banner stones, etc., is owned by Fred Black, of Hobart. A large number of these are from the Morrison Farm, near Liverpool, section 19 (36 north, 7 west), where a few years ago a cache containing numerous unfinished, as well as finished, flints was unearthed.

PORTER COUNTY has not been found to be as rich in prehistoric remains as has Lake. The High School at Valparaiso possesses a goodly collection, but the data pertaining to the specimens is mostly lacking, and a specimen without data loses more than half its value. On the farm of Hon. Nelson Barnard, section 24, Jackson Township, some fine specimens have been taken—among others a hammer of granite $4\frac{1}{2}$ by $3\frac{1}{2}$ inches in size, with a deep groove passing around the center. In the southeast corner of the county, on the farm of S. L. Stowell, section 2 (32 north, 5 west), a celt formed of diorite, finely polished and ten inches long, has been found; also a cache of more than a peck of flint arrowheads. Oliver Hoffman, of Boone Grove, has some fine specimens found in the vicinity of that town.

Dr. J. K. Blackstone, of Hebron, had also at one time a large collection from the south part of Porter County, but it has become scattered. In it was some pottery, taken from a mound on the Maxwell farm, south of Hebron, and a fine plummet from a point three miles southwest, near the Lake County line.

The mounds of Porter County are also much less numerous than those of Lake. Four miles east of Hebron, near Cornell Creek, section 9 (33 north, 6 west), one was excavated some years ago by Hon. G. C. Gregg, and a number of skeletons were found. The mound was composed wholly of black earth (muck?) which had been carried from the banks of the creek some ten rods distant.

The finest group of mounds in the two counties is located about one and a half miles a little north of east of Boone Grove, Porter County. At present eight are visible on an area of about 30 acres, but a number have probably been leveled by cultivation. Seven of the eight are in a piece of high wooded ground close to Wolf Creek. The one nearest the creek is the largest of those in the woods. It is 210 feet in circumference and its crest is 10 feet above the surrounding level. Growing on it are a number of black oak trees, one of which is 4.5 feet in circumference. A *second* mound is located 150 feet a little north of west. It is 170 feet in circumference and eight feet high, with a flatter top and fewer trees growing from it. One hundred yards to the northwest is the *third*, 180 feet in circumference and but four feet high, with a black oak 5.7 feet in girth growing from its side. These mounds are in the northwest quarter of section 34 (34 north, 6 west), the third being about 40 rods east of the section line. The *fourth* and *fifth* mounds are situated in the same quarter section, about six rods east of the section line and 1,000 feet south of the section corner. One is 175 feet in circumference and six feet high, the other 75 feet in circumference and four feet in height. Excavations were made in four* of the five mounds mentioned in October, 1897, but no skeletons or implements of any kind were found. Pieces of charcoal and ashes were quite common in three of them, and in the other several flakes of flint and a part of an arrowhead were secured. The *sixth* and *seventh* mounds are lower and about 100 feet in circumference. They are situated in the extreme southeastern corner of section 28 (34 north, 6 west), and have never, as far as known, been disturbed.

The largest mound of the group is located in a cultivated field in the northeast corner of section 33 (34 north, 6 west), 420 feet south

*No. 5, the larger of the two near the section line, was excavated by a party under my direction; Nos. 1, 2 and 4 by Supt. Wood of the Valparaiso schools, and a number of his pupils.

and 310 feet west of the corner of the four sections. It is 300 feet in circumference, 12 feet high, and almost a perfect sugar-loaf in form. The owner of the farm, Mr. John Wark, of Valparaiso, kindly gave his consent to the excavation of this mound, and on October 6 and 7, a ditch was dug three feet wide, 32 feet long, and, at the center of the mound, 14 feet in depth. The mound was found to be composed of a compact, yellowish clay, in which were a few scattered pebbles of small size. In the exact center and ten feet from the crest, the earth became darker, harder and more compact. Six inches lower was a layer of black organic matter, in which were the remains of a very badly decayed human skeleton. It lay in a reclining position with its head to the south. Only a few pieces of bone and 14 teeth were removed, the remainder crumbling to dust. The crowns of the teeth were hard and solid, but the fangs for the most part crumbled like the bone. No implements of any kind were found, though the excavations were extended four feet lower, and over an area 5x7 feet in the center of the mound.

In the original field notes of this locality, made by the United States Land Survey in 1834, the north and south line between sections 33 and 34 is said to pass over "a large artificial mound surrounded by a number of smaller ones," and a copy of the original plat now in the State Auditor's office shows this larger mound on the line, with nine smaller ones in a circle about it. As noted above, all the mounds are at some distance from the line, and if smaller ones surrounded the larger, as shown on the plat, they have long since been leveled by cultivation.

Who were the Mound Builders? Whence came they? Whither did they go? These questions are as yet unanswered, and probably ever will be. Their works and their implements show them to have practiced agriculture and to have been in many respects more civilized than their followers, and, perhaps, descendants, the Red Men. Their mounds are scattered throughout the Western States, in some places in great numbers. Some were erected for sacrificial purposes; some for signal or lookout stations—while more, perhaps, mark the burial places of their priests, their great warriors or their rulers. As we, by lifting heavenward a monument of granite or of bronze, pay tribute to the memory of our great men, so these primitive people built mounds of earth above their noted dead, giving to the chief or king the higher and more prominent.

NOTES ON THE FAUNA OF LAKE AND PORTER COUNTIES.

Each species of animal on earth has, in time, become adapted to a certain environment. If the elements of that environment be largely present in any prescribed area, the animal, or a closely allied form, may be sought for, even though its known center of distribution be in a far distant locality. The number and variety of animals inhabiting any limited area depends, therefore, upon the variety of its topography and the character of its soils. Possessing, as they do, lakes, rivers, swamps, upland woods, prairies and sand hills, Lake and Porter counties can but possess a large and varied fauna. To give anything like an accurate account of the fauna of such a region, one must reside therein for years. He must visit daily the haunts of the animals, note their coming and going, their food habits and their life histories. Passing, as I did, but hurriedly over the region, a few notes concerning such vertebrate forms as were seen, or those whose presence was deemed worthy of especial mention by the citizens of the counties, and all that can be given in this connection.

The Mammoth and the Mastodon.

Many of the animals which once roamed over the area under consideration are now wholly extinct or are only represented by scattered individuals in the far West and North. Among the largest forms which inhabited this region at the close of the glacial period were the two American elephants, now extinct. The smaller of the two, known as the mammoth — *Elephas primigenius* Blum.—was over twice the bulk and weight of the modern elephant and nearly one-third taller. It occurred in numbers over all of Europe and over the northern part of North America. A number of specimens so well preserved that wolves and dogs fed

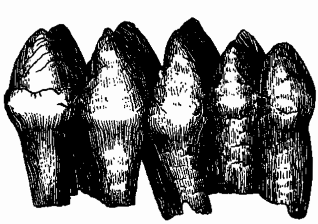

FIG. 8. Tooth of Mastodon.

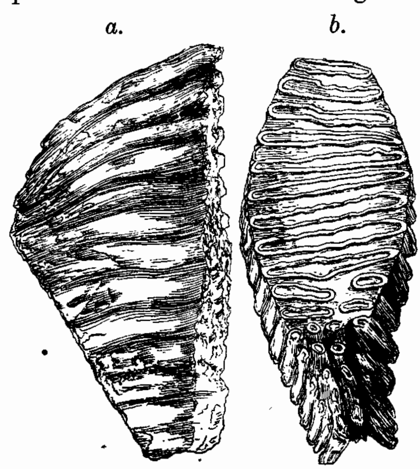

FIG. 9. Molar Tooth of Mammoth. *a*, side view; *b*, grinding surface.

on their flesh have been found frozen in the ice in Siberia. From these it was learned that in life the skin of the animal was covered with a brownish wool and in parts with long hair. It was therefore enabled to withstand the severe cold of the northern regions.

The mastodon—*Mastodon americanus* L.—was of still larger size, being 12 to 13 feet high and, including the tusks, 24 to 25 feet in length. Its remains are readily distinguished from those of the mammoth by the teeth. The difference is shown in Figs. 8 and 9. These two great mammals roamed in separate herds over the prairies and along the margins of forests, lakes and streams, where they often became mired and perished in the bogs. It is on the site of former marshes that their remains are now mostly found. A skeleton of the mastodon unearthed in Iroquois County, Illinois, in 1880, had between the ribs a crushed mass of herbs and grasses, the remains of its last meal. These, on close examination, were found to be very similar to those now growing in that vicinity.

In Lake County an almost complete skeleton of a mammoth was found in a marsh on the head waters of Deep River, in the north half of section 35 (35 north, 9 west), about two miles east of St. John's. In Porter County remains of the mastodon have been found in the following localities: In the Kankakee Marsh, section 25 (33 north, 7 west), three miles southeast of Hebron; in a marsh by the side of Cobb's Creek, just east of Hebron; near Sandy Hook Creek, northwest of Kouts, and on the farm of Peter A. Bair, southwest quarter of section 27 (35 north, 6 west), two miles southwest of Valparaiso. In each case but a few teeth and one or two bones were exhumed while ditching, and no extensive search was made for the other portions of the skeleton. Close to the teeth found near Kouts were the antlers of a large elk which had perished in the same bog. Antlers of the same species have also been found in Lake County.

Buffalo and deer were once common in the two counties, but the finding of an occasional skull or pair of antlers are now the only evidence of their former presence.

Mammals.

The Opossum, *Didelphis virginiana* Shaw, though an animal of southern range, is occasionally taken in small numbers in both counties. A pair of porcupines, *Erethizon dorsatus* (L.), are in the State Museum from Laporte County, and though no definite record of its occurrence in Lake or Porter was secured, it doubtless belongs to their fauna. The muskrat, *Fiber zibethicus* (L.), is one of the most common mammals in the Kankakee and Calumet basins. According to Ball, from 20,000 to 40,000 a year were trapped in Lake County alone previous to 1884. Except in the marshes that have been drained, their numbers do not appear to become appreciably less. The remains of dams thrown up by the beaver, *Castor fiber* L., are found in a number of localities in Lake County, but the animal itself had disappeared before the coming of the first settlers. The woodchuck, *Arctomys monax* (L.), is common among the upland wooded ridges, as is also the chipmunk, *Tamias striatus* (L.). The little striped gopher, *Spermophilus tridecemlineatus* (Mitchell), is common on the prairies and among the sand ridges. The gray gopher, *S. franklini* (Sabine), locally called the "prairie squirrel," was seen on several occasions along hedge rows on the borders of prairies, and one, which had already entered a state of hibernation, was captured, October 6, in the large mound excavated near Boone Grove, Porter County.

The fox squirrel, *Sciurus niger* L., is very scarce, but a few are said to reside in the upland woods in Jackson Township, Porter County. The gray squirrel, *S. carolinensis* Gmlin., and the little red squirrel or chickaree, *S. hudsonicus* Erx., are common in the timbered areas. Jet-black specimens of the first named are occasionally seen.

The otter, *Lutra hudsonica* (Lacepede), was, in the early settlement, quite common, and a few are yet taken almost every Spring along the Kankakee. The skunk, *Mephitis mephitica* Cuvier, and the mink, *Putorius vison* (Schreber), are both rather common and both yield a considerable annual revenue to the professional trapper. The large gray timber wolf, *Canis lupis* L., once common, is still occasionally seen in the region of the Kankakee marshes, three having been killed by Oscar Dinwiddie in Eagle Creek Township, Lake County, in 1895.

About 16 additional species of mammals doubtless occur in the two counties, but the above constitute all which came to my notice or to which reference is made in my notes.

Birds.

Mr. A. W. Butler, in his work on Indiana Birds in the present volume, has a number of notes pertaining to the birds of this region. For this reason no specific mention of those noted is given in this connection. Probably 225 or more species occur in the counties during a single year. Of these about 30 are *permanent residents*, i. e., reside in the region throughout the year. Common examples are the crow, blue-jay and quail. Probably 65 are *summer residents*, i. e., arrive from the South in the Spring, nest and rear their young, and depart southward again in Autumn. The orioles, catbird and chipping sparrow belong to this group. About 10 are *winter residents*, coming from the North in Autumn and departing northward in Spring, the snowbird and the tree sparrow being familiar examples. Eight or ten are *winter visitors*, such as the great white owl and the red cross-bill, which may or may not appear during the coldest weather of the season. The remaining 110 are *migrants;* birds which regularly pass through the counties, northward bound in Spring and again southward bound in Autumn. The majority of the water fowl and warblers and a number of sparrows, thrushes and vireos are members of this class.

Reptilia.

But few notes concerning the reptilian fauna were secured. The prairie rattlesnake still exists in small numbers; and probably 15 kinds of harmless snakes occur in the two counties. Among the sand dunes the six-lined lizard, *Cnemidophorus sexlineatus* (L.), was quite common. They scampered swiftly from one clump of grass to another; so swiftly, in fact, that a great deal of maneuvering was necessary to capture one with a butterfly net. This species has been heretofore considered rare in Indiana, having been recorded only from Knox and Monroe counties. The four varieties of lizard mentioned by Ball* were probably salamanders, since he states that they live in dark cellars. Ten or more species of this group probably occur in the counties. They can be readily told from lizards by their having the skin smooth instead of covered with scales. They also pass through a larval (tadpole) stage, while the lizard undergoes no such change. Sixty or more species of fish doubtless occur in the streams and lakes of the area.

NOTES ON THE FLORA OF LAKE AND PORTER COUNTIES.

While engaged in gathering data concerning the surface geology, notes were taken and specimens secured of a number of the scarcer and more characteristic plants of the two counties, especially those of the Calumet area, and the immediate margin of Lake Michigan. For the most part these notes pertain only to such plants as were in bloom in July and September, and to those whose distribution in Indiana is restricted to this region of the State. But little attention was given to the forms common to the entire State, as it is impossible for any one to gather data for anything like a complete flora of such an area, unless he is able to spend the greater part of several seasons in careful investigation.

The flora of the sand dune area is especially interesting and has been studied in the past by Rev. E. J. Hill, of Englewood, Ill., who has found there a number of species not elsewhere recorded from Indiana. Messrs. Higley and Raddin, in their "Flora of Cook County, Illinois, and a part of Lake County, Indiana,"† have published the results of much of Mr. Hill's work, as has also Stanley Coulter in the Proceedings of the Indiana Academy of Science for 1895.

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* Lake County, 1884, 155.

† Bull. Chic. Acad. Sci., II, No. 1, 1891. This paper included the flora of that portion of Lake County lying north of the Little Calumet River. Reference to the paper in these notes will be by the initials H. & R.

A person interested in botany, and living in easy reaching distance of this area, could render a valuable aid to science by preparing a special paper, based on a number of years of observation on the variations, habitat and insect visitors of the different species of plants growing on the sand covered area along the south shore of Lake Michigan.

The nomenclature and order of the following list is that of Gray's Manual of Botany, sixth edition.

ANNOTATED LIST OF PLANTS.

Ranunculus pennsylvanicus L. f. Bristly Crowfoot.

Frequent along the borders of a marsh near Tolleston. July 29. Has been noted only in the northwestern part of the State.

Coptis trifolia Salisb. Goldthread.

Borders of a marsh near Calumet River, northwest of Miller's. In fruit. Recorded from Berry Lake and Pine Station by H. & R., and from the "Knobs" in the "Catalogue of the Plants of Indiana."

Asimina triloba Dunal. Common Pawpaw.

The pawpaw was noted as frequent in several wooded tracks in Jackson Township, Porter County, but not elsewhere in the area. It is not mentioned by H. & R., being partial to open woods in rich soil and not growing in sandy soil nor in prairie regions.

Sarracenia purpurea L. Pitcher Plant. Side-saddle Flower.

Common in a peat bog on the Hayward farm, one mile east of Merriville, Lake County. This bog is noteworthy from the fact that a thicket of white pines (*Pinus strobus* L) surrounds it, instead of the tamarack (*Larix americana*), which one would expect.

Cakile americana Nutt. American Sea-Rocket.

North of Miller's and Dune Park in the bare sand, within 200 yards of the lake margin. Often the only herb present on the areas in which it grows.

Hudsonia tomentosa Nutt. Wooly Hudsonia. Poverty Grass. False Heather.

Sand ridges north of Dune Park. Recorded by H. & R. from Pine Station, Miller's and along the ridge from Tolleston to Miller's. Grows in low, densely matted tufts. The leaves are closely appressed, and in late summer or autumn the plant resembles a dwarfed evergreen.

Lechea major Michx. Hairy Pin-weed.

Sandy margin of marsh near Tolleston. July 29. Known in the State only from Lake and St. Joseph counties.

Lechea minor L. Thyme-leaved Pin-weed.

Border of marsh north of Dune Park, September 7.

Hypericum prolificum L. Shrubby St. John's-wort.

Abundant along borders of swamps east of Whiting, within one-fourth mile of lake front. In flowering prime July 27.

Vitis labrusca L. Northern Fox Grape.

Frequent on the sandy, wooded "islands" of the Kankakee valley.

Vitis rupestris Scheele Sand Grape. Sugar Grape.

Grows abundantly on the top and sides of the highest sand ridges near Miller's and Dune Park. A southern form not before recorded from Indiana, the manual range being "Mo. to Tex., Tenn. and southern Penn." The fruit is larger and in more compact, rounded bunches than either that of the frost grape, *V. cordifolia* Michx., or the summer grape, *V. aestivalis* Michx. The leaves are also smaller and the vine spreads over the ground or low bushes, instead of climbing high, even where trees or tall shrubs are present.

Rhus typhina L. Staghorn Sumach.

Sides of sand ridges north of Miller's; scarce. Before recorded from Gibson and Posey counties.

Rhus copallina L. Dwarf Sumach.

Borders of marsh north of Tolleston. This form is probably more widely distributed through the State than the above, though neither is anywhere near so common as *R. glabra* L.

Rhus canadensis Marsh. Fragrant Sumach.

Grows in dense clumps along the lake shore, 100 yards or more from the margin of the water, east of Whiting to Brimson, near Miller's, etc. Much smaller and less spreading than on the rocky hillsides of Monroe and Crawford counties. For its distribution in the State see Proc. Ind. Acad. Sci., 1896, 137.

Polygala cruciata L. Marsh Milkwort.

Common along the borders of marshes north of Dune Park. Recorded also by H. & R. from near Hammond. The flowers vary from purple to pure white.

Baptisia leucantha Torr. & Gray. White False-Indigo.

Prairies and borders of copses; common throughout the central region of both counties.

Lupinus perennis L. Wild Lupine.

Crests of high wooded sand dunes, northeast of Miller's. In fruit July 28.

Amorpha canescens Nutt. Lead Plant.

Road sides in prairie regions; common.

Petalostemon violaceus Michx. Violet Prairie Clover.

Prairies and sand dunes; frequent.

Tephrosia virginiana Pers. Goats-Rue. Catgut.
Dry sandy hillsides; common in Calumet region north of Miller's, etc.

Lespedeza capitata Michx. Round-headed Bush Clover.
Low sandy soil north of Dune Park; frequent.

Lathyrus maritimus Bigelow. Beach Pea.
Sands along the beach of Lake Michigan, east of Whiting; frequent. In flower and fruit July 27.

Prunus americana Marshall. Wild Plum.
Common on the beaches of old Lake Chicago and on the sand islands of the Kankakee valley.

Prunus pumila L. Dwarf Cherry. Sand Cherry.
Common in clumps along the sand ridges 100 feet or more from the water margin of Lake Michigan and extending back one-fourth of a mile or more. The fruit is very abundant, and when fully ripe is quite palatable, much more so than that of the next two species. Specimens bearing fruit vary in height from two to six feet.

Prunus pennsylvanica L. f. Wild Red Cherry.
A tall shrub or small tree which occurs sparingly along the sand ridges near Brimson and north of Miller's.

Prunus virginiana L. Choke Cherry.
Rather frequent along the sandy margins of swamps near Tolleston, etc.

Spiræa salicifolia L. Meadow Sweet.
Common in low, damp prairies.

Spiræa tomentosa L. Hardhack. Steeple-bush.
With the above, but much less common.

Physocarpus opulifolius Maxim. Nine-bark.
Swampy woods and banks of streams; frequent north of Miller's, Pine Station, etc.

Potentilla fruticosa L. Shrubby Cinquefoil.
A single clump, one mile east of Whiting in sandy soil, 100 yards from lake shore.

Pyrus arbutifolia melanocarpa Michx. Black Chokeberry.
Margin of swamp near Tolleston. Leaves larger, smoother beneath, and more rounded than in the typical form. Not before recorded from the State.

Parnassia caroliniana Michx. Grass of Parnassus.
Low moist grassy places; frequent.*

* For range in State see Proc. Ind. Acad. Sci., 1896, 136.

Ribes floridum L'Her. Wild Black Currant.

Frequent on a sandy wooded "island" in the S. E. part of Lake County. Not before recorded in the State north of Jefferson County.

Hamamelis virginiana L Witch Hazel.

On sides of wooded sand dunes northeast of Miller's; scarce.

Lythrum alatum Pursh. Loosestrife.

Low damp prairies and marshes; frequent north of the Calumet.

Ludwigia polycarpa Short and Peter. False Loosestrife.

Abundant in swales near Tolleston. Before recorded from "Knobs," and Gibson and Vigo counties.

Opuntia rafinesquii Engelm. Prickly Pear Cactus.

Common on the low sand ridges of the Calumet region, growing where nothing else will. Flowers large and handsome.

Eryngium yuccæfolium Michx. Rattlesnake Master. Button Snake-root.

Borders of damp prairies and roadsides; frequent south of the Calumet in both counties.

Nyssa sylvatica Marsh. Black Gum. Sour Gum. Pepperidge.

Sand ridges and islands; also on north margin of Cedar Lake; frequent.

Mikania scandens Willd. Climbing Hemp-weed.

Found in abundance covering the button-bush (*Cephalanthus occidentalis* L.) and other shrubs growing in the low ground 50 feet south of the wagon bridge across Sandy Hook Creek, five miles east of Hebron, Porter County, September 21. Before recorded in Indiana only from Gibson County. Manual range—"E. New Eng. to Ky. and southward."

Liatris scariosa Willd. Button Snakeroot.

Sand ridges near Dune Park; frequent.

Liatris spicata Willd. Blazing Star.

Margin of marshes and damp prairies; frequent.

Solidago ohioensis Riddell. Ohio Golden-rod.

Border of marsh near Dune Park, September 7. Known in the State only from Tippecanoe and Lake counties.

Aster novæ-angliæ L. New England Aster.

Common along roadsides in the central and southern portions of the two counties. One of the largest and most handsome of the asters, its numerous violet-purple rays quickly attracting the attention and admiration of the observer.

Aster sericeus Vent. Silky Aster.

Low sandy soil north of Dune Park; scarce. Not mentioned in the

State Catalogue, and, as far as known, not before definitely recorded from the State, though H. and R. mention it as frequent, without accrediting it to Indiana. Heads large and showy.

Aster polyphyllus Willd.

Borders of marshes north of Dune Park; scarce. Recorded from near Whiting by Coulter, loc. cit. p. 190.

Aster linariifolius L. Double-bristled Aster.

Sandy ridges north of Miller's and Dune Park. Readily known by the shortness of the stems, which grow in clumps from a woody base, and by the rigid linear leaves and showy heads.

Silphium laciniatum L. Rosin-weed. Compass-plant.

A typical prairie plant, yet common along the roadsides and on the upland prairies, especially in Lake County. The large, vertical and pinnately parted, radical leaves resemble somewhat those of the sensitive fern, *Onoclea sensibilis* L. The upland prairie hay formerly contained large numbers of these plants, which served the buyer in distinguishing it from the lowland hay. The former was considered the more valuable, and it is said that some farmers were in the habit of harvesting the compass-plants and afterwards mixing them with the lowland hay in order that it might be mistaken for that from the upland, and so bring a higher price.

Silphium terebinthinaceum L. Prairie Dock.

In similar localities, but more common than the last species, and readily distinguished by its large, undivided root leaves.

Silphium perfoliatum L. Cup Plant.

Sides of ditch near Dyer, Lake County. Not noted elsewhere.

Lepachys pinnata Torr. & Gray.

Roadsides and margins of prairies in Lake County; scarce. Leaves very rough.

Helianthus occidentalis Riddell.

Rather common in dry upland prairies and along sandy ridges.

Artemisia caudata Michx. Wormwood.

Side of sand ridge north of Dune Park; scarce. September 9. For the only previous State record of this and the next species, see Proc. Ind. Acad. Sci., 1895, p. 191.

Artemisia canadensis Michx. Hoary Wormwood.

North of Miller's at foot of sand ridge; scarce. September 8.

Cnicus pitcheri Torr. Pitcher's Thistle.

Sides of the highest sand ridges and dunes north of Miller's. In fruit, July 27. Known in the State only from Lake County.

Cnicus arvensis Hoffm. Canada Thistle.

This well known pest has undoubtedly gotten a foothold in northern Indiana, which will be troublesome to overcome. Numerous large patches were seen along the railways of the Calumet region, and a half acre or more flourished undisturbed near the center of the city of Hammond. Isolated specimens were also noted near Cedar Lake and other localities. It may be readily distinguished by its numerous small heads, which are less than half the size of those of the common thistle; also by its slender stem and upright flowering branches. It is seldom more than eighteen inches in height.

Lobelia kalmii L. Kalm's Lobelia.

Margin of low grassy pond north of Miller's, July 27. Frequent.

Campanula aparinoides Pursh. Marsh Bellflower.

Wet, grassy meadows; common. This and the preceding species occur, as far as known, only in the northern third of the State.

Gaylussacia resinosa Torr. & Gray. Black Huckleberry.

Common in the sandy soil along the borders of marshes in the Calumet region, especially in Lake County.

Vaccinium pennsylvanicum Lam. Dwarf Blueberry.

Common on the sand ridges and dunes in the northern third of both counties.

Vaccinium vacillans Solander. Low Blueberry.

Dry, sandy hills north of Miller's; scarce.

Vaccinium corymbosum L. Swamp or High Blueberry.

Margin of marshes in the Calumet region; common. Grows to a height of six to eight feet, and produces the blue huckleberry of the latter part of the season.

Vaccinium macrocarpon Ait. American Cranberry.

Noted growing wild only in the peat bog one mile east of Merriville, though doubtless occurs in numerous places in the swampy area of the Calumet region, which is well adapted to its cultivation. Much of the waste land of this area could be profitably put to that use.

Arctostaphylos uva-ursi Spreng. Red Bear-berry.

Sides of sand ridges within 100 feet of the lake shore east of Whiting and north of Miller's. In fruit July 28. Occurs only in the counties bordering on Lake Michigan.

Gaultheria procumbens L. Creeping Wintergreen. Checkerberry.

Abundant around the borders of a marsh northeast of Tolleston; also sparingly near Dune Park. It has also been taken by the writer at the Pine Hills, Montgomery County, but does not occur in Monroe County, as stated in the catalogue of Indiana plants.

Cassandra calyculata Don. Leather Leaf.

Margins of swamps east of Whiting, north of Miller's and near Dune Park; frequent. Occurs also abundantly in the tamarack swamps near DeLong, Marshall County.

Chimaphila umbellata Nutt. Prince's Pine. Pipsissewa.

High wooded sand dunes northeast of Miller's; scarce. In fruit July 28.

Asclepias verticillata L. Whorled Milkweed.

Sand ridges near the railways east of Whiting; frequent.

Acerates viridiflora Ell. Green Milkweed.

With the above, but scarce. In flower July 27.

Sabbatia angularis Pursh. Bitter-bloom. Rose pink.

Common about the margins of low, grassy meadows. One of the most handsome of our midsummer wild flowers. Occurs probably throughout the State.

Gentiana crinita Froel. Fringed Blue Gentian.

Borders of marshes north of Miller's and Dune Park. September 8 and 9. Occurs in suitable localities throughout the northern half of the State.

Veronica scutellata L. Marsh Speedwell.

Slough north of Tolleston; July 29; scarce. Recorded only from Steuben and Noble counties.

Gerardia purpurea L. Purple Gerardia.

Abundant in low, damp meadows, both in the Calumet region and the Kankakee Valley.

Pedicularis lanceolata Michx. Lanceolate-leaved Lousewort.

Borders of marshes north of Dune Park; scarce.

Utricularia vulgaris L. Greater Bladderwort.

Scarce in marshes north of Miller's, between the Calumet and the Lake Shore; July 28.

Utricularia cornuta Michx. Bladderwort.

With the above but much more frequent; also Sep. 8. *U. gibba* L.; *purpurea* Walt., and *resupinata* Greene, are also recorded from near Miller's in the H. & R. list, but no specimens were seen during my visit to that locality.

Monarda punctata L. Horse Mint.

This is one of the prevailing plants in all the sandy region north of the Kankakee, being as common in the streets and on the sandy ridges as is the dog fennel, *Anthemis cotula* DC., in the central part of the State.

Cycloloma platyphyllum Moquin. Winged Pigweed.

Sandy shore of Lake Michigan, east of Whiting and north of Dune Park; frequent. The first record for the State.

Salsola kali tragus L. Saltwort. Russian Thistle.

Found sparingly in loose sand within 100 yards of the margin of the lake, between Whiting and Dune Park. Is liable to spread and prove a very troublesome weed.

Euphorbia corollata L. Flowering Spurge. White Spurge.

One of the most common and characteristic plants of the sand covered area of the two counties. Noted here only because of its abundance.

Myrica asplenifolia Endl. Sweet Fern.

Noted just west of the station of Highland, where it was common in the sandy soil on the south slope of Calumet Beach. Recorded from Miller's by Coulter—Proc. Ind. Acad. Sci., 1895, 195. These are the only two records for the State.

Betula populifolia Ait. White Birch.

Sand ridges west of Miller's; scarce.

Betula papyrifera Marshall. Paper or Canoe Birch.

More frequent than the above. Not found more than three miles back from the lake, and not noted in Porter County. Most of the trees close to the lake have been killed by fire.

Betula nigra L. River or Red Birch.

Common along the banks of the Kankakee. Recorded in the Catalogue of Indiana Plants only from Gibson County, but has been noted by the writer in Martin, Vigo, Owen, Jackson, Putnam, Marion and Lake, so that it probably occurs throughout the western two-thirds of the State.

Betula pumila L. Dwarf Birch.

Borders of swamps north of Tolleston; common.

Alnus incana Willd. Speckled or Hoary Alder.

Banks of Calumet north of Miller's; frequent. Known in the State only from Lake County.

Salix glaucophylla Bebb. Broad-leaved Willow.

Sand ridges near the Calumet, north of Miller's; frequent.

Pinus banksiana Lambert. Gray or Northern Scrub Pine.

Sand dunes and ridges within three miles of the lake shore, between Whiting and Michigan City; common. Specimens 40 to 60 feet high were plentiful.

Juniperus communis alpina Gaud. Low Juniper.

This form is recognized by Britton & Brown* as a distinct species under the name of *Juniperus nana* Willd. It occurs sparingly north of Miller's on the sand ridges, forming dense circular masses six to ten feet

*Illustrated Flora, I., p. 60.

in diameter, with the individual stems about two feet high and recurving or depressed. The leaves are shorter and more numerous and the berries larger than those of the common *J. communis*. The latter is widely distributed over the State, while the one under consideration is a northern and eastern form not before recorded from within its bounds.

Spiranthes cernua Richard. Ladies Tresses. Screw Stem.

Borders of low damp meadows; frequent in the Calumet region.

Habenaria ciliaris R. Br. Yellow Fringed Orchis.

Frequent about the borders of a marsh northeast of Tolleston, July 29. In a paper entitled the "Distribution of the Orchidaceæ in Indiana,"* Miss A. M. Cunningham gives the known State records of this species as St. Joseph, Noble and Steuben counties. I have found it in numbers also at DeLong, Marshall County.

On account of the lateness of the season the above were the only two orchids seen by me in the counties, though H. & R. record *Liparis lœselii* Rich., *Aplectrum hyemale* Nutt., *Corallorhiza innata* R. Br., *C. multiflora* Nutt., *Goodyera pubescens* R. Br., *Arethusa bulbosa* L., *Pogonia pendula* Lindl., *Habenaria tridentata* Hook., *H. virescens* Spreng., *H. bracteata* R. Br., *H. hyperborea* R. Br., *H. hookeri* Torr., *H. lacera* R. Br., *H. psycodes* Gray, and *Cypripedium spectabile* Swartz, from definite localities in Lake County, besides mentioning ten additional species as being found southeast of Chicago, in the territory covered by their list, without giving localities.

Aletris farinosa L. Colic Root. Star Grass.

Sandy soil near border of marsh north of Tolleston ; scarce.

Smilacina stellata Desf. Star Flowered Solomon's Seal.

Very common on the "sand islands" of the Kankakee Valley, and the barrens of the Calumet region. I have never met this species in central or southern Indiana, though I have studied the plants of those regions for ten or more years.

Lilium philadelphicum L. Wild Orange-red Lily.

Borders of prairies; scarce. One specimen north of Cedar Lake, July 11.

Tofieldia glutinosa Willd. False Asphodel.

Margin of a swale, north of Miller's; July 28 ; scarce. Known in the State only from Lake, Fulton and Noble counties.

Commelina virginica L. Virginia Day-flower.

Frequent on the side of wooded sandy hills, northeast of Miller's.

Triglochin maritima L. Arrow Grass.

Shallow water of marshes north of Miller's; frequent, July 28. Recorded before in Indiana only from near East Chicago.

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* Proc. Ind. Acad. Sci., 1895, 201.

Cyperus filiculmis Vahl. Slender Cyperus.

Side of sand hills at Dune Park; frequent. Known in the State only from Lake and Porter counties.

Cyperus houghtoni Torr. Houghton's Cyperus.

Side of sand ridge near Tolleston, July 29. The first record for the State, the manual range being "Mass. to Minn., Kans. and Oregon." A handsome species with the plumes two feet or more tall, the spikes numerous and densly flowered.

Panicum autumnale Bosc. Diffuse Panicum.

Frequent along sides of the sand ridges in the Calumet region. Grows in dense tufts. The panicle much branched and spreading, and of a handsome purplish tinge. Recorded only from Lake and Vigo counties, but has been noted, by the writer, also in Jasper and Starke.

Zizania aquatica L. Indian Rice. Wild Rice.

Shallow water of marsh north of Miller's; scarce.

Ammophila arundinacea Host Sand-Reed.

Frequent on crests of the higher sand ridges and dunes all along the lake shore. The spike-like panicle eight to twelve inches in length and quite handsome.

Phragmites communis Trin. Reed.

One of the tallest members of the grass family, sometimes reaching a height of eighteen feet. Grows in dense isolated patches in the sloughs and swamps of the Calumet and Kankakee regions.

* * *

The 103 species above recorded comprise probably less than one-tenth of the flowering plants of the two counties, being only such as were especially noted or collected as I passed hurriedly from place to place. Higley and Raddin give definite localities for about 400 additional species in Lake County, many of which occur nowhere else in Indiana.

There is no better place for an extended botanical study of a limited area in the State than among the dunes, swamps, peat bogs, prairies and river bottoms of this area, and it is to be hoped that some one with leisure and ability will, before it is further modified by man, make a complete and permanent record of its flora.

ELEVATIONS.

A list of elevations of a number of points in the two counties is here given. It has been compiled from the following sources:

Gannett's Dictionary of Altitudes; Campbell's Survey of the Kankakee Region; data furnished by Henry Rankin, Ex-County Surveyor of Porter County; by Geo. Fisher, County Surveyor of Lake County, and by Frank Leverett.* The initials "G.", "C.", "R.", "F." and "L." after the location refer, respectively, to the authority cited.

ALTITUDES IN LAKE COUNTY.

Creston, railway—L	740	feet.
Crown Point, C. & E. Railway—G	702	feet.
Crown Point, Court House yard—F	714	feet.
Crown Point, Panhandle Railway at station—F	695	feet.
Dyer, M. C. Railway—G	638	feet.
Fancher Lake, surface of water August, 1896—F	713	feet.
Griffith, railway crossing—G	636	feet.
Hammond, M. C. Railway—G	595	feet.
Hammond, Nickle Plate Railway—G	598	feet.
Hessville, railway—G	623	feet.
Highland, railway—G	617	feet.
Hobart, P. F. W. & C. Railway—L	622	feet.
Kankakee River, old mouth of Eagle Creek—L	†660	feet.
Kankakee River, surface of water at Monon Railway bridge —C	635.7	feet.
Kankakee River, surface of water at State Line—C	624.3	feet.
Lake Michigan, mean surface level—G	‡582	feet.
Leroy, railway—L	683	feet.
Little Calumet Marsh, sections 16 and 21 (36 north, 9 west)—L	595	feet.
Liverpool, M. C. Railway—G	627	feet.
Lowell, railway—L	690	feet.
Miller's, L. S. & M. S. Railway—G	625	feet.
Palmer, railway—L	733	feet.
Ross, M. C. Railway—G	638	feet.
Schererville, railway—L	644	feet.
Shelby, railway crossing—C	642	feet.
St. Johns, railway—L	697	feet.
Watershed, near head waters of Eagle Creek and Deep River—L	747	feet.

*In sending his data Mr. Leverett wrote as follows: "I send some elevations which I obtained from Mr. Gannett last winter, some of which I do not think appear in his Dictionary of Altitudes. Some are slightly different from the altitudes given in his Dictionary because of a revision which he has made in the light of fuller data. I have also inserted a few aneroid determinations which I made in Porter County. To these I have affixed the + sign."

† This level is from the report of the U. S. Deep Waterways Commission, below cited.

‡ The standard low water elevation of Lake Michigan as given by the U. S. Deep Waterways Commission for 1896 is 579.60 feet, and the high water elevation is 584.34 feet.

ALTITUDES IN PORTER COUNTY.

Chesterton, L. S. Railway—L	659 feet.
Chesterton, L. S. Railway—R	670 feet.
Coburg, B. & O. Railway—G	786 feet.
Coburg, B. & O. Railway, at summit—G	795 feet.
Crest of Moraine in section 35 (36 north, 6 west)—L	825 ± feet.
Crest of Moraine in section 11 (35 north, 6 west)—L	840 ± feet.
Crissman, railway crossing—L	645 feet.
Flint Lake, surface of water—R	825 feet.
Furnessville, railway—L	670 feet.
Gossett's Mill Pond, south end; northwest quarter of section 28 (36 north, 6 west)—L	620 ± feet.
Hebron, Panhandle Railway—L	713 feet.
Kankakee River, Dunn's bridge, surface of water—C	663.7 feet.
Kankakee River, Grand Junction, surface of water—C	660.5 feet.
Kankakee River, Baum's bridge, surface of water—C	659.4 feet.
Kouts, railway crossing—L	687 feet.
Liberty Township, east line, point of crossing B. & O Railway —L	687 feet.
Morgan Prairie, northwest quarter of section 36 (35 north, 5 west)—L	758 feet.
Old shore of Lake Chicago Bay, west of Wheeler, northeast quarter of section 3 (35 north, 7 west)—L	640 ± feet.
Old shore of Lake Chicago Bay, southeast quarter of section 28 (36 north, 6 west)—L	650 ± feet.
Porter, M. C. Railway—R	668 feet.
Salt Creek, crossing of P. F. W. & C. Railway bridge—L	650 ± feet.
Sandy Hook Creek, crossing of Panhandle Railway—L	673 feet.
Summit, near center of section 30 (36 north, 5 west)—R	888 feet.
Valparaiso, G. T. Railway—R	820 feet.
Valparaiso Court House yard—R	803 feet.
Valparaiso P. F. W. & C. Railway Station—L	736 feet.
Wheeler, P. F. W. & C. Railway—L	665 feet.
Woodville, B. & O. Railway—R	721 feet.

* * *

In the preparation of the foregoing paper on the Geology of Lake and Porter counties, I have been aided by a number of persons to whom acknowledgments are due. To Mr. Frank Leverett, of Denmark, Iowa, I am under special obligations for the use of notes pertaining to the physiography of the Calumet region—and for data used in the preparation of the accompanying map. Rev. T. H. Ball and Hon. J. W. Youche, of Crown Point; Mr. A. F. Knotts, of Hammond, and Mr. Henry Rankin, of Valparaiso, also furnished me much data; while Mr. Rankin, Herbert Ball of Crown Point, Hon. Jerome Dinwiddie of Hebron, Hon. Geo. C. Gregg of Hobart and E. L. and Hon. L. G. Furness of Furnessville accompanied me for a portion of the time during my researches throughout the area, and aided me in securing much data which might otherwise have escaped my attention.

THE CLAYS AND CLAY INDUSTRIES OF NORTH-WESTERN INDIANA.

BY W. S. BLATCHLEY.

During the past five years the clay industries of Indiana have had a steady growth. The ever increasing demand for clay products for structural and road uses has been the chief incentive to this growth. The rapid advancement in the price of lumber, due to the disappearance of the forests of the State, has led architects and builders to investigate more carefully than ever before the advantages of clay products for structural purposes. These investigations have, for the most part, proven satisfactory, and have shown the unexcelled fitness of such products for many uses to which stone, wood or other materials were previously put.

As a proof that the general public is beginning to appreciate this fitness, one has but to note the rapidly increasing use of terra cotta and pressed brick for the fronts of business blocks and the more fashionable and costly private residences; of hollow brick for their partition walls; of flue linings for their chimneys; of clay shingles for their roofs, and of encaustic tiles for their floors and mantels. Indeed, all present signs point to clay—that most widely distributed and cheapest resource known on earth—as the leading factor in the future structures built by man.

Nor has the increased demand for clay products been confined to those used for building purposes. The use of vitrified products, such as sewer pipe and paving brick, and refractory clay wares such as fire brick and furnace linings, has also been constantly growing. To supply these increased demands new industries have sprung up in many portions of Indiana, and new discoveries have been made concerning the practical uses of many deposits of clay before considered worthless. Meanwhile, constant inquiries for literature relative to the clays of the State have been received at the office of the Department of Geology. To meet this demand for literature, the writer, in 1895, made a careful study of the clay deposits of the coal-bearing counties in southwestern Indiana, and a detailed paper concerning them was published in the Annual Report of the Department for 1895.

In that paper it was shown that with the exception of some of the clays used in making the better grades of terra cotta, encaustic tile and china ware, Indiana has within her coal-bearing counties the raw material in abundance for making every kind of clay product used within her borders. Some of the best clay deposits and the largest clay factories of the State are, however, located in the northwestern counties, and a portion of the time of the writer during the field season of 1897 was spent in the study of the clays of that region. The results of that study are incorporated in the present paper.

Definition of Clay.

It is difficult to give an accurate definition of the term "clay," as commonly used. In general, the name is applied to any soft, earthy substance which, when wet, can be readily fashioned into any desired shape, which shape it will retain while being dried or burned. All clays are, however, not soft. Many of the best clay deposits of the State are hard, rock-like substances, which must be blasted and ground into powder, before being used. Such clays are either shales or fire-clays. The shales are only clays which, many centuries ago, were deposited in deep water. By pressure they have since become consolidated and separated into rather thin layers or laminæ. A shale is therefore only a hardened, laminated clay. The fire clays are the under-clays of the coal veins. At one time they formed the soil from which sprung the luxuriant plant growth which was afterwards changed into coal. Those plants removed from that soil many of the elements now found in shales and clays, and as a result articles made from fire-clays are more refractory; i. e., will withstand far greater heat without melting, than will those made from shales or ordinary soft clays.

According to the chemist, pure clay is a "hydrated silicate of alumina," the formula of which is $Al_2O_3 2SiO_2+2H_2O$. This simply means that two atoms of the element aluminum, two of silicon and seven of oxygen are united into a molecule of the compound, silicate of alumina, and that that molecule is combined with two molecules of water, to form the clay. Pure clay, with the above composition, is called *kaolin*. Most clays are, however, impure and contain numerous other compounds mixed with their kaolin. The kaolin, called the "clay base," is present in all material to which the term clay rightfully belongs. The purer the clay the greater the amount of kaolin which it contains.

Many inquiries are made concerning "aluminum clay." From the above it will be seen that all clays contain aluminum in greater or less quantities. All clays are, therefore, aluminum clays. The metal aluminum is not, however, separated from a clay, but from a compound called bauxite, which differs from a pure clay in that its aluminum is combined with oxygen to form a soluble oxide instead of with silicon and oxygen to form an insoluble silicate. Bauxite occurs in Alabama, Arkansas, and other Southern States, but not in Indiana.

Origin of Clays.

The clay base or kaolin in all clays had its origin in the decomposition of granite or other primitive rocks which contained feldspar. Granite is composed of three minerals: quartz, mica and feldspar. Quartz or silica is wholly insoluble in rainwater or ordinary acids. Mica is also as insoluble as quartz. The feldspar of granite is composed of a silicate of potash which is soluble combined with a silicate of alumina which is insoluble, and this combination acts as a cement. Granite, then, may be regarded as composed of particles of insoluble quartz, united to particles of insoluble mica by a cement called feldspar which is partially soluble and partially insoluble.

When the granite of the first crust of the earth was exposed for centuries to the air and water, the oxygen of the former and the carbonic and other acids in the latter, acted in time upon the feldspar or cement. As the water percolated through the granite which had been softened by long exposure to the air, the carbonic acid united with the potash of the feldspar to form a carbonate of potash very soluble in water. The feldspar or cement was thus destroyed and the granite crumbled. From it resulted a mass of kaolin (the insoluble silicate of alumina of the feldspar) mixed with quartz particles or sand and numerous scales of mica. This resulting kaolin now forms the clay-base, or essential part of all clays. Besides granite, syenite, gneiss and other primitive rocks contained much feldspar, and by a similar decomposition as that noted have yielded their proportion of kaolin. The latter is, therefore, simply one of the kinds of matter resulting from the decay of feldspathic rocks.

VARIETIES OF CLAYS.

When the clay remains in the place where it has been formed it is called a *residual clay*. When it has been carried by water, ice or other agency to a new location and redeposited in water it is called a *sedimentary clay*. Ninety per cent. of the clays of Indiana belong to the latter group. Among the sedimentary clays are the shales, above mentioned, which were deposited in deep water, and the fire-clays, deposited in the more shallow lagoons and swamps in which the coal plants grew. In the area considered in the present paper, all the clays are sedimentary and most of them are soft clays, belonging to one of three subdivisions: namely, drift clays or "hard pans;" alluvial clays, and silty or marly clays.

Drift Clays or Hard Pans.

The drift clays or hard pans are by far the more common clays in northwestern Indiana. They form a very large percentage of the unstratified morainic material or till which was dropped where it now lies by the melting of one or more of the great ice sheets or glaciers which many centuries ago invaded Indiana.* Transported and deposited as they were, these drift clays are, in general, too impure for any use but the making of ordinary brick and drain tile, and oftentimes they contain too much lime even for this purpose, numerous analyses showing the presence of as high as 40 per cent. of calcareous material. This is due to the grinding up and mixing with the clays much of the surface limestones over which the glacier passed, as the erosion of that epoch not only removed and commingled the previously formed residual deposits, but planed away the country over a vast area to a greater depth than had been reached by any previous decay. These eroded limestones and the clays with which they were mixed were many of them ground into impalpable powder and deposited before a subsequent decay could take place, so that, as has been well said, "the drift clays are, many of them, rock flour, and not, as are the residual clays, the products of rock rot."†

Alluvial Clays.

Along the lowlands and second bottoms of the larger streams of northwestern Indiana are found, at intervals, very large deposits of alluvial clays. These are sedimentary clays of the present age. They owe their origin either to the deposition of fine particles of clay in the eddies of the streams, or to the slow accumulation of the clayey sediment during the annual overflows of the areas which they now occupy. In some places they are 30 to 90 feet in thickness and remarkably free from pebbles or coarse impurities of any kind. They are usually very plastic owing to the presence of salts of lime and iron oxides which are intimately diffused through them.

Silty or Marly Clays.

Silty or marly clays resemble very closely alluvial clays. They differ in that they were deposited in bays, lakes or harbors, by still instead of by flowing water. Much "rock flour" containing a large percentage of kaolin was produced by the passing of the glaciers over beds of shale. This was held in suspension by the glacial streams and finally deposited

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* For a more extended account of one of these ice sheets see p. 30 of this volume.

† Chamberlain, T. C.—Sixth Ann. Rept. U. S. Geol. Surv., p. 249.

in the bays and lakes of that epoch. These marly clays are, in general, composed of finer grains, and are more usually in thin layers, separated by a coating of sand, than are the alluvial clays. They contain a greater percentage of finely disseminated lime and magnesium carbonates, and for that reason products burned from them are usually cream colored or whitish.

The beds of sedimentary clay now found upon the surface of Indiana are very few of them identical with those first formed after the decay of the primitive crystalline rocks. That igneous force which somewhere is ever pushing the bottom of the sea upward, long ago raised the first shale beds into dry land. Rain and frost again caused their decay, and again did the agency of flowing water mix and grind and bear their particles to the bottoms of new seas and lakes. No one knows, or can ever know, how often these successive changes of elevation, disintegration, erosion and deposition have taken place in the ages past; but the clay-base in the materials of our buildings and roadways of to-day, would, if traced backwards, lead us through many a geologic change to the granites and gneisses of the old archæan times.

PROPERTIES OF CLAYS.

All clays suitable for manufacturing purposes possess certain essential and characteristic properties which will now be briefly considered. The most important of these is plasticity. It is this property which causes clay, when mixed with water, to become a tough, pasty mass readily capable of being fashioned into any form by the hands or molds. This plasticity is due to several causes, chief among which is the presence of the water combined with the silicate of alumina in the formation of the clay. When the clays are once burned and this combined water driven off by heat, they lose their plasticity. Brick dust or burned clay may be ground fine and moistened, but unless mixed with some unburned plastic material the particles will not cohere. The absence of crystals in the clay-base or kaolin also adds greatly to the plasticity of the clay, as does also the fineness to which the grains of kaolin have been reduced. Clays which are mixed in autumn and "weathered"—i. e., exposed to rain and frost throughout the winter, have the crystalline structure of their kaolin more or less broken up by alternate freezing and thawing. Their degree of fineness is at the same time increased, rendering them more highly plastic and therefore more readily molded into any desired shape.

Plasticity.

A second important property of clay is infusibility or refractoriness. Kaolin and the best grades of fire clay cannot be melted in the highest heat produced by man. This property is very valuable, in that it enables clay to be formed into many products used in the structure of fire proof buildings, and in furnaces for the reduction of ores. Most sedimentary clays contain lime, potash, iron and other impurities which weaken the property of infusibility, and cause them to melt or fuse at a comparatively low temperature. Such impurities are called "*fluxes.*" Good grades of fire-clays cannot contain more than three to four per cent. of these fluxes. All sedimentary clays contain a much higher per cent. and for this reason fire bricks, furnace linings, crucibles, retorts, etc., cannot be made from them. Great care must be taken in the burning of wares from such clays, in order to prevent the heat from rising to or above that point where fusion takes place.

Infusibility.

A third property of clay is insolubility. The better grades of clay are not affected by any acid or other chemical. On impure clays, however, especially those containing much lime, carbonate of iron or allied chemical, muriatic or sulphuric acid will cause an effervescence or bubbling, and the clay will be in part destroyed. This property of insolubility possessed by the raw clay is not lost in the burning and the finished clay product can be brought in contact with acids or chemicals without being impaired.

Insolubility.

The fourth and last property of clay to be here mentioned is that of induration. By this is meant the power which it possesses of hardening when subjected to heat. The importance of this property can scarcely be over-estimated. Without it an article fashioned from clay would be only so much stiff mud which on exposure to rain or frost would soon crumble to dust on account of its porosity and attraction for moisture. Almost any clay which possesses plasticity enough to be molded into shape can be baked and thereby made to become hard, solid, and stone-like in appearance.

Induration.

IMPURITIES OF CLAY.

The uses to which any clay can be put are determined very largely by the impurities which it contains. Anything other than the clay-base or kaolin may be considered an impurity. The impurities most commonly found in clays are silica or sand, compounds of iron, lime, magnesia, potash, soda, and sometimes organic matter.

Of these the most common is silica or sand in a free or uncombined state. It is found in all clays, and though classed as an impurity, it is in most instances a necessary constituent, since its presence prevents that warping, shrinking and cracking while drying which is sure to take place in the made-up ware when too great a percentage of pure kaolin is present. Clays which are tough and exceedingly plastic are termed "fat clays," and to them sand is often added artificially to lessen the plasticity and render their products more easily dried. Uncombined silica in moderate quantities is thus beneficial, since it preserves the form at high temperatures. When in excess it destroys cohesion and renders the ware brittle and weak.

Sand.

Next to sand, compounds of iron are the most common and the most important impurities of clays. The two oxides, ferrous and ferric, the carbonate, and the sulphide are the forms of iron compounds usually occurring, though others may be present.

The oxides of iron have much to do with the colors of clays, both in the raw and burned state. Ferrous oxide—the more common of the two—is found in all drift and alluvial clays, especially those of a bluish or greenish-blue color. When such clays are burned the ferrous oxide is changed to a ferric oxide, which is brownish red, and the wares become the same color.

Compounds of Iron.

Besides imparting a color to clay products, the oxides of iron act as fluxes. Especially is this true where from 5 to 15 per cent. of these oxides are present, as in many of the shales and drift clays. Such clays fuse at much lower temperatures than others which are similar in every respect, except in the percentage of iron oxides. The carbonate, sulphide and sulphate of iron, when present, also act as fluxes and are liable to produce a distortion of the brick or other product.

Among the sedimentary surface clays, especially those treated in the present paper, lime and magnesia are always present. If in fine particles, thoroughly disseminated through the clay, they only act as fluxes, and so limit the use of the clay to the making of certain products. Lime, however, more commonly occurs in the drift clays or till, in the form of small grains or pebbles of the carbonate. Unless these can be removed or ground to powder by a crusher, the clays containing them are practically worthless. If burned with the clay each lime pebble loses carbon dioxide and is changed from a carbonate to an oxide or quick-lime. This has great attraction for water, and when exposed each pebble absorbs moisture, swells and bursts off a piece of the ware, causing a defect or shallow pit in its surface.

Lime and Magnesia.

When lime and magnesia are present in quantity in a finely divided state they combine with the oxides of iron and with some of the sand to form a light colored double silicate of iron and lime. For this reason many of the alluvial and marly clays in northwestern Indiana—especially those near Hobart, Michigan City and South Bend—although rich in iron oxide, produce whitish or cream colored instead of red products.

Potash and Soda.

Potash and soda are two of the most powerful fluxes found in clays. They melt at a lower temperature and unite more readily with the clay-base than do iron, lime or magnesia. Their amount is not large, being, on an average, but 2 to 4 per cent., but in fusing power this is equal to more than double that percentage of the fluxes above mentioned. If vitrified products, such as paving brick and sewer pipe are desired, a total of from 10 to 14 per cent. of all the fluxes named are necessary in the clay. When the ware is raised to a temperature sufficient to melt the potash, iron, lime, etc., these fluxes fuse with the silica and give to the ware that dense, tough, non-porous condition characteristic of all so-called "vitrified" products.

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On account of office work connected with the issuing and distributing of the 21st Annual Report, I was unable to begin field investigations in 1897 until July 10th. The most of the time thereafter was spent in gathering data for the detailed report on Lake and Porter counties which appears in the present volume. The time left at my disposal for studying the clays of northwestern Indiana was very limited, and the present paper, therefore, deals only with the more important clay deposits of Benton, Newton, Jasper, Starke, Lake, Porter, Laporte and St. Joseph counties.

THE CLAYS AND CLAY INDUSTRIES OF BENTON COUNTY.

Benton County comprises an area of 414 square miles of the most fertile portion of northwestern Indiana. It lies on the western border of the State and is the third county south from Lake Michigan. Its entire surface is a gently rolling prairie broken only by three prominent morainic ridges which run in an easterly and westerly direction across its area. Standing upon one of these ridges near the center of the county one can behold the undulating prairie spreading away in all directions like the billows of the ocean. Timbered groves—island-like—dot here and there its surface, and well built farm houses with surrounding orchards are seen on every side. No finer body of farming land exists in the Mississippi Valley than these rolling plains of Benton County.

The soil is everywhere a rich, black loam, composed of the remains of plants which have decayed under water, and of silt which has been mixed with them by slow deposition. For, after the recession of the great ice sheet which covered the underlying rocks with a thick deposit of bowlder clay, all these prairies were covered with shallow lakes, which by natural causes were gradually drained. In the first settlement of the county many of the prairies were too wet for cultivation, and a number of marshes which had not yet reached the stage of "wet prairies" were scattered at intervals within its bounds. To properly drain these wet regions has been the chief problem of the land owners. This has been accomplished by the construction of a great system of surface ditches which ramify throughout every portion of the county. These have necessitated the using of an immense quantity of drain tile. The manufacture of this tile has been the chief, and up to 1896, practically the only clay industry in the county.

The clays of Benton County are all of them of glacial origin. They lie immediately beneath the black prairie loam, and vary in known thickness from 5 to 130 feet. When first deposited by the melting ice these clays were a uniform blue in color. In the course of time, however, the upper portions of the clay beds have been percolated by waters containing humic acids and other substances from the decaying vegetation above. These have changed the ferrous or lower oxide of iron to the ferric or higher oxide. As a result the upper 5 to 20 feet or more of the clay, is now a brownish yellow. There is often a sharp line of division between the yellow, weathered portion and the blue or unweathered part of the clay. The latter is usually the more plastic and the better in quality.

The best deposit of clay in Benton County, so far as known, is the one at Earl Park, on the Chicago Division of the Big Four Railway. It has been worked since 1891 by the Earl Park Elevator and Tile Co., whose works are located about 150 yards from the pit in the south part of the town. A section obtained at the pit showed as follows:

1.	Soil—stripped for working	8 inches.
2.	Coarse-grained yellow clay, with many small pebbles	4 feet.
3.	Fine-grained drab clay	8 feet.
4.	Blue clay—marly—fine-grained	38 feet.
5.	Limestone	? ?

No. 2 of this section contains little lime, except what is in the pebbles. It is more refractory than the clays of the lower strata, but the lime and other pebbles must be removed or crushed, else they will spoil all wares produced from it.

The clay of stratum No. 3 is very similar to that of No. 4, except in color. Its lighter hue is due to leaching waters. The sediment of which the two strata are composed was probably deposited in still water by a stream from the retreating ice sheet. They contain an occasional drift pebble, but no large number of small limestone pebbles as does the upper stratum. Both are very fine grained, effervesce freely with acids and are to be classed as marly clays. They probably contain about 8 per cent. of carbonate of lime and magnesia in addition to the other fluxes. For this reason vitrified products of high quality cannot be made from them. Mixed with the upper clay, No. 2, they will withstand more heat. From them alone can be made, however, good pressed front brick, terra cotta lumber, drain tile and ordinary building brick.

The company operating this deposit has been recently reorganized and have put in some good machinery. Before 1896 only drain tile and ordinary brick had been made; the former from a mixture of all the clays, the latter from the two upper strata. They had used only a Pott's disintegrator to separate the pebbles, and a "Little Wonder" stiff-mud brick and tile machine. In that year they put in a 9-foot dry pan for crushing the clays; a Boyd dry press for pressed front brick, and a Boyd steamer to moisten the clay dust, after the latter has passed through two inclined screens. For drying the stiff mud brick and tile they have four floors, each 60x90 feet, heated by steam pipes, and for burning all their wares, four down-draft kilns, each of which hold 40,000 brick.* Hereafter the making of pressed front brick will be carried on to quite an extent. The color of these will depend upon the mixture of the clay, those from the blue clay alone being whitish yellow, and from the other clays different shades of red. At the time of my visit the making of such brick was yet in the experimental stage. Too many different shades were being made and too large a percentage were warped. Experience will doubtless remedy these defects, and with a man who has a practical knowledge of clay manufacturing in charge of the plant, there is no doubt but that its future will be a success.

At Lochiel, on the C. I. & C. Railway, drain tile have been made for a number of years by the Lochiel Tile Company. The material

*For further statistical information concerning this and other factories see table near close of this paper.

used is a stiff, dark colored drift clay which contains numerous small pebbles of lime. It is rather coarse grained and resembles the upper stratum at Earl Park in containing too small an amount of disseminated lime to effervesce with acids. Six inches of soil are stripped and the clay used only to a depth of four feet. It is hauled in carts to the plant and passed through a crusher and then through an Adrian brick and tile machine. Experiments in making pressed brick have been tried, but the brick were too brittle and the clay in general too coarse. Some hollow brick, of good quality for foundation work, have been made at this place. This company formerly produced the second largest output of tile of any in the county. Of late years the demand has fallen off and the production is much less. They have ample dry sheds and three round down-draft kilns of standard size. If the clay be properly crushed a good grade of tile can be made at Lochiel, but the qualities of the clay are not of the best for making other wares.

Drain tile have been made at Fowler, the county seat, by the Fowler Tile Works, since 1883. The material used is a rather coarse grained "hard pan" or "drift clay" very similar to that at Lochiel, but contains a much smaller number of lime pebbles. Five feet of clay are utilized after six inches of soil have been stripped. This clay is passed through a Potts disintegrator and pug mill, then made into tile on a Frees brick and tile machine. The tile are dried in sheds heated with exhaust steam for about one week. They are then water-smoked for 24 hours and burned from 24 to 30 hours. The burning is done in three round down-draft kilns, each capable of holding 15,000 4-inch tiles. The fuel used here, as elsewhere in the county, is slack coal. The clay burns red, but in time there appears on many of the tile a whitish efflorescence. This does not injure the quality of the tile.

The following is the daily capacity of the different sizes of tile made on a Frees brick and tile machine at the Fowler Works, and the price of tile at that place in 1897. Fifteen tile of any size equal one rod in length.

Size.	*Daily Capacity.*	*Price.*
3½ inch	12,000	$10.00 per thousand.
4 inch	10,000	12.00 per thousand.
5 inch	7,000	18.00 per thousand.
6 inch	5,000	23.00 per thousand.
7 inch	3,500	32.00 per thousand.
8 inch	3,000	40.00 per thousand.
10 inch	2,500	60.00 per thousand.
12 inch	2,000	80.00 per thousand.
14 inch	1,200	110.00 per thousand.
15 inch	1,000	125.00 per thousand.

The deeper the clay the better the quality for tile-making at the Fowler plant. The upper portion contains less sand and shrinks more in drying than the lower. A mixture of clays from top to bottom of the pit is aimed to be used, and the more thorough the mixture the better the product. By going deeper it is more than probable that a finer-grained blue clay will be found which can be made into terra cotta lumber, hollow brick and other products.

Ordinary building brick in small numbers are also produced at Fowler. It is claimed, however, that, on account of being made on a tile machine, they are compressed too firmly, and are left with too smooth a surface. As a consequence, they crack too easily in drying. There is at Fowler, however, room and plenty of raw material for a good, ordinary brick factory.

At Oxford, John Lawson has been making drain tile on a small scale for 15 years. On his tile yard is a flowing well 50 feet deep, which pierces the gravel beneath the blue clay. The clay for tile is gotten from low ground. Eight inches of soil are stripped, and 16 inches of a blackish sedimentary clay wholly free from lime pebbles are first taken out. This is mixed with three feet of underlying yellowish clay, then passed through a crusher and made into tile on a Hoosier tile machine. The tile are air-dried in sheds and when burned are smooth, a bright-red in color and of excellent quality. About $5,000 are invested in the enterprise and the annual output is valued at $3,500.

At Otterbein tile have been made by Wm. Lawson since 1891, and a factory is also in operation on Pine Creek, in the eastern part of the county. I was unable to examine the clays at these factories, but it is said that they are "drift clays" of good quality for tile-making.

Other tile factories have been in operation at Templeton, Wadena and Boswell, but have been abandoned in recent years. The reason for this abandonment as well as that of the decreased output at all other factories are several; chief among which was the business depression of 1893-5, causing farmers to stop drainage on account of a lack of money; the gradually decreasing amount of lands needing drainage, and the selling in Benton County of tile from Summitville and other points in the natural gas field, cheaper than they could be there manufactured at a living profit.

On the whole, it may be said that the clay resources of Benton County are inferior in value to those of the counties in the coal-bearing area of Indiana, or of some of the counties adjacent to Lake Michigan. But what the county lacks in clays it far more than offsets in the richness and productiveness of its prairie soils.

THE CLAYS AND CLAY INDUSTRIES OF NEWTON COUNTY.

Newton County comprises 400 square miles of northwestern Indiana, lying adjacent to the Illinois line, north of Benton and west of Jasper counties. The Kankakee River forms its northern boundary and drains the northern half of its area. The Iroquois River flows across the southern half of the county from east to west. It forms the northern boundary of that magnificent prairie region which embraces the southern third of Newton and all of Benton counties. North of the Iroquois are also some fine prairies which extend to the southern border of McClellan and Colfax townships.

With the exception of about 25,000 acres, formerly comprising Beaver Lake, the surface of the four northern townships of Newton County is covered with loose sand. Up to the present this sandy area has been deemed comparatively worthless for agricultural purposes, but the time will soon come when, by proper cultivation, it will be made to yield handsome returns in small fruits and certain vegetables. The area covered by Beaver Lake was long since drained into the Kankakee and now comprises one of the most productive regions of the county.

The clays of Newton County are, all of them, drift clays or marly clays. They were deposited either by melting ice or by the still water of the numerous shallow lakes which for centuries immediately following the glacial period covered the greater portion of the county. In many places they cover the uppermost rocks to a depth of 120 to 140 feet, and in but a few known places are they less than 10 feet in thickness. The northern third of the county was not visited since it is so covered with sand and lacking in railway facilities for transporting clay products. The fine-grained blue clay common to the region will doubtless be found to underlie all of this sandy area to a great depth.

In the vicinity of Kentland there are no clay factories, and no openings where the strata of underlying clay are exposed. The record of the well in the public square shows the blue glacial clay to be 146 feet in thickness. At Kent's warehouse it was 80 feet, and on Kent's farm, two miles southwest of Kentland, section 29 (27 north, 9 west), 50 feet in thickness.

A brick yard was for some time located on the north side of the Iroquois River, where the road running north from Kentland crosses that stream, southwest quarter of section 34 (28 north, 9 west). The clay is yet exposed in a cut by the roadside to a depth of five feet. It is a fine-grained, reddish, loamy clay, free from pebbles and lime, and will withstand much heat when burned. It should make excellent ordinary brick, but is not suited for drain tile on account of the large amount of free silica which it contains.

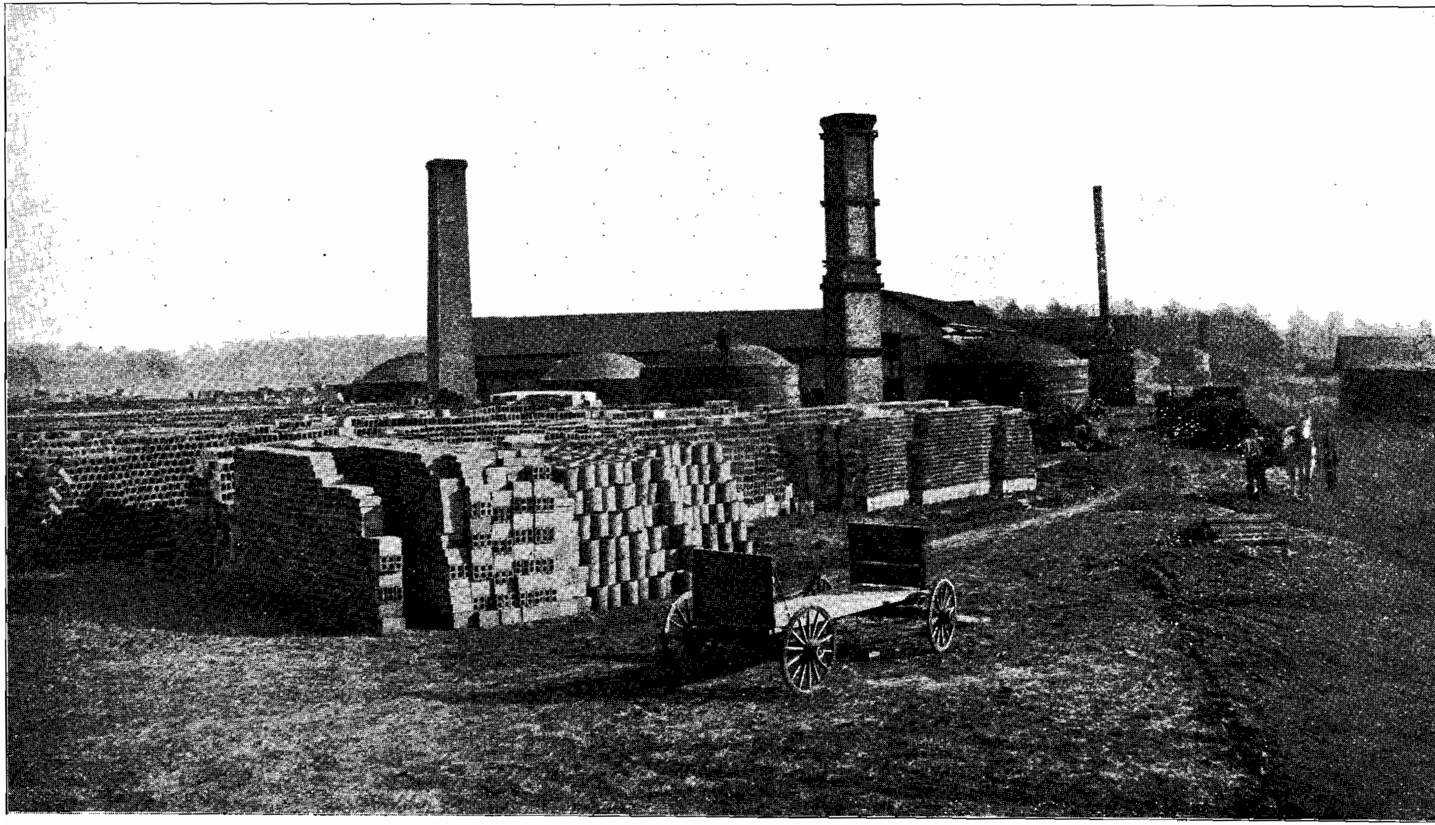
At Morocco, in the south half of section 21 (29 north, 9 west), Darroch Bros. have been operating a brick and tile yard for four years. The firm have their plant very well fitted with machinery, but are unfortunate in the selection of their clay. Seven inches of soil is stripped and three feet of brownish drift clay is utilized. It is very full of lime pebbles, and for that reason the tile and brick are of poor quality. One hundred yards north of their plant the blue clay comes within five feet of the surface and will make much better tile, but they will be yellowish-white in color. Two well sections at Morocco show this blue clay to be 113 and 120 feet in thickness, very fine-grained and very plastic.

A much better clay for tile and brick-making occurs at Beaver City, and has been worked by M. E. Handley since 1893. The section at the pit is as follows:

1.	Soil—stripped	½ foot.
2.	Yellowish sandy clay	3½ feet.
3.	Tough, bluish clay	4½ feet.

Wares made from the above yellowish clay air crack in drying, especially if exposed to the wind. When the yellow clay is mixed with the blue this is prevented. The blue clay has been proven by a bore to be 140 feet in thickness. But little trouble is had with lime pebbles, as comparatively few are present. The clay is thoroughly moistened, pugged and crushed before entering the machine. The mixture burns red, and the owner claims that red tile sell much better than white, as they stand freezing better. Tile from 3½ to 12 inches in size are made and more were sold in 1897 than any year since the factory was started. The brick made are of fair quality and bring $8.00 per thousand at the yard, but the local demand is small.

At Mt. Ayr, on the La Crosse Branch of the C. & E. I. Railway, a grayish-blue clay comes close to the surface in a marshy field in the eastern outskirts of the town, and is worked into brick and clay by Stucker & Coovert. It is fine-grained and tough, but contains occasional botryoidal masses of pure amorphous carbonate of lime the size of a marble or smaller. No true pebbles of lime are found in the clay and a similar occurrence of amorphous lime was noted nowhere else in northwestern Indiana. The clay itself possesses scarcely enough lime in its composition to cause an effervescence with acids, and burns a bright red. Four to six feet of it are used, the deeper portions burn-



YARD AND WORKS OF THE J. H HAYNES CO., BROOK, NEWTON COUNTY, IND.

ing to wares of a lighter color. About 25 kilns of a good quality of tile are made at this factory besides enough brick to supply the local demand. If the lime above mentioned was absent, the clay would be of most excellent quality for drain tile, flue linings and fire-proofing.

The J. H. Haynes Company, of Brook, have the largest and best-equipped clay factory in Newton County. Their clays are also excellently suited for the wares which they are making. A section at their pit, northwest quarter of section 20 (28 north, 8 west), showed as follows:

1.	Black soil	1 foot.
2.	Yellowish loamy clay	2 feet.
3.	Grayish or drab, marly clay	3 to 6 feet.
4.	Tough blue marly clay	2 to 5 feet.
5.	Gravel and sand	? ?

The entire deposit was evidently laid down in still water instead of being dropped by melting ice. As a consequence but little trouble is experienced with lime pebbles. From a portion of the soil and the loamy clay—No. 2—ordinary red brick and drain tile were made for a number of years. In 1895 the company begun to utilize the upper marly clay—No. 3—in making terra cotta lumber for the Chicago market. This clay is a silt, the lower part of the stratum being in thin layers with a coating of sand between them. An incomplete analysis shows that it contains about 10 per cent. of magnesium and lime carbonates. In the making of terra cotta lumber three parts of clay are mixed with one part of sawdust. The mixture is passed through a pugmill and crushed, and then through an Adrian tile machine fitted with dies of the proper pattern for the product desired. The so-called lumber is in reality a hollow brick, 12x12 inches square and 3, 4 or 6 inches thick. The walls are three-fourths of an inch thick and the hollow portion has two partitions to give the structure additional strength. At the present time the brick are dried in sheds for six to eight days, but a tunnel dryer will soon be constructed. After drying they are burned for 36 hours, and, the sawdust being consumed, leaves the product very light and porous, but at the same time strong enough for all purposes for which it is used.

On account of the porosity, this "clay lumber" can be readily sawed to any desired shape, and a nail can be driven into it with as much ease as into a pine board. It is used mainly for partition walls in fire-proof buildings, and is rapidly taking the place of ordinary brick and solid fire-proofing for that purpose. Its advantages over the latter are obvious. On account of a grooved outer surface, plaster is spread over it without the use of intervening laths. Any wood finish can be nailed directly to it; while with a saw or trowel it can be quickly cut into any desired shape. Its weight is as follows:

3 inch	13,500 lbs. per 1,000 square feet.
4 inch	15,000 lbs. per 1,000 square feet.
6 inch	20,000 lbs. per 1,000 square feet.

The prices at which it was sold in 1896 were $27.50, $30.00 and $35.00, respectively for the sizes made, delivered in Chicago.

From the blue clay, No. 4 of the section, flue linings, solid fire-proofing, furring brick and foundation brick are made. This clay, as well as No. 3, burn to a cream color on account of the large percentage of lime which they contain. With a better system of drying their wares, and with a few additional kilns, this company will have their plant in excellent condition to meet almost any demand. Their trade is constantly increasing, as they aim to make all their products of the best possible quality and sell them at reasonable prices.

The Goodland Tile Company has been making brick and tile at Goodland, in the southeast corner of Newton County, for 12 years. The clay which is mostly used is peculiar for this region of the State, in that it is a pinkish-red in color. It resembles closely the clay of the same color found near Freedom, Owen County,* which is quite largely used in the making of encaustic tile and terra cotta. Both are very fine-grained, free from grit and pebbles, and exceedingly tough and plastic. The clay at Goodland effervesces rather freely with muriatic acid, showing that it contains several per cent. of lime carbonate, while on that from Owen County acid has no effect. The latter is, therefore, much the more refractory.

The section at the clay pit at Goodland was as follows:

1. Soil	1	foot.
2. Grayish pebbly hard pan or drift clay	2 to 3½	feet.
3. Pink clay	4 to 10	feet.
4. Blue clay merging into shale	5 to 8	feet.

The pink clay covers a large area southeast of Goodland, southwest quarter of section 25 (27 north, 8 west), on the land of W. J. Stewart. Burned by itself, it produces ware of a dark-red color. Mixed with the overlying grayish clay, it burns brown. Drain tile made from it are very hard and ring when struck, as though composed of iron. On account of its tough, plastic condition it is apt to twist and shrink under the influence of great heat. It must be thoroughly moistened

*See 20th Ann. Rep. Ind. Dep. Geol., 1895, 85.

in a pug mill, as it is too tough to work dry. When properly tempered or weathered it does not air-crack in drying. It possesses all the properties of an excellent modeling clay, and is of too high a grade to be used only for brick and drain tile, as it is at present.

The Goodland Company have a very well equipped plant, but in the past have made many poor tile from the upper pebbly clay, and have thousands of them on their yard. Besides drain tile and ordinary brick, they make solid fire-proofing, hollow brick and foundation brick. Of ordinary brick their output is only about 100,000 per year, which they sell for $8.00 per thousand at the yard. In 1896 they made 55 kilns of drain tile, but in 1897 the long strike among the coal miners shortened their season and they produced less than half as many.

From what has been stated it will be seen that the clays of Newton County are more varied in character and of better average grade than those of Benton. Good deposits of marly clay, suitable for terra cotta lumber, doubtless occur along the Iroquois River, east and west of Brook. Three railways pass through the county and its proximity to the coal fields of both Indiana and Illinois renders cheap fuel a certainty. There is no reason why larger clay industries should not start up and flourish, especially at Goodland and Brook.

THE CLAYS AND CLAY INDUSTRIES OF JASPER COUNTY.

Jasper County lies east of Newton and south of the Kankakee River, which forms its northern boundary. The Iroquois River, with its tributaries, Pickamink River and Carpenter's Creek, drains about three-fourths of its area. The county contains 550 square miles of surface, which is very diversified in character. The northern half is, for the most part, sandy, with intervening low prairies, marshes, and ridges and knolls covered with scrub oak timber.

The marshes and wet prairies, when drained, produce excellent crops, and comprise the best land in this section of the county. In Barkley, Gillam and Walker townships is one tract of 33,000 acres, owned by Benjamin J. Gifford, of Kankakee, Illinois, a large portion of which has been drained since 1893. On it are now more than one hundred dwellings, with good outbuildings and young orchards. Immense crops of oats and corn are produced and a thriving farming community now exists where, but a few years ago, only the wild duck and the muskrat flourished. The southwestern part of the county is a gently rolling prairie of black loamy soil.

The clays of Jasper County are the characteristic drift and marly clays of northwestern Indiana. The best grade of clay noted is located one and one-half miles north of Rensselaer, in section 7 (29 north, 6 west), and is utilized for drain tile by A. E. & H. A. Alter. A prominent ridge rises 30 or more feet above the plain on which Rensselaer stands, passes east and west through this and adjoining sections and contains the deposit of clay. At the pit near the summit of this ridge, the section exposed was as follows:

1.	Soil	8 inches.
2.	Yellow clay with occasional pebbles	3½ feet.
3.	Grayish blue clay	10 feet.

A well close to the pit pierced the blue clay to a depth of 126 feet before striking a water supply in gravel. In the making of tile but a few inches containing the roots of grass are stripped, and the clay from top to bottom of the pit is mixed, in the proportion in which it occurs. This mixture is soaked for a day or two and then passed through a Potts disintegrator and made into tile on a New Departure machine. The mixture burns pinkish on account of the presence of the top stratum. By itself the lower stratum burns to a cream color.

The grayish blue clay is very hard and has to be dug with a pick, as a spade will not penetrate it. It is fine-grained and very stiff and tenacious. It makes a firm, smooth tile of excellent quality, for which the demand has lately been greater than the supply. With proper weathering and tempering it could be made into hollow brick, flue linings, fire-proofing and many similar products, but contains too high a percentage of fluxes for paving brick, sewer pipe or other vitrified wares. The deposit of this clay comes close to the surface over several sections, both east and west of the point where it is worked and its quality is such as to merit a more extended use.

On the land of John T. Randall, near the postoffice of Pleasant Grove, 10 miles northeast of Rensselaer, drain tile has been made for 11 years. The material used is the ordinary fine-grained blue clay, mixed with about one foot of black soil and two feet of red clay. The blue clay at this point is 50 feet in thickness. Wares made of it alone air-crack in drying. Many unburned tile which had been exposed to a strong wind and had cracked were scattered about the yard. Some trouble is also experienced with lime pebbles in the red clay. About 50 kilns are burned each year. The tile are not nested when set in the kiln, and for that reason the average value of the kiln is but about $90.00. Wood is used for fuel at a cost of about $2.00 per cord. The owner claimed that below the depth exposed the blue clay became of the same character as that north of Rensselaer.

Good clay for drain tile, fire-proofing, etc., also occurs on the land of John English, northeast quarter of section 9 (29 north, 6 west), and on that of Murray Bros., northeast quarter of section 10 (29 north, 6 west).

Just west of Rensselaer, on the north half of section 25 (29 north, 7 west), John Kohler & Son have been making brick and tile for 11 years. The section exposed at their clay pit is as follows:

1. Soil and surface clay	1½	feet.
2. Tough, plastic bluish clay	4	feet.
3. Bluish pebbly clay	1½	feet.
4. Bluish clay free from pebbles	8 to 10	feet.

Stratum No. 1 is used for making brick and No. 2 for tile. Several kilns of brick were at one time made from the pebbly clay. No. 3. The lime in these caused them to crumble badly and gave the brick from this yard a poor reputation, causing the local trade to go elsewhere for its supply. More care is now taken to avoid the use of this stratum, and the brick on the yard were of good quality, but were bringing but $4.75 per thousand, delivered in Rensselaer.

Were it not for the heavy stripping the lower stratum, No. 4, would be used for brick. It has been tested and forms a very hard, whitish product. Clays of the same quality as those of this yard occur close to the surface over an area of one and one-fourth miles long and one-half mile wide west of Rensselaer.

On the land of Dr. W. W. Hartsell, two miles west and one mile south of Rensselaer, a well section showed 4 feet of soil and loam and 30 feet of clay; the latter being very sticky, fine-grained and free from grit or pebble. Just as it comes from the bed it can be formed by the hands into shallow vessels which will hold water until it evaporates. It can be burned into solid fire-proofing, flue linings, foundation brick, etc.; but will probably need some tempering with sand on account of its great tenaciousness.

A similar clay to that on the Hartsell farm is exposed in a large dredged ditch in Milroy Township. This ditch is a mile in length, extending from the center of section 10 to the center of section 15 (28 north, 6 west). The upper portion of the clay lies from two to four feet below the surface, but its thickness has never been ascertained. When damp it can be cut into ribbon as thin as a knife blade and a yard long. When dry it is very hard and tough. It is probably too far distant from a railway for utilization.

At Remington, on the P., C. & St. L. Railway, near the southern edge of the county, a tough blue clay is made into tile by Samuel Bowman. It lies immediately below eight inches of soil, part of which is mixed with it when used. It contains numerous pebbles which must be crushed, or thrown out by a disintegrator, but otherwise is well suited for tile-making. Enough ordinary brick are made to supply the local demand.

This comprises all the exposures of clay which I was enabled to visit in Jasper County. The blue clay which is the more common probably underlies the entire county, but only in the vicinity of Rensselaer was it found of a quality suitable for making other wares than drain tile.

THE CLAYS OF STARKE COUNTY.

Starke County lies east of Jasper, in the second tier of counties south of Michigan, and in the third east of Illinois. Its eastern border is 18 miles and its southern border 24 miles in length. Nine miles west of its northeastern corner the Kankakee River intervenes between it and Laporte County, and, flowing southwesterly, forms the remainder of the northern and all but five miles of the western boundary. Yellow River, flowing west through the center of the county, and Bogus River and Pine Creek, north through the southwestern fourth, empty into the Kankakee. Bass Lake, formerly known as Cedar Lake, lies in the southeastern part and is 3x1½ miles in area, with an average depth of about 20 feet.

The county has an area of 306 square miles, the surface of which is diversified by marsh, wet prairie, dry prairie and sand ridge, the latter predominating. More than half of the area is covered to a depth of 2 to 15 feet by the fine-grained buff sand so characteristic of all the region adjacent to the Kankakee on the south. Experience has proven that this sandy soil, if properly cultivated, will produce excellent melons, sugar beets, berries, grapes, etc. Where ploughed deep and fertilized it also yields good crops of corn, oats and potatoes. Within the past ten years colonies of frugal, industrious Germans and Swedes have bought at a low price large areas of this once despised land and are making a good living from it. They utilize all fertilizers produced on the farm; they haul muck from the lowlands and mix it with the sand; they plough deeply each season; and by these means and others are proving the land of far greater productive power than it was ever believed to be.

Many thousand acres of the marsh land in the northern half of the county have been recently drained, and where a few years ago the waters were waist-deep the year round bountiful crops of corn are now produced. That the county is rapidly coming to the front agriculturally is proven by the growth of Knox, the county seat, where several fine business blocks were erected in 1897, and where a $90,000 court house will be finished next year.

Beneath the sand, the prairie sod and the marsh bottoms of Starke County there is everywhere the fine-grained, ash-blue bowlder clay which covers the entire area of northwestern Indiana. In many places this comes close to the surface, yet there is not at the present time a brick yard, tile factory or clay industry of any kind within the bounds of the county. Several brick factories have been started in the past, but always by some one inexperienced in clay-working and usually without capital. As a result, they were failures, and, after a few kilns were burned, they were abandoned.

One of these factories was located in section 5 (32 north, 2 west), one and three-fourths miles east of Toto, a station on the "Three I" Railway. A record of the well on the former yard is as follows:

1.	Sand	2 feet.
2.	Yellow clay	4 feet.
3.	Blue clay	38 feet.
4.	Sand	8 feet.
5.	Blue clay	23 feet.
6.	Sand	5 feet.

A plentiful supply of water was obtained in the third stratum of sand.

The clay used was that from stratum No. 2, mixed with a foot or two of that from No. 3. It contains quite a percentage of disseminated carbonate of lime, but no lime pebbles. The mixture burns red, and, from samples of brick and tile left on the yard, produced wares of good quality. Wood, costing but $1.25 per cord, was used for fuel, and the brick were sold at the yard for $6.00 per thousand. They were made on a Penfield brick and tile machine, which is still in the abandoned shed, and dried in an open yard. The parties claimed that the location was too distant from Knox, about five miles to the northeast, where the brick were mostly sold, and that the demand was too limited to continue the business.

On the land of Isaac R. Bascom, northeast quarter of section 1 (32 north, 3 west), one-third of a mile west of Toto, a reddish yellow clay comes to the surface near the right of way of the "Three I" railway. This clay has been proven by tests in three factories to be well fitted for the making of brick and tile. It contains some pebbles, and a disintegrator and crusher would have to be used. This location is probably the best in the county for a clay factory for brick and tile, as a switch could be put into the plant with but little expense. Water in abundance can be obtained at all seasons from the Bass Lake outlet, which passes through the deposit. A factory started at this place could supply at a low rate all the brick needed in the towns of Starke County along the "Three I" railway, and at the same time the constantly increasing local demand for tile among the farmers. At present these clay products are shipped into both Knox and North Judson from other counties.

Three miles south of Knox, on the land of John Lindstrand, northwest quarter of section 3 (32 north, 2 west), is also a deposit of clay suitable for brick and tile. It covers 40 or more acres and comes to within less than a foot of the surface.

On the line between Marshall and Starke counties, section 36 (33 north, 1 west), a brick and tile factory was in operation for a number of years, but has been recently abandoned on account of its distance from a town of any size. I did not visit this point, but was informed that the wares made gave good satisfaction wherever used.

Nine miles west of Knox, on the land of Fred. Surma, northeast quarter of section 33 (33 north, 3 west), a number of kilns of brick have been burned to supply a local demand, but no permanent factory has been started. Just across Yellow River, one-third of a mile north of the Court House at Knox, several kilns were also made a number of years ago, but the clay is of poor quality and in no place more than two feet in thickness, and overlies a bed of sand. It was used only because no better deposit was thought to occur in the county.

These constitute all the points, as far as could be ascertained, at which clay suitable for brick or tile comes close to the surface in Starke County. By stripping the sand the blue clay will be everywhere found, but ordinary brick have not as yet been made from it. Custom has established the idea that brick and tile should be of a red color, and since the blue clay burns yellow, it is wrongly considered to be useless for such wares. At any one of two or three of the points mentioned a man with a practical knowledge of clay working and possessed of energy could establish a combined brick and tile factory on a paying basis, since a county which is advancing as rapidly as Starke should by all means support at least one such factory within her bounds.

THE CLAYS AND CLAY INDUSTRIES OF LAKE COUNTY.

The location and leading surface features of Lake and Porter counties are given in another paper in the present volume, hence they are not treated in this connection. The clays of the county which come close enough to the surface for utilization are of two kinds, drift clays and silty or marly clays. The drift clays are utilized at Lowell and Crown Point in the making of brick and drain tile, and the silty clays, at Hobart, on an extensive scale, in the making of terra cotta lumber, flue lining, fire-proofing and ordinary and pressed front brick.

At Lowell the clay factory has been operated by P. D. Clark for 13 years. The amount invested is but $5,000 and the value of the annual output is about the same, equally divided between the two products. The clay used is gotten from a hillside northwest of the town, northwest quarter of section 23 (33 north, 9 west). It is a tough yellowish drift clay about 12 feet in thickness, with many small pebbles of lime carbonate and other material scattered through the basal portion. For this reason only the upper four or five feet are used and this has to be passed through a crusher. Underlying the clay stratum is a thick deposit of coarse sand.

The plant is located at the base of the hill, and the clay is hauled to it in carts. After being crushed it is passed through a perpendicular pug mill and then through a "Little Wonder" brick and tile machine. The products are dried by air in sheds and burned in round down-draft kilns. Aside from an occasional pebble, which escapes the crusher, and causes a flaking of the surface, the brick and tile are of good quality. The clay, however, is not suited for higher grade products.

Drift clay similar to that used at Lowell lies near the surface over an area about three miles wide between Lowell and Crown Point. At the latter place H. W. Wise has been making brick from it for 24 years and has lately begun the making of tile. Only about three feet of the clay can be used on account of the pebbles in the lower portion of the bed. A Penfield brick and tile machine is used and the value of the annual output is about $2,500.

By the side of the Pittsburg, Fort Wayne & Chicago Railway, just north of Hobart, in the southwest quarter of section 29, and the southeast quarter of section 30, (36 north, 7 west), is one of the largest, best known and most valuable deposits of silty clay in northwestern Indiana. For a long period ordinary soft mud brick were made in large numbers from the surface portion of this deposit, but in April, 1887, W. B. Owen began the making of terra cotta lumber and fire-proof products from the deeper portions of the clay bed, and this business, now carried on under the name of "The Hobart Terra Cotta Lumber Company," has become one of the most important clay industries in the State. The pit at the Owen yard covers an area of about four acres and is 25 feet deep. A section of it showed as follows:

1. Soil	6	inches.
2. Fine grained yellowish marly clay	2½ to 3	feet.
3. Grayish-blue clay, exceedingly fine grained	21	feet.

The two clays, Nos. 2 and 3, were, when deposited, doubtless of the same color, and the difference in hue now existing has been caused by leaching waters. No. 3 has been pierced by a bore to a depth of 132 feet without reaching its base. The deposit is a well-defined silt, the upper six to ten feet of blue clay being in layers two to six inches thick, with each layer separated from the one above and below by a thin coating of sand. Towards the bottom of the exposure the layers become thicker, eight to fourteen inches, and the clay is more condensed and contains less free silica. Not a pebble or solid body of any size occurs in the entire deposit, and it was most probably laid down by slow deposition in the waters of a shallow bay which formed an adjunct to the highest stage of the old glacial Lake Chicago.*

When dry the clay becomes much lighter in color. By itself it burns to a dark cream, and, when mixed with the surface stratum, to a light pinkish hue. On account of the presence of about 20 per cent. of calcium and magnesium carbonates, the clay effervesces freely with acids. Its chemical composition, as determined by Noyes, is as follows:

ANALYSIS OF MARLY CLAY FROM HOBART, IND.

		Per Cent.
Silica	50.56	
Titanium oxide	1.00	
Alumina	13.11	
Combined water	2.76	
Clay base and sand		67.43
Ferric oxide	2.98	
Ferrous oxide	2.32	
Lime	7.87	
Magnesia	5.06	
Potash	3.74	
Soda	.70	
Fluxes		22.67
Carbon dioxide	9.62	
		9.62
Total		99.72

The large percentage of the fluxes present shows that wares from this clay can not be subjected to great heat on account of the danger

*See p. 33 of the present volume.

CLAY PIT OF HOBART TERRA COTTA LUMBER COMPANY, HOBART, INDIANA.

of their melting down. The clay is peculiarly fitted for a light, porous product, which does not require the properties of hardness or toughness.

In the making of the terra cotta lumber and other fire-proof products, the clay is excavated with spades and elevated in tram-cars as fast as needed to the upper floor of the plant, where it is dumped by the side of an opening leading to a perpendicular pug mill. From the opposite side of the building a belt carrier elevates screened sawdust and drops it near the same point. The clay is moistened by sprinkling water over it with a hose, and two men scoop alternate shovelfuls of clay and sawdust into the pug mill. In it the two are thoroughly mixed and then passed into a horizontal brick machine, from which the mixture emerges as a cylindrical roll eight inches in diameter. This is cut into blocks 14 inches long, which are elevated to the top of a Vaughn & Taylor sewer-pipe press fitted with dies of the proper size and pattern for the product desired. As fast as taken from the press the wares are placed on double-deck iron cars, 280 of which are in use, and dried by steam in tunnel dryers. The kilns in which it is burned are ten in number, rectangular down-draft, each one holding 10,000 feet of six-inch partition. The output of the plant averages 60 tons a day of the finished product, and the drying and burning capacity is sufficient to take care of this amount. About nine days are required from the time the clay is taken from the pit until the finished material is ready to load on the cars. Sixty carloads a month are shipped to all parts of the United States; the value of the annual output being from $60,000 to $75,000. The products of this plant consist of wall partition or fire-proofing, from seven-eighths to twelve inches in thickness; floor arching, wall furring, column and girder covering, under-roofing to which slate or roofing tile can be nailed, and everything in the clay line that goes inside the walls of a fire-proof building. For the porous wall partition the following points of advantage are claimed:

1. It is a non-conductor of heat, cold and sound.

2. One coat of plaster, without studding or lath, finishes the partition.

3. It can be shaped with edge tools and holds nails and screws.

4. It can be put in place more rapidly and at less cost than brick.

5. Its cost to the consumer is only slightly greater than wood.

But three factories are at present making this porous partition in the States of Illinois and Indiana; one located at Pullman, Illinois, one (described in the present paper) at Brook, Indiana, and the one at Hobart. The demand is constantly increasing and the factory at Hobart made no stop during the panic of 1893-'95.

Just across the railway from the Owen factory is the Kulage Brick and Tile Works, where, for a number of years, large quantities of ordinary brick and drain tile have been made. In 1897 the owners began the erection of a large plant for the making of dry pressed brick.

From numerous experiments which have been made it has been found that by proper mixture high-grade dry-pressed brick of a number of different shades between a deep red and a handsome cream color can be made from the clays of the vicinity. A mixture of equal parts of the upper and the lower clays burns to a beautiful shade of pink.

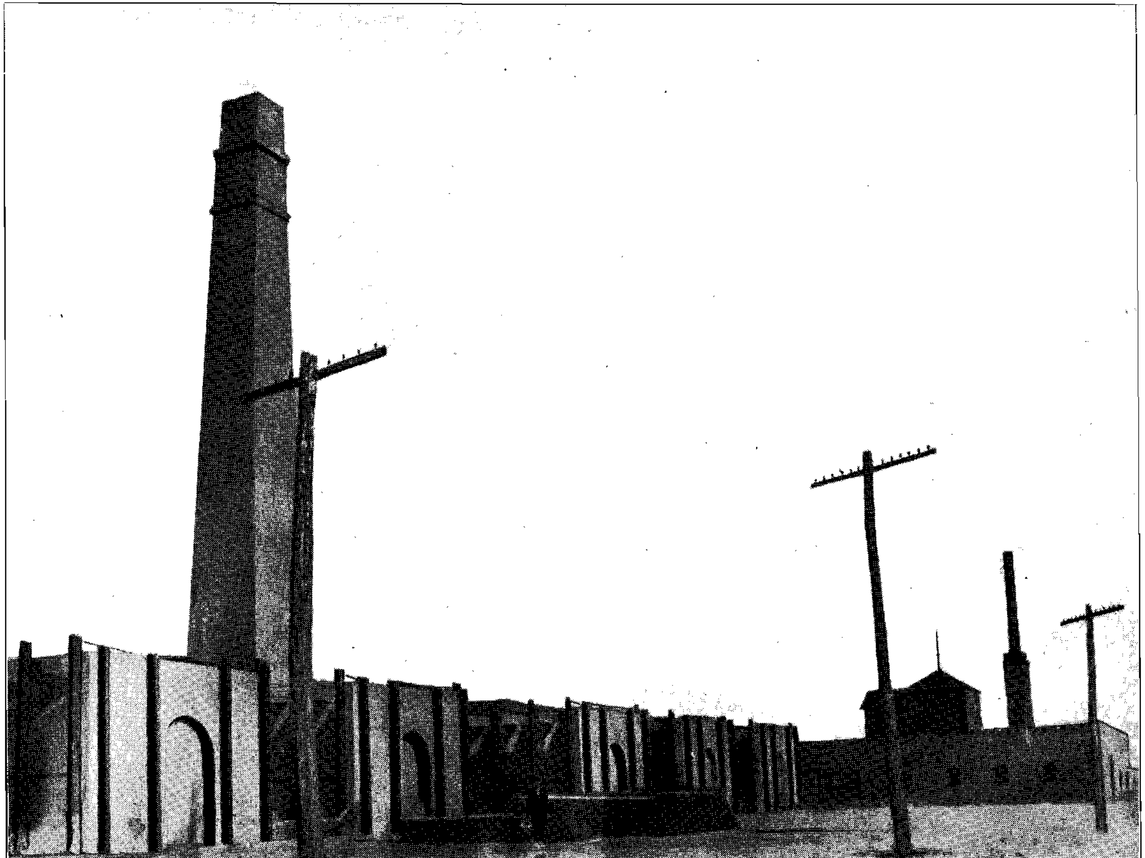
Five large, rectangular down-draft kilns, each 100 feet long by 20 wide, and holding 260,000 brick, were erected in 1897. These kilns were constructed of ordinary brick burned from the clays at hand, and were lined with Ottawa fire block. They were built according to the designs and inventions of the Kulage Company, and are probably the largest kilns of the down-draft type in existence, their combined capacity being nearly as great as that of a dozen down-draft kilns of the usual size. Each kiln is so constructed as to be operated separately and independently, or the entire set may be connected and used as a continuous system, thereby reducing materially the cost of burning. These kilns also admit the setting and burning of shaped, ornamental, glazed and enameled brick with the plain brick without interfering with the latter.

When in operation the clays will be ground in a nine-foot dry pan, passed over rotary screens and made into brick on presses designed and manufactured by the Kulage Company, of St. Louis, who are erecting the plant. Their presses are the "Challenge," of 25,000, and the "Triumph," of 35,000 daily capacity. The latter is a quadruple pressure machine, weighing 40,000 pounds, and it is claimed, gives a pressure three times as great as any secured on the ordinary pressed brick machine in use.

The section exposed in the Kulage Company's pit in July, 1897, was as follows:

Soil	4 to 6 inches.
Yellow marly clay	6 to 7.5 feet.
Bluish-gray marly clay	4 to 7 feet.

The blue clay has been proven by bores put down in a number of places on the land of the Kulage Company to be more than 90 feet in



KULAGE BRICK AND TILE WORKS, HOBART, IND.

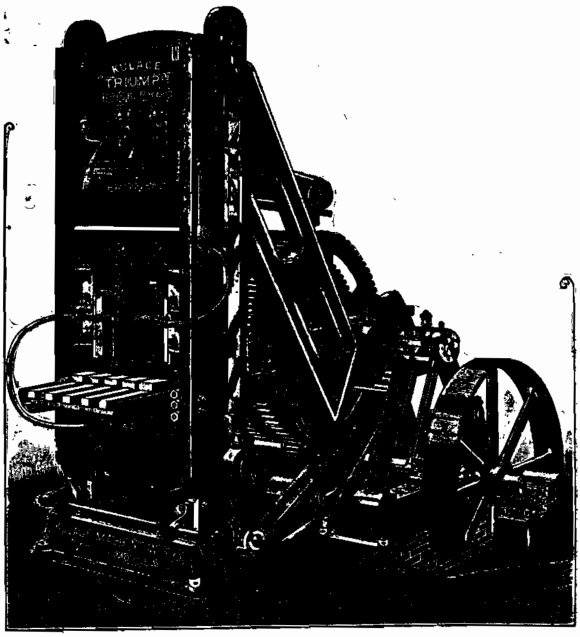


FIG. 10. TRIUMPH BRICK PRESS. (Front View.)

thickness. Its properties are essentially the same as those of the clay at the Owen pit above mentioned. It is found over a large area in sections 19, 20, 29 and 30 (36 north, 7 west), north of Hobart, and also south and east of that town, but in most places the stripping is so heavy as to prevent its utilization. In a well near the center of Hobart it was found to be overlain by 22 feet of sand. In the yard of J. A. Johnson, in the northwest quarter of section 20, seven feet of sand and six feet of yellow clay lie above it. Along Deep River it outcrops in a number of places, but usually in localities where it can not be utilized on account of the Spring overflows. Its constituents and properties are the same wherever found within the limits once occupied by the bay of Lake Chicago. This is shown by the chemical analyses, printed on succeeding pages of this paper, of samples taken at Garden City, Chesterton and near Michigan City.

THE CLAYS AND CLAY INDUSTRIES OF PORTER COUNTY.

The clays of Porter County, like those of Lake, are sedimentary in nature and belong to the two groups of "drift clays" and "marly clays." The drift clays are made into ordinary brick and drain tile at Hebron and Valparaiso, and the marly clays into pressed front brick at Porter, and ordinary brick at Garden City and Chesterton.

One-third of a mile west of Hebron the "Panhandle" Railway has exposed the drift clays to a depth of 14 feet. At this cut, in September, 1897, the following strata were disclosed:

1. Soil	16	inches.
2. Bluish "joint clay"	3	feet.
3. Hard yellow clay	7 to 10	feet.

The bluish clay immediately below the soil was broken into irregular four-sided masses two or three inches long and an inch thick. The yellow clay was a solid homogeneous body, with here and there a lime pebble or small bowlder embedded in its mass. Both clays effervesced freely with acids, showing the presence of a large percentage of lime carbonate.

In the south part of the town, H. Folsom has made brick from the upper clay for 28 years. The annual output is only enough to supply the local demand and varies between 100 and 500 thousand. Six inches of the surface are stripped and the remainder of it and two feet of the underlying clay are used; all below that containing too many lime pebbles. The brick are made on a "Quaker" machine, dried in an open yard and burned with wood in temporary or "scove" kilns. They sold, in 1897, at $5.50 per thousand at the yard.

One-half mile north of Hebron, Kenny Bros. have been making drain tile from a clay found in marshy ground near their plant. Six inches of the soil are removed and three feet of the tough, bluish, very plastic clay utilized. Sand and gravel set in at about three feet and prevent the use of the lower portion of the clay bed. After passing the clay through a crusher the tile are made on an "A. C. Hocket" machine, and are of excellent quality. The value of the annual output is but about $1,750.

In the south part of Valparaiso, Lambke Bros. are using the drift clay for making ordinary soft-mud brick and also a harder "sidewalk" brick for pavements and foundations. The clay used is obtained on a hillside and is quite free from pebbles to a depth of five feet, but below that distance they become more plentiful, and prevent its utilization. The clay is first passed through a disintegrator, then through a Williams pulverizer and over an oscillatory-inclined screen. It is then passed through a pug mill and a "Creager" machine, and the resulting brick are dried on pallets in open sheds. Two round downdraft kilns, each holding 43,000 brick, are used in burning the sidewalk brick, 600,000 of which were made in 1897, and sold at $6.75 per thousand. The building brick are burned in "scove" kilns of 280,000 capacity. Crude petroleum is used as fuel and costs at the plant $1.60 per hundred gallons. On account of the thorough preparation which the clay receives, the brick made are of excellent quality and find a ready market in Valparaiso at $5.50 per thousand, delivered. The annual output is about one million.

In the north part of Valparaiso, Coovert & Clevenger are making drain tile from clay which they obtain from a swamp, one-half mile northeast from their plant. It is the characteristic tough blue clay which underlies the mucky soil of the swamps of this region. Three and one-half feet are used after stripping four inches. The clay is passed through two crushers, and then through an "Ohio" auger machine. The resulting tile are air-dried in sheds and burned 48 hours with crude oil. It is claimed that this fuel burns the product more quickly, requires less labor and produces better ware than any other. The value of the annual output at this plant is about $3,000; the price for four-inch tile in 1897 being $14.00, and for ten-inch, $75.00 per thousand, at the yard.

At Garden City, two miles southeast of Hobart, on the line between Lake and Porter counties, a fine bed of marly clay occurs which was deposited at the same time and by the same agencies as the bed at Hobart. The P., F. W. & C. and the "Nickle Plate" railways, which here run side by side, are just south of this deposit, and a switch from the latter enters the yard of the factory which has been erected. At this factory ordinary stiff-mud brick have, in the past, been made in large quantities for the Chicago market. The plant has been well equipped for making these brick in large numbers, but, unfortunately, has been owned and managed by parties who were not practical brick men, and who, therefore, could not successfully carry on the business. As a result, it has been idle for a large part of the time during the past three years. At the pit the following section was exposed in August, 1897:

1.	Soil	8 inches.
2.	Reddish marly clay	4 feet.
3.	Buff sand	2 feet.
4.	Bluish-gray marly clay	6 feet.
5.	Bluish sand	2 feet.
6.	Bluish-gray clay, fine grained	20 feet.

A well on the yard has been sunk to a depth of 150 feet through the bluish clay, No. 6, to gravel, and an inexhaustible supply of good water obtained. With the exception of the sand strata, Nos. 3 and 5, this deposit is very similar to the one at Hobart. The blue clay is the same fine-grained, silty material, with a very similar chemical composition, as the following analysis, made by Noyes, will show:

ANALYSIS OF BLUISH GRAY CLAY AT GARDEN CITY, INDIANA.

		Per Cent.
Silica	50.37	
Titanium oxide	.65	
Alumina	9.93	
Combined water	1.50	
Clay-base and sand		62.45
Ferric oxide	2.10	
Ferrous oxide	2.05	
Lime	10.26	
Magnesia	6.26	
Potash	3.04	
Soda	.79	
Fluxes		24.50
Carbon dioxide	12.50	
		12.50
Total		99.45

The samples analyzed were taken from near the surface of the bluish clay. If they had been gotten from a greater depth, as was the one from Hobart, the percentage of alumina would doubtless have been larger, and that of some of the fluxes less. The clay will be found to be well suited for the making of the same products as are made by the Owen Company at Hobart. Experiments will also doubtless show its fitness for structural terra cotta of good quality, since its constituents are very similar to those of one of the clays used by the largest factory manufacturing that product in New York, the Glens Falls Terra Cotta Company. An analysis of their clay is added for comparison:

ANALYSIS OF TERRA COTTA CLAY AT GLENS FALLS, N. Y.

Silica	48.35 per cent.
Alumina	11.33 per cent.
Oxides of iron	4.02 per cent.
Lime	15.38 per cent.
Magnesia	3.17 per cent.
Organic matter	1.18 per cent.
Potash and soda	6.05 per cent.
Carbon dioxide	10.52 per cent.

The high amount of lime and magnesia in the bluish-gray clays at Hobart and Garden City causes them to produce a light-colored ware. A mixture of this clay with the red clay above produces a speckled, pinkish product, and the red clay alone a deep red product. A variety of different colored terra cotta can thus be made without the use of artificial coloring matter.

A new company has recently secured possession of the clay deposit and factory at Garden City and will make porous fire-proof products instead of brick. With a man who has a practical knowledge of the making of such wares in full control of the factory, there is little doubt of their ultimate success.

The same silty clays come near the surface in a number of places in the area formerly covered by the bay of the old glacial Lake Chicago, especially in sections 15, 22, 27 and 34 (36 north, 7 west), Portage Township, Porter County. They are at present at too great a distance from transportation facilities, but the time will come when their value for terra cotta and similar products will be better known, and to some of them railway switches will then be extended.

Near the junction of the Michigan Central and Lake Shore railways, at Porter, Indiana, is located the largest pressed front brick factory in the State. It is one of the several factories in different parts of the Union owned and operated by the Chicago Hyraulic Press Brick Company, and has been in operation since July, 1890. The clay used is a peculiar, fine-grained, buff material, entirely free from lime pebbles, and containing but a small percentage of lime carbonate as a constituent. It covers to a depth of six feet an area of 45 acres, owned by the company, in the northeast quarter of section 34 (37 north, 6 west), and is also the surface clay over quite an area in sections 27, 35 and 36, in the same township and range. Below it is usually found a bed of sand 25 or more feet in thickness.

In September, 1897, the clay was being gathered at the yard just north of the company's plant, and stored in sheds for winter use. A special harrow-shaped plow, designed and made at Findlay, Ohio, and propelled by a 12-horse-power traction engine, loosens the clay over an area six feet wide, to a depth of three inches. This plowing is done on a gradual slope, so as to get a uniform mixture of the clay and prevent uneven shrinkage in the brick. Ten rotary excavators, each holding enough clay for 300 bricks, follow the plow and gather up the clay. They convey it to the storage sheds, three in number, which, when full, hold enough to make seven millions of brick. From the sheds it is conveyed in carts and so dumped that it feeds itself between a set of steel rollers. These grind enough clay to make 24,500 brick every ten hours. After being ground the clay is elevated to the top of the building and passed through a disintegrator and two rotary or revolving screens. From the latter it descends into a perpendicular "mixer box" eight feet in diameter, where it is acted upon by revolving iron arms, and reduced to as nearly a homogeneous mass as possible. From the mixer it passes into a five-die hydraulic press of the Company's patent and make. This subjects it to a pressure of 2,750 pounds per square inch. Three such presses, each capable of making 24,500 brick daily, are in the plant, and connected with each of these is a set of steel rollers, disintegrators, screens, etc., as noted above. Besides these there is a press for making brick of special shape, which has but two dies and makes but 2,500 brick daily.

From the presses the brick are wheeled on trucks to the kilns. These are of the "Groves" pattern, and 14 in number, each holding 130,000 standard-sized brick. The kilns are so connected with one another and with a system of large exhausters or "blowers" that as soon as one is filled and hermetically sealed, the cold air which it contains is drawn off, and hot air from a freshly burned kiln rushes in to take its place. In this way much heat is used for drying which would otherwise be lost. After drying for one week the brick are burned, with crude oil as fuel, for an equal length of time. The oil burners used are an especial invention of Mr. Soper, the Superintendent of the company. Sixteen of them are used in each kiln, and it is claimed that they effect a great saving of the fuel. The advantages of oil as a fuel are well shown in such a large plant. A great saving of labor and time is effected, and a product free from dust, ashes, smut or discoloring matter of any kind is obtained. From the kilns the brick are taken to the stock room, 710 feet long, 33 feet wide and 14 feet high, where several millions of front brick of many colors, as well as large supplies of "special shape" brick, are kept constantly on hands. A double railway track runs through this room, so that the brick can be loaded from either side with ease.

Nine different shades of red brick are made and three of brown, the latter color being produced by mixing a salt of manganese with the clay as it enters the steel rollers to be crushed. About 100 different forms of "special shape" brick are made, one or two of which are sold as high as 65 cents each. The patterns or dies for each of these are owned by the company, and are kept in a separate fire-proof building. The amount of capital invested in the plant is about $300,000.

One-half a mile east of the pressed-brick factory, the Chicago Brick Company are making soft mud brick in large numbers for the Chicago and other markets. These brick are made from the same stratum of fine grained, buff clay as are the pressed brick. At the pit this clay is ten feet in thickness and overlies the same kind of blue, marly clay as occurs at Hobart and Garden City. The brick are made on a Martin machine at the rate of 35,000 daily for six months in the year. They are dried on pallets in sheds and are burned in permanent clamp kilns, of which seven, with a total capacity of 2,150,000, are in use. Wood is used for water-smoking and oil in burning, the two processes requiring twelve days.

One miles northeast of Chesterton, P. E. Anderson & Sons have been making brick and tile for ten years. For seven years the brick were made by hand, but since 1894 a Brewer brick and tile machine has been in use. A section of the pit at this yard is as follows:

1. Soil and surface—stripped........................ 6 inches.
2. Yellow coarse-grained clay...................... 5 feet.
3. Bluish marly clay with a few lime pebbles.......20 feet.
4. Bluish-gray marly clay, free from pebbles, pierced by bore ....35 feet.

The uppermost clay burns to a bright cherry red color, and makes a brick far above the average in quality. The next stratum, No. 3, burns pink and is mainly used in tile making. The lower stratum, No. 4, is very similar to the clay found at Hobart and burns to a cream color. An analysis of a mixture from strata Nos. 3 and 4 resulted as follows:

ANALYSIS OF BLUISH-GRAY CLAY AT CHESTERTON, INDIANA.

		Per Cent.
Silica	53.02	
Titanium oxide	1.30	
Alumina	10.72	
Combined water	2.21	
Clay-base and sand		67.25
Ferric oxide	2.54	
Ferrous oxide	2.22	
Lime	8.38	
Magnesia	5.28	
Potash	3.25	
Soda	.86	
Fluxes		22.53
Carbon dioxide	10.48	
		10.48
Total		100.26

The products made at this factory are dried in open air sheds and burned with wood. The brick are sold at the yard for $4.50 to $5.00 per thousand, and the four-inch tile at $11.00 per thousand. The clays are suited for the making of pressed front brick, terra cotta and fire-proofing. The blue marly clay is said to outcrop near City West in section 18 (37 north, 5 west), and also at the overhead bridge across the Michigan Central Railway one mile north of Chesterton.

THE CLAYS AND CLAY INDUSTRIES OF LAPORTE COUNTY.

Laporte County is in the third tier of counties from the western line of Indiana, and lies adjacent to the south border of the State of Michigan. Its northwestern corner is bordered by the shore of Lake Michigan for a distance of seven miles. The Kankakee River, flowing southwest, forms the larger portion of its southern boundary and receives from the county Mill Creek and several small tributaries. The area of the county is 562 square miles. Of this the northern third is somewhat broken and hilly and was formerly covered with timber. The central and southern portions contain about 200 square miles of fine prairie and a large area of Kankakee marsh land, much of which has been drained, and now forms excellent grazing and farming lands.

Numerous small lakes are scattered over the central or morainic portion of the county, and add much to the beauty of its scenery. The largest of these are Pine, Clear and Stone lakes, just northwest of Laporte, the county seat.

The limited time at my command allowed me to examine only the clays in the vicinity of Michigan City. Along Treaty Creek, northeast of that city, large deposits of an excellent bluish-gray marly clay come to the surface. Two miles east of the city Roeske Bros. have, a short distance from the creek, an extensive plant for the making of soft mud brick from a deposit of this and other clays. A section at their pit in September, 1897, showed as follows:

1. Soil	6	inches.
2. Buff sand	3½	feet.
3. Reddish "loam"	2	feet.
4. Yellow marly clay	2½	feet.
5. Bluish-gray clay	16	feet.

After stripping the soil and a portion of the sand, the remainder, down to No. 5 of the section, is used in making red brick. The "loam," No. 3, can be used for lining ladles, etc., in iron furnaces. The same material is shipped in quantity to Chicago from near McCool, Porter County.* The layer of bluish-gray clay has been pierced by a bore to the depth of 40 feet without reaching its bottom. It burns to a whitish or cream color, and two-thirds of the output of the factory

*See page 71 of this volume.

are from it alone. The deeper the point from which the clay is obtained, the stiffer and more tenacious it is, and the better the quality of brick made from it. The following analysis of this clay, made by Dr. Noyes, shows its constituents to be practically the same as the deposit so extensively worked at Hobart for fire-proof products:

ANALYSIS OF BLUISH-GRAY CLAY FROM MICHIGAN CITY, INDIANA.

		Per Cent.
Silica	50.47	
Titanium oxide	1.45	
Alumina	12.77	
Combined water	3.14	
Clay-base and sand		67.83
Ferric oxide	2.44	
Ferrous oxide	2.52	
Lime	8.17	
Magnesia	5.22	
Potash	3.70	
Soda	.73	
Fluxes		22.78
Carbon dioxide	9.80	
		9.80
Total		100.41

In the making of brick the clay, after being weathered for some time, is passed through a crusher, and then through a horizontal pug-mill, after which it is elevated by a belt-carrier to the top of a soft-mud machine. The brick are dried in sheds and burned in a peculiar "continuous" kiln. This kiln is divided into sixteen chambers, each capable of holding 16 to 17 thousand brick. After the fire is once started, the fuel, which is screened coal, is put in at the top of the chamber instead of at the bottom. Each chamber is connected by pipes with the ones adjacent to it, and the heat passes from chamber to chamber and "water-smokes" or dries the brick. In this way little heat is lost and the brick are burned for about 35 cents per thousand. Hocking Valley coal is used, costing $2.80 per ton at the plant, as it is claimed that Indiana coal is too dirty. Aside from their color, the brick made from the blue clay at this factory are of most excellent quality. When burned very hard they become a greenish cast and are then used for paving alleys, sidewalks, etc., and are sold at $8.00 per thousand, delivered. The ordinary quality bring $6.00 per thousand at Michigan City. Four and one-half millions of both grades were made in 1897.

As already noted, the same clay as is used by Roeske Bros., outcrops in quantity along Treaty Creek. The L. E. & W. Railway runs over some of the best deposits. There is thus room and excellent facilities for the erection in this vicinity of several large factories for the making of fire-proofing, terra cotta, pressed front brick and other products. Too high a percentage of fluxes are present for its utilization in making sewer pipe, paving brick and similar vitrified wares.

THE CLAYS AND CLAY INDUSTRIES OF ST. JOSEPH COUNTY.

St. Joseph County lies east of Laporte and is bounded on the north by the State of Michigan. It comprises an area of 477 square miles, the surface of which is diversified by prairies, marshes, "oak openings," and rolling timber lands. The "oak openings" are covered with a light sandy soil excellently suited to the raising of small fruits; the timberlands possess a subsoil of clay, covered with a rich dark soil, which under proper cultivation and rotation of crops, yields all the cereals in abundance. The prairies, both old and young—for the marshes are but incipient prairies—where properly drained, are unexcelled for the raising of any farm product except wheat, which in places winter-kills.

The Kankakee River rises about two miles southwest of South Bend, and flows in a southwesterly direction through the county. The most of the marsh land adjacent to it has been or is being drained. The St. Joseph River is the principal stream within the county; entering it a little north of the middle of the eastern boundary, flowing westerly about ten miles, and then northerly into the State of Michigan. On its great bend to the northward is the flourishing city of South Bend, possessing a population of almost 30,000, and noted for its manufactures, especially wagons and plows, which are shipped to all portions of the world.

The clays of St. Joseph County, which have been found the best suited for manufacturing, are in the immediate vicinity of South Bend. Along the St. Joseph River are thick deposits of a pearl-gray marly clay, exceedingly fine grained and plastic, which for many years has been made into light yellow building brick, or, when burned harder, into a darker, greenish-yellow paving brick. In the eastern part of the city, near the west bank of the river, C. Soens & Co., have been making these brick for a number of years. In October their pit was quite deep, and was partially filled with water, so that it was impossible to obtain a section of the most recently worked portion. On the western side the strata were as follows:

1. Soil	8	inches.
2. Sand, coarse-grained, reddish, impregnated and discolored with iron oxide	4½	feet.
3. Gravel	3	feet.
4. Sand—gray	3	feet.
5. Clay, bluish-gray	15	feet.

From this bluish-gray clay, which in places is 50 feet thick, the brick are made. The deposit was evidently laid down in still water since it is wholly free from pebbles. Aside from the heavy stripping, which is a great draw-back to securing it in proper quantity, the clay is well suited to the uses to which it is put. In places small pockets of so-called "quicksand" occur, which lessen to some extent its value. The lower half of the clay stratum is better suited for burning the hard brick used for paving purposes. The clay effervesces very freely with acids, and probably contains 10 to 15 per cent. of the carbonates of lime and magnesia.

In the making of the brick the clay is first passed through a Wallace crusher and pug-mill, then through a Penfield stiff-mud, plunger machine, with a Freese "side-cut" attachment. They are dried on pallets and burned in temporary kilns, with both wood and coal for fuel, the former for water-smoking. The burning of ordinary brick from this clay requires about six days after the water-smoking process is finished. If paving brick are desired, about 48 hours longer are necessary. When burned the shorter time the brick in a large kiln appear of four different shades. The three or four outside layers are pinkish red; the next four or five a darker red; the next six or eight are yellow, while those in the center of the kiln are greenish-yellow and are said to be "vitrified," though not to the extent as are the average paving brick made of shale. Besides being darker in color, the brick from the center of the kiln are much smaller, being but 2x3⅝x7⅝ inches, as against 2½x4x8½ inches, the size of the standard building brick from the outer layers.

The output of the Soen's yard is about 25,000 daily for 5½ months in the year. The building brick bring $5.25 and the paving brick $7.50 per thousand delivered in the city.

On the east side of the river, about one-half mile north of the Soen's yard is another large yard owned and operated by Leeper & Longley. Their clay pit is in the second bottom or terrace of the St. Joseph River, and a section exposed in October, 1897, was as follows:

1. Soil	8	inches.
2. Sand and "loam"	4	feet.
3. Coarse gravel	4½ to 7	feet.
4. Bluish-gray marly clay	18	feet.

The clay has been proven by bores to be 50 feet thick. Brick made by this firm in 1888 were used in paving two blocks of a street that has been much used for nine years, and shows as yet but few signs of wear. Round down-draft kilns have been tried in burning the pavers, but did not prove satisfactory. The output is mainly a cream-colored, side-cut, building brick, made on a Penfield plunger machine, dried in an open yard, and burned with wood. Oil has been tried as fuel, but the claim is made that it stained the brick and so lowered their price. This yard, in 1897, had an output of three million, most of which were sold in South Bend.

The blue clay used by these yards ranges from 30 to 50 feet in thickness. It evidently covers a large area, since it overlies a bed of gravel, from which is secured the water supply of the city. The clay forms an impervious cover for this water-bearing stratum, and when pierced the water rises from two to ten feet above the surface. At the site of the old "Water Works" in the eastern part of the city, 32 wells have been put down 112 feet deep. An average section of these wells is as follows:

1. Soil and sand	12 feet.
2. Blue clay	40 feet.
3. Sand	40 feet.
4. Gravel	20 feet.

At the new Water Station, on North Michigan Street, are thirty wells, the average section of which is:

1. Soil and sand	14 feet.
2. Gravel	3 feet.
3. Clay	30 feet.
4. Sand	22 feet.
5. Gravel	14 feet.

The brick made from this blue clay are hard, tough and durable. If the proper kilns and other facilities were erected, paving material of good quality could doubtless be made from it; but it is better suited for terra cotta, fire-proofing, flue linings and those numerous other products for which the ever increasing number of fire-proof buildings is creating a constantly growing demand.

About two miles southwest of South Bend are three factories which make soft-mud brick from a buff, porous, loamy "drift clay." This material, to a depth of four to seven feet, is free from carbonate of lime or lime pebbles, and burns to a handsome dark red. The brick made from it are hard, tough and durable, and above the average of those which go into the inner and side walls of buildings. The clay covers a large area in sections 21 and 22 (37 north, 2 east), being found on the surface of a ridge which rises 30 to 40 feet above the Kankakee marsh-land to the northward.

At the yard of Frank Fisher, in section 22, the clay used averages four feet in thickness and overlies a darker clay which contains pebbles of lime. Beneath the latter is the characteristic blue clay of the region. One-half mile southwestward, at the yard of John H. Shank, the porous buff clay is almost eight feet in thickness, and overlies a "hard pan" three feet in thickness, containing numerous pebbles. Beneath the latter is a bed of sand of unknown thickness. The three yards in this locality use soft-mud machines, dry on pallets and burn with wood. Their combined output in 1897 was about three millions, which were sold in South Bend at $5.50 per thousand. The buff clay is not suited for the making of drain tile, nor was I able to learn of any such tile being made in the county.

THE CLAYS OF JACKSON COUNTY.

At the earnest solicitation of Hon. Louis Schneck of Seymour, and several other gentlemen who were desirous, if possible, of locating a deposit of clay suitable for vitrified wares in Jackson County, I spent several days in the early part of July in an investigation of the clays along or within a few miles of the lines of the B. & O. S. W. and E. & R. railways, in that county. These lines of railway cross the county from east to west and pass through the only portion of it in which there is any likelihood of such clays being found close to the surface in commercial quantities.

Jackson County lies in the southern third of the State and about midway between its eastern and western borders. It comprises an area of 490 square miles. The East Fork of White River enters the county three miles west of its northeastern corner, and flowing southwesterly, divides its area into two triangular shaped districts, which are very unlike in their topography, and in the character of their soils. In the southeastern district the surface is mostly rolling, with low sandy hills 50 to 100 feet in height. The northwestern district is very broken, and is traversed by a number of ridges which rise from 250 to 300 feet above the plains of White River, and trend in a northeasterly and southwesterly direction. In places these spread out into broad table-lands, which possess a sub-soil of clay.

Few counties in the State can boast of better agricultural resources than Jackson. About three-fourths of its area is composed of table-land and river bottom and one-fourth clay land and sandy loam. No better crops of corn, oats and melons are produced in Indiana than are grown on the first and second bottom lands of White River west of Seymour; while the sandy loam soils of the southern part of the county are especially adapted to the raising of peaches and grapes.

The clays of Jackson County which are sufficient in quantity and of suitable quality for extensive manufacturing are the Knobstone shales which outcrop along White River southwest of Seymour and on the sides of a number of the ridges west and northwest of that city.

On the roadside, one-fourth mile east of White Creek, in the northwest quarter of section 32 (7 north, 5 east), is an outcrop of grayish soapstone or argillaceous shale, very fine grained, wholly free from grit, and, where weathered, very soft and plastic. It is overlain by a bowlder clay from three to ten feet in thickness, from which it is separated by a thin stratum of carbonate of iron. This shale deposit is about three miles north of the E. & R. Railway. There is no doubt but that it could be made into paving brick of excellent quality. It will also make pressed front brick, roofing tile and sewer pipe.

One-half mile farther west, in the northeast quarter of section 31 (7 north, 5 east), on the farm of Hon. L. Schneck, a brick and tile factory has been in operation since 1893. The brick are made from a buff loamy clay, evidently of glacial origin, the deposit of which covers 30 or more acres to a depth of 13 feet and overlies a stratum of sand, 12 feet in thickness. But five feet of the clay are used, since below that depth lime pebbles appear. These are not so many, however, but that they could be crushed with a dry-pan, and their harmful tendencies thus destroyed.

From this clay end-cut brick have been made on a Frey-Sheckler auger machine, which were used for paving alleys and street crossings in Seymour several years ago. They have since been subjected to much heavy traffic but show as yet no signs of wear.

A square down-draft kiln has been used in burning these brick and a handsome dark glaze was formed on their surface without the use of salt or other artificial substance. By mixing this surface clay with the above mentioned shale, one-half mile distant, in the proportion of two parts of the former to one of the latter, and then making the brick on a side-cut machine and burning in a standard round, down-draft kiln, there is little doubt but that paving brick of unexcelled quality would result. At present, however, the deposit is too far from transportation facilities and fuel to carry on the business on an extensive scale.

A deposit of true argillaceous shale, suitable for vitrified products, outcrops on the roadside in the southeast quarter of section 1 (6 north, 4 east), one mile west and two south of the brick factory above mentioned. It is ten feet in thickness where exposed and is overlain by bowlder clays.

West of the Station of Surprise, in the northwest quarter of section 9 (6 north, 4 east), there is an exposure of Waverly or "Knobstone" shale in a ravine a few rods south of the E. & R. Railway. This bed of shale covers a large area in the ridges to the south and is capped with a thin covering of soil, bowlder clay, iron carbonate and geodes. The exposure is 15 feet in thickness, but the total thickness of the deposit was not determinable. It weathers into a soft, plastic, grayish clay. One hundred yards farther west the same shale is cut to a depth of 17 feet by the railway and is overlain with three feet of a mixture of the materials above noted.

One mile a little south of west of the above exposure, and 150 yards south of the railway on the land of John W. Lucas, east one-half of section 7 (6 north, 4 east), a bold bluff of the Knobstone shale rises 40 or more feet above the water of Salt Creek at its base. In this bluff are four parallel layers of large concretions of ironstone (siderite). One of these layers was three feet above the surface of the water on July 10th, 1897. Six feet higher was a second; eight feet higher a third, and two feet higher the fourth. Some of these concretions were flat, several feet across, and six to ten inches thick. Between these layers of ironstone the shale weathers in small quadrangular blocks.

This "knobstone" shale is called "soapstone" by the residents in that vicinity. The term "soapstone" rightfully belongs to the mineral steatite or talc, a magnesium silicate which does not occur in Indiana. However, the term is applied, in most parts of the State, to a very soft, fine-grained argillaceous shale, which is unctuous or greasy to the touch. The Knobstone shales, if properly weathered and then ground fine, will be found in every way suited for making vitrified products. In the bluffs above mentioned, and in others farther down the stream in the same and adjacent sections, they are found in practically inexhaustible quantities. Their proximity to a railway and to a good supply of water cannot be excelled. The only thing lacking is a fuel supply, which can be readily and cheaply obtained from the coal regions to the westward through which the railway passes.

South of Freetown, in sections 18, 19 and 30 (6 north, 4 east), many outcrops of the Knobstone shale occur in the hillsides. In general they are overlain with layers of geodes and ironstone clays. The latter, when exposed for some years to rain and frost, weather into small, quadrangular, brownish pieces called "creek gravel." This is often used in repairing roads, since but little true drift or water-worn gravel is found in the region.

Taking into consideration its location, quantity and quality, the best deposit of shale in Jackson County for vitrified products is at a point called "Blue Lick" on the south side of the B. & O. S. W. Railway in the northeast quarter of section 6 (5 north, 5 east). The deposit is 50 or more feet thick, and consists of a soft, fine-grained, argillaceous variety of the Knobstone shale. It is wholly free from grit and lime impurities, contains but few concretions of ironstone, and weathers into a soft, unctuous, plastic clay. It outcrops along the ridge for a distance of several hundred yards and forms the main body of the ridge throughout its full width. The railway formerly ran at the very foot of the outcrop, but the shale weathered and fell down over the track to such an extent that the latter had to be moved several rods to the north. A railway switch can be put in with little expense, and cheap fuel can be obtained from the coal mines of Daviess and Knox counties.

Believing that this deposit of shale was in every way worthy of utilization for paving brick, I had a chemical analysis of it made by Dr. Noyes. The results of that analysis are here given side by side with those of an analysis, by the same chemist, of an average sample of the material used in the making of paving brick by the Wabash Clay Company of Veedersburg, Indiana, whose output is of excellent quality and the largest in the State.

ANALYSES OF SHALES FROM "BLUE LICK," JACKSON COUNTY, AND FROM VEEDERSBURG, FOUNTAIN COUNTY, INDIANA.

	BLUE LICK. Per Cent.		VEEDERSBURG. Per Cent.	
Silica	59.64		59.55	
Titanium oxide	1.05		1.00	
Alumina	19.14		16.21	
Combined water	4.36		5.62	
Clay-base and sand		84.19		82.38
Ferric oxide	3.39		2.18	
Ferrous oxide	4.20		7.13	
Lime	.26		.75	
Magnesia	2.31		1.58	
Potash	3.53		2.81	
Soda	.80		.28	
Fluxes		14.49		14.73
Carbon dioxide	.35		3.15	
		.35		3.15
Total		99.03		100.26

From these analyses it will be seen that the Blue Lick shale contains almost three per cent. more alumina, and is, for that reason, that much stronger and better than the one from Veedersburg.

In the report on the "Clays and Clay Industries of the Coal-bearing Counties of Indiana," published in the 20th Annual Report of this Department, the *average composition* of *the shales* used by *ten* of the leading paving brick and sewer pipe factories in Ohio was taken as a *standard of comparison* for the composition of Indiana shales suitable for vitrified products. That average showed the presence of

Clay-base and sand	84.78 per cent.
Fluxes	13.22 per cent.

By comparing with this average the composition of the "Blue Lick" shale as follows:

Clay-base and sand	84.19 per cent.
Fluxes	14.49 per cent.

we find a *very close* approximation to the standard of comparison and prove the chemical fitness of the shale for the making of paving brick and sewer pipe.

Edward Orton, Sr., in a paper on "The Clays of Ohio, Their Origin, Composition and Varieties,"* speaks of the division of the Waverly shales of that State which correspond to the Knobstone shale of Jackson County "as a great stratum 160 to 450 feet in thickness, consisting of light colored blue or gray shales that have unlimited possibilities of service in the practical way, but which have been almost completely ignored thus far. Their day, however, is sure to come. Their adaptation to paving block manufacture in particular will be recognized and it will be at once shown as soon as it is used that no better material for this purpose is found in our entire series than this shale can supply."

The use of brick for paving streets and roadways has as yet hardly begun in Indiana, yet, between 1890 and 1896, twenty-seven towns and cities (not including Indianapolis) of the State expended for paving brick and block alone $884,667, and for brick pavements $2,416,131. Of the sum expended for the pavers, no less than $647,022 were sent to the States of Ohio and West Virginia for brick, every one of which could have been made in Indiana and laid down at a handsome profit in the cities using them, for a less price than they were shipped in from other states.

At Seymour, several million brick have been brought from Ohio and laid down in the streets. These cost from $10.00 to $14.00 per thousand. The raw material for making them was to be found in abundance by the side of a railway within six miles of the spot where they were used. The extra amount paid for transportation of these brick would

*Geol. Surv. of Ohio, VII, 1893, 58.

have paid for a good plant for manufacturing them which, in the future, would have furnished labor for many hands. No paving brick factory exists at present in southern Indiana, except the one at Evansville. All the towns of that region of a thousand or more inhabitants, will within ten years, use brick for paving their leading streets. No cheaper or more durable pavement can be put down. All things considered, no better point exists for locating the factory to supply the brick for these future pavements, than at "Blue Lick," in Jackson County.

REMARKS ON THE CLAY ANALYSES.

The following analyses of clays were made especially for this report by Prof. W. A. Noyes, of the Rose Polytechnic Institute, of Terre Haute, Indiana. The analysis is, in each case, based on the substance dried at 135° C. The portions marked insoluble were found to be insoluble in acids and sodium carbonate.

No. 1. Average of the material used in the making of terra cotta lumber at Hobart, Lake Co., Indiana. See p. 128.

No. 2. Average sample of the upper portion of the bed of bluish-gray marly clay at Garden City, Porter Co., Indiana. See p. 133.

No. 3. Average sample of the bluish-gray marly clay from the pit of P. E. Anderson & Sons, Chesterton, Porter Co., Indiana. See p. 137.

No. 4. Average sample of the bluish-gray marly clay from the pit of Roeske Bros., Michigan City, Indiana. See p. 138.

Clays Nos. 1 to 4, inclusive, will be found in every way suitable for making terra cotta lumber, solid fire proofing, flue linings, foundation brick, under-roofing, column and girder covering, etc., etc.

No. 5. Average sample of Knobstone shale from "Blue Lick," Jackson Co., Indiana. Suitable for paving brick, sewer pipe, roofing tile and other vitrified products. See p. 146.

Chemical Analyses of Five of the Clays Mentioned in the Preceding Paper.

	1		2		3		4		5	
	Total.	Insol-uble.	Total.	Insol-uble.	Total.	Insol-uble.	Total.	Insol-uble.	Total.	Insol-uble.
Silica (SiO_2)	50.56	31.35	50.37	35.62	53.02	35.21	50.47	30.20	59.64	30.22
Titanium Oxide (TiO_2)	1.00		.65		1.30		1.45		1.05	
Alumina (Al_2O_3)	13.11	3.06	9.93	1.95	10.72	2.94	12.77	2.51	19.14	1.61
Combined water (H_2O)	2.76		1.50		2.21		3.14		4.36	
Clay-base and sand	67.43		62.45		67.25		67.83		84.19	
Ferric Oxide (Fe_2O_3)	2.98		2.10		2.54		2.44		3.39	
Ferrous Oxide (FeO)	2.32		2.05		2.22		2.52		4.20	
Lime (CaO)	7.87		10.26		8.38		8.17		.26	
Magnesia (MgO)	5.06	2.14	6.26	2.35	5.28	1.65	5.22	1.38	2.31	
Potash (K_2O)	3.74		3.04		3.25		3.70		3.53	.60
Soda (Na_2O)	.70		.79		.86		.73		.80	
Fluxes	22.67		24.50		22.53		22.78		14.49	
Carbon dioxide (CO_2)	9.62		12.50		10.48		9.80		.35	
Total	99.72	39.55	99.45	39.92	100.26	39.80	100.41	34.09	99.03	32.43

Rational Analyses of Above Clays.

	1		2		3		4		5	
Quartz	23.61		28.78		24.89		21.39		25.57	
Feldspathic detritus	15.94		11.14		14.91		12.70		6.86	
Calcium carbonate	14.05		18.32		14.86		14.59		.....	
Magnesium carbonate	6.54		8.48		7.60		6.42		0.67	
Clay substance	39.86		33.28		37.74		44.90		66.90	

Statistics of the Clay Industries of Northwestern Indiana.

Name of Firm or Individual.	Location.	Capital Invested.	Products.	Machinery Used.	How Dried.	Value of Output in 1897.	No. Hands Employed.	Av'ge Daily Wages.	No. Months Worked.
Fowler Tile Works.	Fowler.	$10,000	Drain tile.	Potts disintegrator and pug mill; Freese brick and tile machine.	In sheds with exhaust steam.	....	15	$1 45	7
Lochiel Tile Works.	Lochiel.	$7,000	Drain tile.	"Adrian" brick and tile machine.	Sheds by air.	....	13	$1 25	6
Earl Park Elevator and Tile Co.	Earl Park.	$20,000	Pressed brick, ordinary brick, and drain tile.	Potts disintegrator; 9-foot dry pan; "Little Wonder" brick and tile machine; Boyd & White brick machine.	On floors with steam.	$7,000	20	$1 25	7
John Lawson.	Oxford.	$5,000	Drain tile.	Frankfort crusher; Hoosier tile machine.	Sheds by air.	$3,500	4	$1 30	6
Wm. Lawson.	Otterbein.	$6,000	Drain tile.	"Little Wonder" brick and tile machine.	In sheds with steam.	$3,500	8	$1 30	7
Darroch Bros.	Morocco.	$3,000	Drain tile.	Crusher; pug mill, and "Little Wonder" brick and tile machine.	In sheds by air.	$1,500	8	$1 25	7
M. E. Handley.	Beaver City.	$4,000	Drain tile and brick.	Frankfort crusher; Hoosier brick and tile machine.	In sheds by air.	$2,150	9	$1 25	6
Stucker & Coovert.	Mt. Ayr.	$3,000	Drain tile.	Freese brick and tile machine.	In sheds by air.	$3,750	6	$1 25	6

J. H. Haynes Co.	Brook.	$16,000	Terra cotta lumber; flue lining; solid fire-proofing; drain tile; ordinary brick, etc.	Crusher; pug mill; Adrian brick and tile machine.	In sheds by air.	$15,000	16	$1 50	7½
Goodland Tile Co.	Goodland.	$5,000	Drain tile, hollow brick and ordinary brick.	Crusher, pug mill and Adrian brick and tile machine.	In sheds by air.	$3,000	12	$1 35	7
A. E. & H. A. Alter.	Rensselaer.	$4,000	Drain tile.	Potts disintegrator; New Departure tile machine.	In sheds by air.	$3,750	7	$1 25	7
John Kohler & Son.	Rensselaer.	$5,000	Ordinary brick and drain tile.	Freese tile machine; "Ander-Chief" brick machine.	In sheds by air.	$3,500	10	$1 25	7
A. C. Robinson.	Pleasant Grove.	$2,500	Drain tile.	Crusher, pug mill and "Little Wonder" brick and tile machine.	In sheds by air.	$2,880	7	$1 25	7
Samuel Bowman.	Remington.	$5,000	Drain tile.	Potts disintegrator; Adrian brick and tile machine.	In sheds by air.	$2,375	6	$1 25	7
P. D. Clark.	Lowell.	$5,000	Ordinary brick and drain tile.	Crusher and "Little Wonder" brick and tile machine.	In sheds by air.	$5,000	8	$1 25	6
H. W. Wise.	Crown Point.	$2,500	Common brick and drain tile.	Penfield brick and tile machine.	Open yard.	$2,500	9	$1 25	6
Hobart Terra Cotta Lumber Co.	Hobart.	$60,000	Terra cotta lumber; floor arching; wall furring, etc.	Pug mill; Adrian brick machine; Vaughn & Taylor sewer pipe press.	Tunnel dryers with steam.	$60,000	46	$1 37	12

Statistics of the Clay Industries of Northwestern Indiana.—Continued.

Name of Firm or Individual.	Location.	Capital Invested.	Products.	Machinery Used.	How Dried.	Value of Output in 1897.	No. Hands Employed.	Av'ge Daily Wages.	No. Months Worked.
Kulage Brick and Tile Works.	Hobart.	$100,000	Pressed front brick.	Nine-foot dry pan; two "Challenge" and one "Triumph" brick machines.	....	Plant not completed.	....	....	12
Garden City Brick Works.	Garden City Ind.	$30,000	Ordinary brick.	Crusher, pug mill and Chambers' stiff-mud, end-cut brick machine.	Tunnel dryers with steam.	$6,250	14	$1 30	4
H. Folsom.	Hebron.	$1,200	Ordinary brick.	Quaker brick machine	Open yard.	$600	4	$1 25	6
Kenny Bros.	Hebron.	$5,000	Drain tile.	Crusher, and A. C. Hocket tile machine.	Sheds by air.	$1,188	4	$1 25	6
Lambke Bros.	Valparaiso.	$8,000	Common brick.	Potts disintegrator; Williams pulverizer, and Creager soft-mud machine.	Sheds and pallets.	$7,500	20	$1 37	4
Coovert & Clevenger.	Valparaiso.	$2,500	Drain tile.	Two crushers; Ohio auger tile machine.	Sheds by air.	$3,000	5	$1 50	5
Chicago Hydraulic Press Brick Co.	Porter.	$300,000	Pressed front and special design brick.	Three crushers, three disintegrators, four hydraulic brick presses.	....	$175,000	75	$1 50	12
Chicago Brick Co.	Porter.	$15,000	Common brick.	Two pug mills, and Martin soft mud brick machine.	Sheds and pallets.	$25,000	35	$1 50	6

P. E. Anderson & Sons.	Chesterton.	$5,000	Common brick and drain tile.	Brewer brick and tile machine.	In sheds, by air.	$5,500	5	$1 40	6
Roeske Bros.	Michigan City.	$15,000	Common brick.	Crusher, pug mill, and Cramer soft mud machine.	Sheds and pallets.	$20,000	35	$1 37	6½
C. Soens & Co.	South Bend.	$8,000	Common brick.	Wallace crusher and pug mill; Penfield plunger, side-cut machine.	Sheds and pallets.	$12,000	22	$1 37	6½
Leeper & Longley.	South Bend.	$12,000	Common brick.	Pug mill; Penfield No. 10 plunger machine.	Open yard.	$17,000	30	$1 50	6
Frank Fisher.	South Bend.	$4,000	Common brick.	"Anderson Chief" soft mud machine.	Sheds and pallets.	$5,500	9	$1 50	6
Edw. Perkins.	South Bend.	$2,500	Common brick.	Quaker machine.	Sheds and pallets.	$3,000	7	$1 50	4
Jno. H. Shank.	South Bend.	$6,000	Common brick.	Quaker machine.	Sheds and pallets.	$7,500	14	$1 50	6
Elmer F. Hoover.	LaPorte.	$2,000	Common brick.	Hand made.	Open yard.	$3,200	10	$1 40	4

THE PETROLEUM INDUSTRY IN INDIANA IN 1897.

BY W. S. BLATCHLEY.

With the exception of a small output in Vigo County, all the petroleum produced in Indiana is yielded by the Trenton limestone of the Lower Silurian formation. The main field is very probably a continuation westward of that of Lima, Ohio, though as yet the connecting area between the two has not been located. This field, comprising about 400 square miles, lies northeast of the center of the State, in portions of Adams, Jay, Wells, Blackford, Grant and Huntington counties. Outside of this area, oil in commercial quantities was being produced on January 1st, 1898, near Peru, Miami County; Walton, Cass County; Rich Valley, Wabash County; Alexandria, Madison County; Washington Township, Delaware County, and Broad Ripple, Marion County. All of these minor productive pools were located in 1897, except the one at Broad Ripple, where one or two bores produced oil the year before. As predicted in my former reports, the main field is thus slowly but surely extending its borders to the south and west, and will eventually cover all, or the greater portion of the area now producing natural gas.

Location of Oil Producing Areas.

The petroleum of the Trenton limestone was formed in that rock many thousands of years ago, by the slow decomposition or destructive distillation of myriads of animals and plants which existed in the Silurian seas at the time the sediment of which the limestone was formed was being deposited. Those animals and plants were buried in vast numbers in that sediment, and by the waters above and the ooze around them shut off from the free oxygen of the air, and the decay ordinarily undergone by dead organisms was thereby prevented. It is a well known fact that if wood, coal or the body of any animal be placed in an air-tight retort and heated, a distillation will occur, and the object will be changed to gaseous, oily and solid matters. In the absence of heat a very long period of time will bring about the same results. By this is meant the process of "slow destructive distillation" above mentioned.

Origin of Petroleum.

The Trenton limestone, when first formed, was a pure calcium carbonate, or carbonate of lime. In the course of time certain areas of the sea bottom, covered with the lime carbonate, were slowly raised until they became higher than the others, and formed shallow basins, lagoons or bays. Some of these raised portions covered very large areas. Others were isolated or separated from the main area sometimes by a distance of 20 to 30 miles. The outline of all was irregular, with many indentations along the margins. In these more shallow portions of the Silurian seas the water became in time very briny and

Formation of Porous Layers in Trenton Limestone

caused a chemical change in the rock. To the lime carbonate was added some magnesia from the brine, and a magnesia-lime carbonate called "dolomite" resulted. Wherever this change took place—which was only in the shallow, briny areas noted—the resulting dolomite was porous. This porous condition was due to the fact that the new crystals of dolomite were smaller than, and never entirely filled the spaces occupied by, the older crystals of lime carbonate.

Trenton limestone underlies the whole State of Indiana at depths varying from 348 feet below the surface at Lawrenceburg to 1,933 feet below at Auburn and 2,300 feet below at Evansville. Only a small

Trenton Limestone in Indiana.

proportion of this underlying Trenton was ever changed into dolomite or porous rock, and only in the porous areas are gas and oil found. There is absolutely no method of telling where the limestone is porous and where it is not, except by putting down a bore.

The Trenton in Indiana varies in known thickness from 470 to 586 feet, and the porous portion is found only near its upper part. It is useless to drill into it more than 70 feet, since, of the eight thousand and more bores which have been put down in the State no oil or gas has been found below that depth.

The surface of the Trenton limestone is not level as many people suppose, but is a series of alternating arches and depressions or ridges and valleys. The arches or domes are like inverted troughs and vary much in width and area, as do also the depressions between them.

Wherever gas and oil occur they will be found in a porous stratum in one of the arches or anticlines as they are called. If a bore happens

Oil in Arches or Anticlines.

to be put down and strikes a depression or syncline between the arches, salt water will invariably be found. If both gas and oil are present in a certain area, and the bore strikes the flank or side of the arch, oil will result. If the bore strikes the crest or dome of the arch, gas will flow. The cause of this is simple, being due to the arrangement of the three fluids according to their relative weights—the lighter gas having in the past risen to the highest portion of the porous limestone; the oil, being heavier than gas and lighter than water, having been stored in the intermediate and the heavier salt water in the lower level. The volume of gas and oil accumulated in any field, will depend, therefore, upon the area and height of the anticline, and upon the relative thickness and degree of porosity of the dolomitic portion of the Trenton limestone.

Where a bore for petroleum has resulted in a good producing well, the level of the surface of the Trenton rock below tide should be carefully ascertained. This can be done only by running a transit level from the nearest point where the surface level is known, usually on a railway, to the surface of the bore. By subtracting the surface level of the bore from the depth at which Trenton limestone is first struck, the surface level of the latter will be obtained. In but few places in the State is Trenton found above sea level. Where so found the depth to Trenton will be less than the surface level of the bore, and should be subtracted accordingly.

Necessity of Accurate Surface Levels.

The location of the first dozen or more wells in any area a mile or two square must of necessity be largely a matter of guess-work, but if the surface level of the Trenton in each bore, productive or dry, be carefully ascertained, the trend of the anticline and the approximate limits of the field or pool can be soon determined. Too much guess-work concerning the surface level of the spot on which the well is located has been done in the past. In a broken country it is difficult for any man to guess approximately at the relative levels of two points a quarter of a mile apart, and the new level should always be ascertained with instruments. Of course the surface level of the bore has nothing to do with the absolute height or surface level of the Trenton, or the absence or presence of the petroleum, but it has a great deal to do with the accurate *determination* of the surface level of the Trenton and therefore with the location of future wells. If a few thousand dollars had been spent in Indiana in past days in the careful determination of surface levels, it would have saved a few hundred thousand which have been sunk in dry holes.

At the main points at which petroleum is produced in Indiana, the surface level of the Trenton lies below sea level as follows:

Alexandria	45 feet.
Broad Ripple	105 feet.
Geneva	164 feet.
Keystone	128 feet.
Montpelier	107 feet.
Peru	210 feet.
Rich Valley	208 feet.
Van Buren	138 feet.
Walton, Cass Co	171 feet.

A fallacy which is possessed by many would-be operators is, that oil fields or pools run in lines, and that one field is connected with all others, the oil flowing from one to the other, through a continuous strip of porous rock. This may in part be true in the Pennsylvania oil regions, but it is wholly untrue in the Trenton limestone area of Ohio and Indiana. While all the so-called "pools" of that area are found in the Trenton formation, they are not necessarily connected, nor do they run in lines. A pool may be of any shape, and may lie in any direction from any other pool. Its boundaries may be straight or sinuous; its area one square yard or one thousand square miles. If the conditions necessary for the storing of petroleum, namely a porous reservoir, located in a dome or anticline of the Trenton limestone, with an impervious cover above it and a water pressure below it, have been present in the past, the oil will very likely be found, whatever the shape, size or relative location as to other similar reservoirs. The operator can only sink his drill; he has no way of knowing before-hand what the result will be. He may pierce the center of the reservoir and get a 500-barrel well; he may strike near its outer rim and get a ten-barrel well—he may miss it altogether and get a dry hole. One thing he can rely upon if he strikes a productive well, and that is, that he is drawing upon a stored product which is not now being formed in the rock from which it is drawn, and that, therefore, he must eventually exhaust the stock from the immediate vicinity of his bore.

Pools Not Necessarily Connected.

More or less salt water is found in all portions of the main field. A difference of only six to ten feet in elevation or depression of the surface of the Trenton defines oil and salt-water territory. Some of the best wells pump a large amount of salt water with the oil. The water seems to keep the pores of the oil rock free from paraffine and other clogging materials, and a well producing four to ten barrels of water a day is preferred by many operators to one that produces oil alone.

Salt Water in Indiana Field

Throughout the Indiana field an eight or ten inch drive pipe is forced down through the drift to the Niagara limestone. The salt water usually found in the Niagara is cased off by an iron tube 5⅝ or 6¼ inches in diameter, which reaches to the soft blue Hudson River limestone underlying the Niagara. This second limestone and the Utica shale beneath it contain no water. The Trenton is everywhere overlain with the soft, dark colored Utica shale which forms an impervious cover through which neither gas nor oil can escape. From the bottom of this shale the drill passes at once into hard limestone. In the main

The Indiana Field Cheaply Operated.

field the first "pay streak" is found at from 15 to 25 feet in the Trenton; and usually a "second pay" 10 to 12 feet lower down. A few feet below the second porous stratum salt water is usually found. The driller aims to go as near this as he can without tapping the stratum in which it occurs.

For a number of reasons a lease in the Indiana field can be operated as cheaply as any in the eastern United States. Chief among these are the following:

(a) The wells are comparatively shallow, the Trenton limestone in most instances being struck at less than 1,000 feet. (b) It is seldom that more than 150 feet of drive pipe and 400 feet of casing are necessary. (c) On account of a comparatively level surface a large number of wells can be connected to and pumped with one power. (d) Gas for fuel or for running gas engines is usually plentiful. (e) Transportation facilities are excellent, a system of pipe lines permeating all parts of the main field.

But few extensions of any importance were made in the main Indiana oil field in 1897. The prevailing low price of petroleum prevented operations in territory which had been fairly well tested. The "wildcatters" gave most of their attention to the pools at Alexandria and Peru, where they hoped to strike something better than the main field promised. Moreover, all of the most promising prospective territory within or near the lines shown on last season's map was under

New Developments in the Main Field.

lease, and the operators only aimed to protect property lines, leaving active drilling for the future when the price of the product shall have raised. In Jay County some good wells were drilled in the south half of section 7, the northeast quarter of section 8 and the north half of section 18 (24 north, 13 east), in territory which had not before been tested.

The Diamond Oil Company has had remarkable success with its lease on the A. H. Myers farm in section 30 (24 north, 12 east), Harrison Township, Blackford County. Of three wells put down in 1896 and nine in 1897, all have been good producers, starting out from 60 to 300 barrels per day. Their total production for the year was 75,000 barrels on the 184 acres, proving it one of the best leases in the main field. The Trenton is found at depths varying from 934 to 972 feet. Numerous bores have been put down on all sides of this lease, but they have for the most part proven dry holes or small producers.

No developments of importance were made in Adams County. In Wells County several good wells were located on the W. Pouless farm, in section 6, Jackson Township, which had before been undrilled. It is estimated by a conservative operator that the old wells of the county have had an average decline of 40 per cent. in output within the year.

In Grant County the only new developments have been in the north halves of sections 2 and 3, Van Buren Township, where some fair wells were completed by the Ziegler Oil Company.

In Huntington County a number of good wells were completed in the southwest corner of Jefferson Township, but the lines of the productive area were unchanged. Sections 27 to 34, inclusive, in Salamonie Township, will doubtless be found to be paying territory in the future—though one or two test bores have developed only salt water.

STATISTICS OF THE OIL INDUSTRY IN INDIANA.

The following table gives the production of petroleum in the United States from 1859 to 1896, inclusive, together with the average yearly prices per barrel:

Production of Crude Petroleum in the United States from 1859 to 1896 (Barrels).

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	Total United States.	Average Yearly Prices per Barrel.
1859	2,000	...	...	...	...	...	...	...	...	...	...	...	...	2,000	...
1860	500,000	...	...	...	...	...	...	...	...	...	...	...	...	500,000	$9 59
1861	2,113,609	...	...	...	...	...	...	...	...	...	...	...	...	2,113,609	49
1862	3,056,690	...	...	...	...	...	...	...	...	...	...	...	...	a3,056,690	1 05
1863	2,611,309	...	...	...	...	...	...	...	...	...	...	...	...	2,611,309	3 15
1864	2,116,109	...	...	...	...	...	...	...	...	...	...	...	...	2,116,109	8 06
1865	2,497,700	...	...	...	...	...	...	...	...	...	...	...	...	2,497,700	6 59
1866	3,597,700	...	...	...	...	...	...	...	...	...	...	...	...	3,597,700	3 74
1867	3,347,300	...	...	...	...	...	...	...	...	...	...	...	...	3,347,300	2 41
1868	3,646,117	...	...	...	...	...	...	...	...	...	...	...	...	3,646,117	3 62½
1869	4,215,000	...	...	...	...	...	...	...	...	...	...	...	...	4,215,000	5 63¾
1870	5,260,745	...	...	...	...	...	...	...	...	...	...	...	...	5,260,745	3 86
1871	5,205,234	...	...	...	...	...	...	...	...	...	...	...	...	5,205,234	4 34
1872	6,293,194	...	...	...	...	...	...	...	...	...	...	...	...	6,293,194	3 64
1873	9,893,786	...	...	...	...	...	...	...	...	...	...	...	...	9,893,786	1 87
1874	10,926,945	...	...	...	...	...	...	...	...	...	...	...	...	10,926,945	1 15
1875	8,787,514	b200,000	b3,000,000	...	b175,000	...	...	...	...	...	...	...	...	b12,162,514	1 36
1876	8,968,906	31,763	120,000	...	12,000	...	...	...	...	...	...	...	...	9,132,669	2 56¼
1877	13,135,475	29,888	172,000	...	13,000	...	...	...	...	...	...	...	...	13,350,363	2 42
1878	15,163,462	38,179	180,000	...	15,227	...	...	...	...	...	...	...	...	15,396,868	1 19
1879	19,685,176	29,112	180,000	...	19,858	...	...	...	...	...	...	...	...	19,914,146	85⅞
1880	26,027,631	38,940	179,000	...	40,552	...	...	...	...	...	...	...	...	26,286,123	94½
1881	27,376,509	33,867	151,000	...	99,862	...	...	...	...	...	...	...	...	27,661,238	85⅞
1882	30,053,500	39,761	128,000	...	128,636	...	c160,933	...	...	...	...	...	...	30,510,830	78⅙
1883	23,128,389	47,632	126,000	...	142,857	...	4,755	...	...	...	...	...	...	23,449,633	1 05¾
1884	23,772,209	90,081	90,000	...	262,000	...	4,148	...	...	...	...	...	...	24,218,438	83½
1885	20,776,041	650,000	91,000	...	325,000	...	5,164	...	...	...	...	...	...	21,847,205	87⅞
1886	25,798,000	1,782,970	102,000	...	377,145	...	4,726	...	...	...	...	...	...	28,064,841	71¼
1887	22,356,193	5,018,015	145,000	76,295	678,572	...	4,791	...	...	...	...	...	...	28,278,866	66¾
1888	16,488,668	10,010,868	119,448	297,612	690,333	...	5,096	...	...	...	...	...	...	27,612,025	87⅝
1889	21,487,435	12,471,466	544,113	316,476	303,220	33,375	5,400	1,460	500	48	20	...	...	35,163,513	94⅛
1890	28,458,208	16,124,656	492,578	368,842	307,360	63,496	6,000	...	1,200	54	278	...	...	45,822,672	86¾
1891	33,009,236	17,740,301	2,406,218	665,482	323,600	136,634	9,000	...	1,400	54	25	30	...	54,291,980	67
1892	28,422,377	16,362,921	3,810,086	824,000	385,049	698,068	6,500	...	...	45	10	80	...	50,509,136	55⅝
1893	20,314,513	16,249,769	8,445,412	594,390	470,179	2,335,293	3,000	...	...	50	50	10	...	48,412,666	64
1894	19,019,990	16,792,154	8,587,624	515,746	705,969	3,688,666	1,500	300	40,000	60	8	130	2,369	49,344,516	72
1895	19,144,390	19,545,233	8,120,125	529,482	1,208,482	4,386,132	1,500	200	44,340	50	10	37	3,455	52,983,526	1 09
1896	20,584,421	23,941,169	10,019,770	361,450	1,252,777	4,680,732	1,680	250	113,571	1,460	43	170	2,878	60,960,361	96
Total	537,241,681	157,284,942	47,199,374	4,458,525	7,936,678	16,022,396	224,193	2,210	201,101	1,811	444	457	8,702	770,582,514	...

a In addition to this amount, it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee. *b* Including all production prior to 1876 in Ohio, West Virginia and California. *c* This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

11—GEOL.

From the above table it will be learned that the production of petroleum in Indiana gradually increased from 33,375 barrels in 1889, when the wells at Terre Haute first began yielding, to 4,680,732 barrels in 1896. In 1897, the production, for the first time, fell below that of the preceding year, the loss being 327,594 barrels, or very nearly 7 per cent. This decrease was mainly due to the prevailing low price of the product, which brought about an inactivity in drilling. As already noted, the production of the old wells in the main field fell off about one-third, and the total production for the year would have been much less had it not been for the new developments at Peru, Alexandria and other points.

In the following table is shown the total production in Indiana by months from 1891 to 1897, inclusive. The largest production in any one month is seen to have been in July, 1895, when 434,376 barrels were produced.

TOTAL PRODUCTION OF PETROLEUM IN INDIANA FROM 1891 TO 1897, BY MONTHS.

[Barrels.]

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	6,171	15.841	111,824	259,000	300,568	365,582	290,746
February	5,981	18,946	96,025	232,107	230,559	341,743	309,922
March	5,159	24,794	134,549	282,376	310,303	386,586	341,961
April	4,973	26,184	146,493	287,330	352,077	395,032	328,779
May	5,757	31,033	186,939	321,502	397,001	417,963	340,023
June	8,136	40,888	209,616	333,479	403,569	434,167	369,803
July	10,809	49,203	221,666	327,349	434,376	422,968	375,249
August	11,603	56,109	248,353	345,031	420,132	407,238	371,921
September	16,500	66,034	245 615	319,588	409,169	415,675	362,528
October	19,029	95,699	252,568	339,424	393,153	394,283	408,179
November	20,801	129,270	245,607	304,030	373,789	337,331	430,958
December	21,715	144,067	236,038	337,450	361,436	362,164	423,069
Total	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138

It will be noted that the production in each of the winter months is less than in those of spring or summer. This is usually the case, there being, during the cold season, fewer wells drilled in and a smaller yield from those already finished. The shipments are greater than the production in winter and the price usually rises a few cents per barrel.

In the following table will be found a statement of the production of petroleum in Indiana from 1889 to 1897, inclusive:

PRODUCTION OF PETROLEUM IN INDIANA FROM 1889 TO 1897.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Total production (barrels of 42 gallons)	33,375	63,496	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138
Total value at wells of all oils produced, excluding pipage ..	$10,881	$32,462	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411	$1,871,849
Value per barrel...........	$0.32⅝	$0.51½	$0.40	$0.37	$0.45	$0.48	$0.64	$0.63	$0.43

From the following table may be learned the number of wells put down in Indiana for oil in any month since June, 1891:

NUMBER OF WELLS COMPLETED IN THE INDIANA OIL FIELDS FROM 1891 TO 1897, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apl.	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	151	113	121	70	57	66	66	1,180
1897........	41	35	40	47	49	52	61	45	55	89	117	54	685
Total													5,223

This table shows that there was less activity in oil operations in Indiana in 1897 than during any year since 1893. On January 1st, 1898, there were 3,648 wells producing oil in the State, so that 1,575 of those completed had either proven dry holes or had ceased to yield oil in sufficient quantity to pay for pumping.

The following table gives the

TOTAL NUMBER OF DRY HOLES DRILLED IN INDIANA OIL FIELDS FROM 1891 TO 1897, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891........	......	......	......	......	......	......	0	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

From the following table may be learned the

NUMBER OF PRODUCING WELLS AND NUMBER OF DRY HOLES DRILLED IN EACH OF THE OIL PRODUCING COUNTIES OF INDIANA IN 1897.

COUNTY.	Producing Wells.	Dry Holes.	Total.
Wells	161	20	181
Blackford	47	23	70
Jay	34	19	53
Adams	29	13	42
Grant	43	1	44
Huntington	29	1	30
Madison	32	34	66
Miami	166	12	178
Marion	11	5	16
Delaware	3	2	5
Total	555	130	685
Total, 1896	1,022	158	1,180
Decrease	467	28	495

One feature of the oil industry which has come into common use, and which should be abandoned, is that of giving the initial output of a well rather than its settled production after 30 or 60 days. Because a well starts out at 100 or 250 barrels a day is no sign that its total production will be a large one. In general it may be said that a 50-barrel well will be down to ten barrels in two months, and to five barrels in a year. A well that has an initial production of 50 barrels is a fair average well for the entire Indiana field, the average production of which is about 3.7 barrels per well per day. A well that starts off at 150 to 250 barrels gets down to the average in time, the only difference being that the oil bearing stratum which the bore has pierced is a little more porous than in the one yielding 50 barrels.

The following table shows the

INITIAL DAILY PRODUCTION OF NEW WELLS IN THE INDIANA OIL FIELDS FROM 1891 TO 1897, BY MONTHS.

[Barrels.]

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	....	342	1,020	2,361	2,132	1,557	730
February	....	250	913	2,935	1,413	1,875	1,000
March	....	289	2,805	3,395	2,504	2,090	1,000
April	....	316	4,135	3,175	3,473	2,825	800
May	....	505	3,155	4,450	3,035	3.149	1,295
June	....	545	5,595	4,886	4,923	3,115	900
July	253	595	3,880	3,530	3,067	2,332	1,780
August	135	1,295	4,184	3,435	2 760	2,650	850
September	875	2,145	2,055	3,149	3,175	1,700	2,010
October	330	4,155	3,442	3,455	2,651	1,515	4,080
November	390	3,050	2,305	3,323	2,560	1,400	3,790
December	175	3,160	2,968	2,654	2,025	1,100	1,045
Average	360	1,387	3,038	3,396	2,810	2,109	1,607

THE ALEXANDRIA OIL FIELD.

On April 23d, 1897, a bore put down on the N. Carver farm, northeast quarter of section 17 (21 north, 8 east), two miles northeast of Alexandria, Madison County, developed a large amount of petroleum. It was a wild-cat bore put down by the Northern Lima Oil Company, and when first drilled in showed but little signs of oil. The Trenton limestone was struck at 890 feet and was pierced 100 feet, the drill passing through two streaks of porous rock with 28 feet of hard, nonporous material between them. The showing of oil was enough to cause the company to shoot the well on the date mentioned, when it at once began to flow about 250 barrels per day. Owing to a lack of tankage and pipe line facilities much of the first week's flow was wasted, but the Buckeye Pipe Line soon made connection with their loading rack at Alexandria, and took care of the product.

The drilling in of such a well awakened the lethargy which for a number of months had enthralled the oil operators throughout the Lima—Indiana field, and hundreds of them flocked to Alexandria and sought leases in the prospective territory. A number of bores were soon started, nine of which were completed in May. Of these, three yielded gas only, and the remaining six had a combined initial output of but 245 barrels of petroleum.

One of these wells, located on the Decker farm, about 20 rods west of the Carver well, showed but a trace of oil, but gave off a large amount of gas which for a time was allowed to escape. This opened up the great question of the waste of gas from oil wells, which has since been the subject of much contention between oil operators and the consumers of natural gas. This question is fully discussed by the State Gas Supervisor, Mr. J. C. Leach, in another part of the present volume.

In June, 11 additional wells were drilled in, but three of which yielded oil, and the remainder gas. One of the oil wells was located on the S. M. Peck farm, in the southwest quarter of section 23 (21 north, 8 east), about two and one-half miles southeast of the Carver well. It started out at 100 barrels, and on September 25th was producing about 60 barrels of oil and wasting 2,000,000 cubic feet of gas daily. Four bores have since been drilled on the same farm, one of which started at 25 barrels and another at 30, the other two being dry.

A second one of the wells, which was finished in June, created much excitement, for the reason of its location within the corporate limits of Alexandria, on a lot in the Hillside Addition. It had an initial output of 50 barrels daily, but by mid-September was down to 10 barrels and a small flow of gas. This immediately started a town lot boom in that section of the city and a number of wells were drilled in, the most productive of which, known as the Stillwell No. 1, was finished July 1st, starting at 150 barrels, with a large accompanying waste of gas.

During July 12 bores were completed in the Alexandria field, five of which were dry. The seven producing wells had an initial output of 605 barrels, 400 of which were yielded by a single well on the W. P. Blake farm, east half of northwest quarter of section 16 (21 north, 8 east). This was one-third mile east of the Carver No. 1, and was the best well drilled near Alexandria in 1897. The Trenton limestone was found at 918 feet. Four other bores on the same lease started at 150, 125, 10 and 100 barrels, respectively. The first two wells soon began to yield large quantities of salt water, and by September 25th the No. 1 was producing 65 barrels of oil and wasting 1,000,000 cubic feet of gas daily.

Bores which were dry or yielded gas only were drilled on the W. P. Perry farm, one mile northwest of Alexandria, where the Trenton was found at 880 feet below the surface; also on the M. E. Tomlinson farm, one mile north; on the Wm. Carver farm, one mile west; on the Sharp farm, four miles southwest; on the Mary Nicson farm, one mile southwest, and on the Thomas Baxter farm, two and a half miles southeast, of Alexandria. Two bores, which furnished gas only, were also sunk on the Rosebaum and Vincent farms, near Summitville. These non-productive bores stopped the growth of the field to the north, west and south. With the exception of three or four, all bores sunk within the limits of the town yielded much gas and little oil, and but eight of them produced oil at all. Several bores which were put down between these town-lot wells and the Blake-Carver pool proved dry, and developments in the former locality came to a close.

During August and September 23 bores were finished, ten of which were dry, and the 13 producing had a combined output of only 425 barrels. The interest of operators was about this time transferred to the field at Peru, and during the last three months of the year but little drilling was done, and this only east and northeast of the original Carver well. This well, by September 25th, was yielding gas only, and a second bore put down on the same lease in December proved dry.

While the results in the Alexandria field have, up to the present, proven unsatisfactory, there is little doubt but that in the future its limits will be extended to the northeast, until it is connected with the main Indiana field. It would be far better, however, to postpone drilling within the limits of the gas-producing territory until the supply of gas has been practically exhausted. The oil can be held in store and will not be wasted while the gas is being drawn off. It is worse than folly to waste the one while trying to secure the other. Wherever the two are found in conjunction, separators should be used and the gas piped to some main where it can be utilized. Such separators are on the market and their utility has been proven. Laws should be enacted giving the Gas Supervisor the right to shut off all wells where either of the two products is being wasted. By such means only can these two fuels be properly conserved and made to be of the greatest and most lasting utility to the people of the State.

The following are the statistics of the Alexandria field to January 1st, 1898. They were in part furnished by Mr. Leach, who has been actively engaged since June 1st in trying to shut off the waste of gas:

STATISTICS OF THE ALEXANDRIA OIL FIELD FOR 1897.

	Wells Drilled.	*Dry Holes or Gas Wells.*	*Production by Months.*
April	1	0	678 barrels.
May	8	3	1,171 barrels.
June	11	8	2,053 barrels.
July	12	5	6,487 barrels.
August	11	3	16,528 barrels.
September	12	7	11,072 barrels.
October	6	4	11,970 barrels.
November	3	2	10,326 barrels.
December	3	2	11,482 barrels.
Total	67	34	71,767 barrels.

Wells drilled for oil in Madison County in 1897	67
Wells that have produced oil in commercial quantities	29
Wells that produce gas in commercial quantities	35
Dry holes	3
Wells producing oil January 1, 1898	21
Wells allowing escape of gas January 1, 1898	17
Am't of gas wasting daily, Jan. 1 (estimate)	20,000,000 cubic ft.
Daily oil production, Jan. 1	400 barrels.
Average production per well, Jan. 1	18 barrels.

Seven miles northeast of Alexandria, in section 36 (22 north, 8 east), Washington Township, Delaware County, several bores were put down in the fall of 1897, two of which yielded oil in commercial quantities. The first of these, on the Wm. Broyles farm, struck the Trenton limestone at 940 feet, the first pay streak at 1,010 and the second at 1,045 feet. The well was not shot, and started with a flow of 50 barrels. The second, on the Robert Livingston farm, three-quarters of a mile southwest, started at 150 barrels, after striking the Trenton at 937 feet. On the first of January Mr. Leach reported that the two wells were producing daily 125 barrels of oil and 3,000,000 cubic feet of gas; the latter being allowed to escape. On the Karus farm, near Matthews, five miles northeast of the Broyles well, a bore put down in December resulted in a dry hole; as did also one on the Vickery farm, a mile east of the Broyles well.

THE PERU OIL FIELD.

The greatest development of the Petroleum Industry in Indiana in 1897 was in the immediate vicinity of Peru, Miami County, about 35 miles northwest of the western end of the main field. Two hundred and twenty-nine wells were put down in this new field between August 15th and January 1st, and of these 178 have proven productive of petroleum in commercial quantities.

It had long been supposed that Peru lay outside of both the oil and gas areas of the State. This supposition was based on the fact that three wells were put down in the vicinity of that city in 1888—all of which yielded salt water, and but one of which showed signs of oil. The first of these was located on the E. A. Bearss land in the southeast quarter of the northeast quarter of section 28 (27 north, 4 east), in the north part of the city, and less than one-third of a mile due east of some of the most productive wells of the present season. The record of that well as given by S. S. Gorby* was as follows:

Alluvium—river drift	36 feet.
Niagara limestone	385 feet.
Hudson River and Utica	454 feet.
Top of Trenton	875 feet.
Total depth	905 feet.
Surface above sea level	657 feet.
Top of Trenton below sea level	218 feet.

In this well a small quantity of oil was found five feet below the top of the Trenton, and at 25 feet in Trenton salt water in abundance was struck.

The second bore was put down on the J. F. Miller farm in the southeast quarter of section 34 (27 north, 4 east)—south of the Wabash River and about one and three-quarter miles southeast of well No. 1. Its surface was 700 feet above sea level, and Trenton was struck at a depth of 929 feet, or 229 feet below sea level, showing a

*16th Ann. Rep. Geol. Surv., Ind., 1888, 184.

descent of 11 feet in the surface of the Trenton between the two wells. This, alone, was sufficient to show that oil would not be found in that direction south of the river, yet a number of bores were sunk the present season to try to prove the contrary.

A third bore was put down on the John Younce farm near the center of section 21 (26 north, 5 east), Butler Township. The Trenton was found at a depth of 960 feet, but the surface level was not determined, hence the record is of little value. A small quantity of gas was found at 970, and salt water, which filled the bore, at 1,000 feet.

The fourth and last well, until those of 1897, was located on the farm of A. C. Bearss in the southwest quarter of section 16 (27 north, 4 east), about three miles north of the center of Peru. The section at this well was as follows:

Drift	324 feet.
Niagara limestone	379 feet.
Hudson River and Utica shale	307 feet.
Top of Trenton	1010 feet.
Total depth	1041 feet.
Surface above sea level	757 feet.
Top of Trenton below sea level	253 feet.

This showed a decline of 35 feet in the level of the Trenton between wells No. 1 and No. 4, and should have proven the futility of farther boring in this direction.

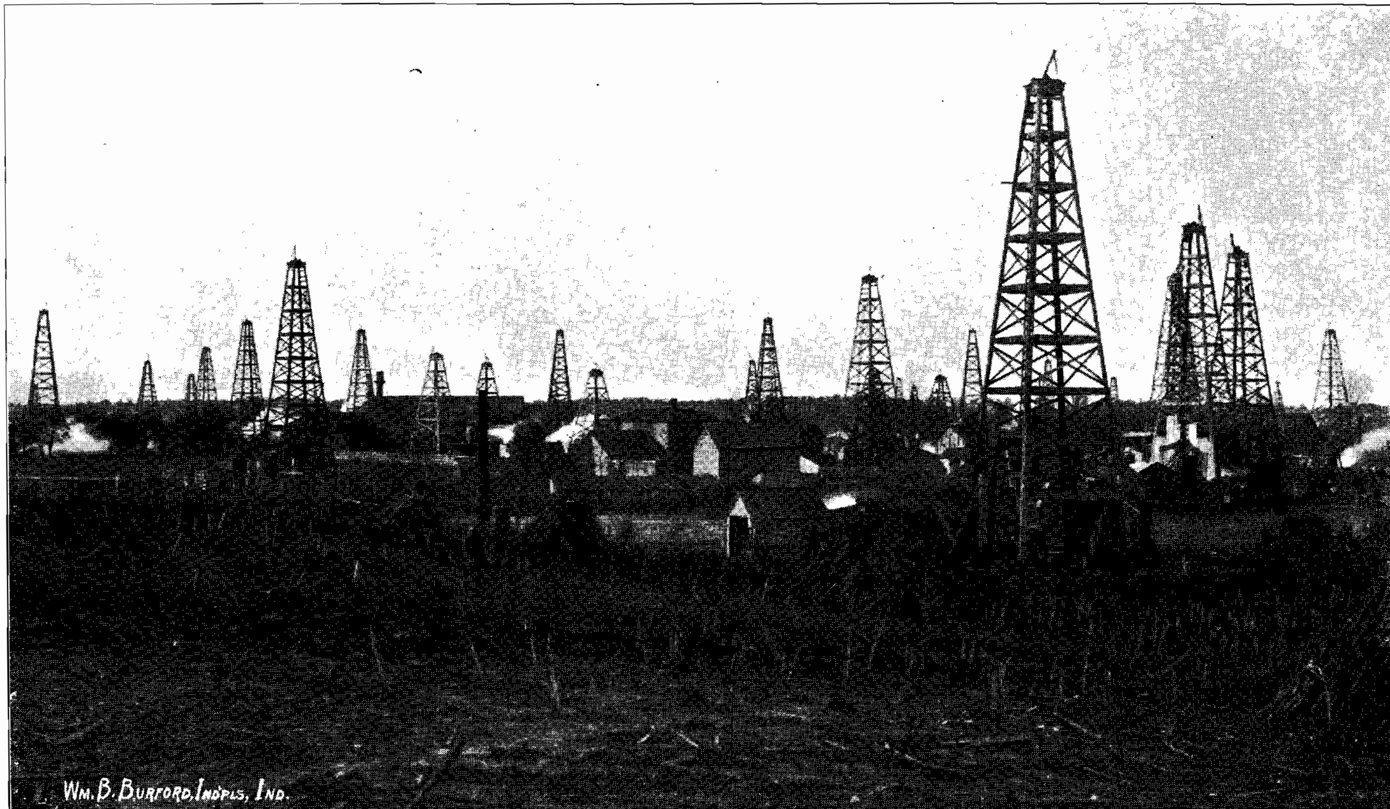
No farther search was made for gas or oil until the spring of 1897, when 100 citizens of Peru organized the "People's Oil and Gas Company." Ten dollars each was subscribed and a bore put down on the B. E. Wallace farm south of the Wabash and just east of the Mississinewa River. No surface level was taken and no accurate record was kept of the well. No one seems to know the depth at which Trenton was struck, which was on June 29th. The bore proved a dry hole, and the contractor agreeing to drill another for $500, the members of the company put up $5 each and the second well was put down in the northwestern part of Peru, on a triangular piece of ground about one-third mile a little south of west of the first bore put down in 1888. This land belongs to W. N. Dukes, and lies just north of the Wabash Railway in the southeast quarter of section 28 (27 north, 4 east). The surface of this well was about 657 feet above sea level, and the top of the Trenton was reached on July 19th, at 855 feet, or 198 below sea level, showing a rise of 20 feet in one-third mile, providing the measurements were correctly made. Oil was found a few feet in the Trenton, and the well filled to the top and flowed a small but steady stream through the casing, yielding about 12 barrels per day for three weeks. The well was then tubed and pumped and began yielding 120 barrels a day, which it kept up for a month or more. As this was the first oil ever found in the county it created no little excitement, and the company immediately began the sinking of two more wells on the same 16-acre lease. A number of new companies were organized, one of which, the Runyan Co., began sinking a well 400 feet east of the Dukes No. 1. These three wells were completed about the same date, September 10th.

In the Dukes No. 2, 350 feet southwest of No. 1, Trenton was struck at 844½, and when penetrated but three feet the bore filled with oil and overflowed faster than the product could be taken care of in barrels. The bore was finally sunk 25 feet in Trenton and tubed, and the well began yielding 175 barrels daily. The Dukes, No. 3, found the Trenton at 848½ and was sunk 21 feet deeper. It started at 150 barrels. The Runyan well pierced the Trenton at 859½ feet, and started with a yield of 140 barrels.

The opening of three new wells, each with an excellent yield, started an oil craze which ran riot through the town. Every citizen who could raise five or ten dollars joined an oil company, and most of the land within five miles of the city which could be leased at all was soon under contract. Old oil operators from the main field and from Alexandria flocked to Peru in droves, but found little choice territory unleased. Royalties of as high as one-fourth were asked and given, and it is even claimed that an over-sanguine farmer refused $3,000 bonus and one-third royalty on a farm which was supposed to be near the heart of the field. Some of the newcomers secured the right of way along the Wabash and L. E. & W. railways, and derricks began to go up on all sides of the little triangular tract known as "the Dukes lease."

By the 25th of September more than 30 rigs were up and wells drilling within one-fifth of a mile of the four producing wells. Town lots were leased and square feet, rather than acres, were contracted for. The local operators, who knew little of the oil business, thought that all that was necessary was room enough to set up a rig and a boiler. Fancy prices were paid for town lots, and as the new wells began to come in as fine producers the craze grew apace, and stock which had cost the owners five to twenty dollars sold for $250 to $1,000, with more eager to buy than there were to sell.

Just north of the Dukes lease the surface rises about 50 feet and forms what is known as Hospital Hill. A number of the wells put down in the first half of October were located on this hill east of Dukes street, and all of them came in with handsome yields. The



A PORTION OF HOSPITAL HILL, PERU INDIANA, DECEMBER 1, 1897, SHOWING OIL DERRICKS ON TOWN LOTS.

best of these, and probably the best well in the entire field, was put down by the Crescent Co. on the Artis lot. A record of this well as kept by the superintendent of the company shows the strata pierced to be as follows:

Drift	20 feet.
Niagara limestone	375 feet.
Hudson River shales and limestone	255 feet.
Utica shale	248 feet.
Top of Trenton at	898 feet.
Total depth	933 feet.

This well was drilled in October 22nd, and produced 400 barrels of oil a day for four days. The production then dropped gradually to 100 barrels, which it was making November 12th, when three weeks old. An experienced operator from Findlay, Ohio, concluded that a well on an adjacent lot would produce as much. Normally the lot was worth $200, but he paid $1,500 for it and put down a well which started at 30 barrels daily.

On ten acres of land owned by the Peru Bagging Co., a short distance from the Artis well, six wells were put down which struck the Trenton at an average depth of 902 feet, and had an initial production of about 75 barrels each. The accompanying plate shows a portion of Hospital Hill as it appeared on December 1st, 1897, the bagging mill with its surrounding derricks being just to the left of the center of the view.

North of the Bagging Co.'s plant several fair wells have been drilled on the R. B. Runyan land; but two put down by the Ohio Oil Co. on the Rachael Zern farm, west half of southwest quarter of section 21 (27 north, 4 east), have yielded much salt water and but 20 to 25 barrels of petroleum.

Progress eastward was stopped by two bores, one a small producer, which was soon abandoned, on the E. A. Beares land, about one-third mile east of the People's No. 1 and 500 feet west of the first well drilled in the county in 1888; the other a bore in North Peru (Godfrey Reservation No. 12), which found the Trenton rock at 867 feet, but proved barren.

South of the Wabash Railway, between Grant Street and the Peru Driving Park, a large number of good wells were put down in October and November by the Klondike, Peru and People's oil companies. In this region the Trenton rock was found between 850 and 860 feet, showing its surface to be from 200 to 215 feet below sea level.

South of the Wabash River a number of bores were put down, the location of each being given in the list which follows, not one of which found more than a mere trace of oil. On the T. Riley farm, just north of the Driving Park, a well which never produced more than ten barrels daily stopped the growth of the field in that direction; while several dry holes farther northwest served to mark more definitely its boundaries.

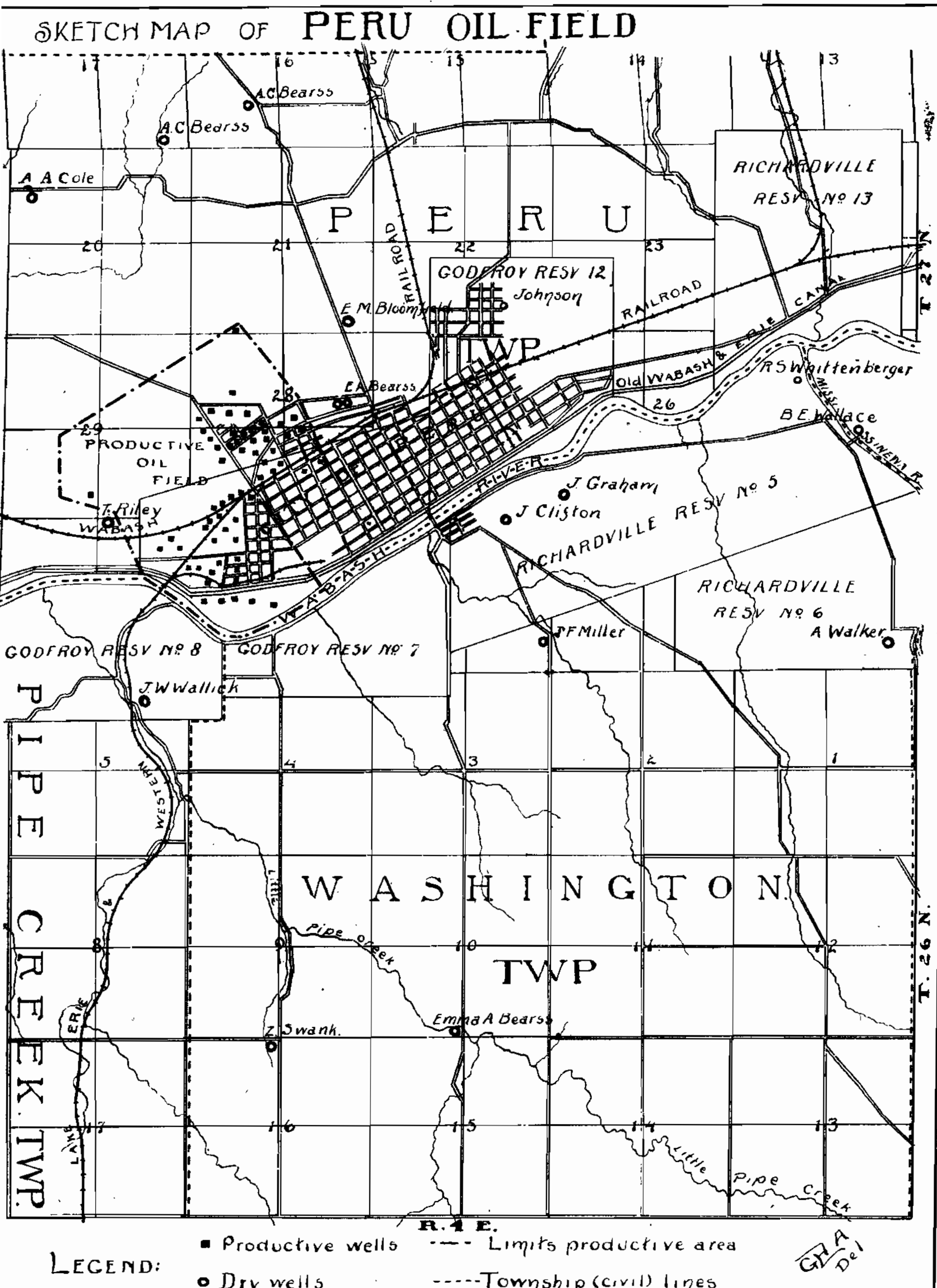
By the first of December the limits of the territory producing oil in paying quantities were fairly well defined, as shown on the accompanying map, and active operations greatly decreased, since all the inside territory was under lease. The number of wells finished in November was 88, 38 more than in October. At the close of the month but 22 wells were being drilled, and in December but 28 were finished, none of which were non-productive.

A list of the dry holes put down in Miami and adjoining counties which served to mark the boundaries of the Peru field is here given.

A LIST OF NON-PRODUCTIVE BORES FOR PETROLEUM IN MIAMI AND ADJOINING COUNTIES.*

	Owners of Land. — *Location.*	*Depth to Trenton Limestone.*	*Approximate Depth of Surface of Trenton Below Sea Level.*
1.	E. A. Bearss—Southeast quarter of northeast quarter of section 28 (27 north, 4 east), Peru Township	875	218
2.	J. F. Miller—Southeast quarter of section 34 (27 north, 4 east), Washington Township	929	229
3.	Jno. Younce—Northeast quarter of southwest quarter of section 21 (26 north, 5 east), Butler Township	960	200
4.	A. C. Bearss—Southwest quarter of section 16 (27 north, 4 east), Peru Township	1010	253
5.	B. E. Wallace—Northwest corner Godfrey Reserve No. 9, Butler Township	? 870	?200
6.	E. A. Bearss—500 feet west of No. 1, Peru Township	870	213
7.	B. A. Blair—Southeast quarter of southeast quarter of section 19 (27 north, 4 east), Peru Township	884	224
8.	E. M. Bloomfield—Southeast quarter of southeast quarter of section 21 (27 north, 4 east), Peru Township	866	206
9.	—— Johnson—East part of North Peru, Godfrey Reserve No. 12, Peru Township	867	207
10.	A. A. Cole—Northwest quarter of section 20 (27 north, 4 east), Peru Township	870	200
11.	Sarah Myers—Southwest quarter of section 18 (27 north, 4 east), Peru Township	920	267

*Much of the data for this list was gathered and kindly furnished for this report by Messrs. Masterman and Chenvront, of Peru.


SKETCH MAP OF PERU OIL FIELD
A.C Bearss
A.C Bearss
A A Cole
P E R U
TWP
RAILROAD
GODFROY RESV 12
Johnson
E M Bloomfield
RICHARDVILLE
RESV Nº 13
RAILROAD
CANAL
Old WABASH & ERIE
R S Whittenberger
B E Wallace
MISSISSINEWA R
E A Bearss
PRODUCTIVE
OIL
FIELD
T. Riley
WABASH
RIVER
J Graham
J Clifton
RICHARDVILLE RESV Nº 5
RICHARDVILLE
RICHARDVILLE
RESV Nº 6
A Walker
P F Miller
WABASH
GODFROY RESV Nº 8
GODFROY RESV Nº 7
J W Wallick
PIPE CREEK TWP.
WESTERN
W A S H I N G T O N
TWP
Pipe Creek
Little
Emma A Bearss
Z Swank
ERIE
LAKE
Little Pipe Creek
T. 27 N.
T. 26 N.
R. 4 E.
LEGEND:
Productive wells
Dry wells
Limits productive area
Township (civil) lines
GHA Del

12. A. C. Bearss—Southeast quarter of section 17 (27 north, 4 east), Peru Township	932	285
13. T. Riley—Just north of Peru Driving Park, Peru Township	875	220
14. J. W. Wallick—East half of Godfrey Reserve No. 8, Pipe Creek Township	907	252
15. G. A. Shuman—Northeast quarter Lablonda Reserve, Pipe Creek Township	871	246
16. J. Graham—Northwest quarter of Richardville Reserve No. 5, Washington Township	902	242
17. J. Clifton—Northwest quarter of Richardville Reserve No. 5, Washington Township	904	244
18. Anthony Walker—East half of Richardville Reserve No. 6, Washington Township	983	228
19. R. S. Whittenberger—Northeast quarter Richardville Reserve No. 5, Washington Township	879	204
20. C. C. Enswiler—North part of Richardville Reserve No. 5, Washington Township	895	220
21. Z. Swank—Northeast quarter of northwest quarter of section 16 (26 north, 4 east), Washington Township	1020	265
22. Emma A. Bearss—Southeast quarter of southwest quarter of section 10 (26 north, 4 east), Washington Township	1006	236
23. S. Thorn—Santa Fe well, Southeast quarter of section 32 (26 north, 5 east), Butler Township	932	215
24. —— North half of section 32 (26 north, 4 east), Bunker Hill well, Pipe Creek Township	992	161
25. Bennett's Station—On L. E. & W. R. R., 15 miles south of Peru	1009	167
26. —— Williams—One mile south of Waverly, Cass County	982	225
27. R. R. Depot—Southeast quarter of section 21 (27 north, 3 east), Waverly well No. 1	1000	
28. —— Davis—Northwest quarter of section 31 (26 north, 3 east), Walton, Cass County	1012	172
29. J. B. Crook—Near Hoover's Crossing, Cass County	1046	346
30. N. Stroud—Northeast quarter of section 6 (27 north, 4 east), Mexico well	998	325
31. ——North half of section 16 (28 north, 4 east), Denver well	1004	329
32. C. C. Mikesell—Southeast quarter section 7 (26 north, 6 east), Waltz Township, Wabash County	945	220
33. E. J. Williams—One mile south of Keller's Station, Wabash County	879	199
34. Andrews well—Near Wabash Railway	938	209
35. Lutz farm—2½ miles north of Wabash, Wabash Co.	1057	284

Up to January 1st, 1898, the only producing wells in the Peru field outside of the area as defined were two in number. One of these was located just north of Keller's or Rich Valley, a station on the

Wabash Railway nine miles east of Peru, and the other on the west side of the village of Walton, Tipton Township, Cass County. The Rich Valley well is on the farm of W. A. Jackson in the southwest quarter of the northwest quarter of section 13 (27 north, 5 east). A record of this well obtained and kindly furnished by Mr. J. E. Chenvront, of Peru, is as follows:

Drive pipe	None.
Casing	450 feet.
Trenton struck at	883 feet.
Total depth	907 feet.
Surface above sea level	675 feet.
Top of Trenton below sea level	208 feet.

Initial production, 35 barrels.

The surface of the Trenton was found at about the same level as in many of the fair producing wells at Peru. In general it may be said that in western Wabash and Miami counties, where the Trenton lies lower than 215 feet below tide, a dry hole or salt-water well will almost invariably result. Whether the Rich Valley strike will develop a pool or an eastward extension of the Peru field only the work of the drill will disclose.

Lying as it does between the western end of the main field and the development at Peru it strengthens the belief that the two are connected. If the connection be not continuous there doubtless exist many small, isolated pools or islands of porous Trenton between the two fields. These islands occupy the sites of lagoons which existed shortly after the time the Trenton was laid down and furnished the conditions favorable for the chemical changes which brought about the porosity of the oil-bearing portions of the Trenton limestone. Therefore, at present the best field for the wild-catter, in the writer's opinion, lies southeast of Rich Valley between that town and Van Buren, Grant County.

The Walton well was sunk on the land of J. Baumgardner, northeast quarter of section 36 (26 north, 2 east), about one-third of a mile west of where a dry hole had been previously drilled.* The Trenton was pierced at 1,011 feet below the surface, and its elevation was therefore about 171 feet below sea level. The drill was sunk 13 feet in Trenton, when the oil rose to within 200 feet of the top of the bore. The well had an initial output of about 35 barrels, and is probably near the outer border of an isolated island of porous rock, or so-called "pool" of petroleum.

*See No. 28 in the table of non-productive bores.

The cost of production in the Peru field is somewhat less than in that of the main Indiana field, especially if the operator owns his own string of tools. The wells are, on an average, 125 feet less in depth. The drift is in general much more shallow and the amount of drive pipe required therefore less. The Niagara limestone is more shelly and broken, and on that account more easily drilled. Between 400 and 425 feet from the surface there is a "break" in the limestone of 20 to 40 feet, which is occupied by a layer of shale. It is customary to case through this break and through eight to fifteen feet of limestone lying below it, which contains a brackish water. The average amount of casing in the Peru field is, therefore, about 450 feet.

The first "pay streak" is found close to the surface of the Trenton, instead of 18 to 30 feet in, as in the main field. In most cases there appears to be but one stratum of porous rock, though in some of the wells where the Trenton is high there are two, the second being about 25 feet in the limestone. In numerous wells there is found below the first pay streak a fine-grained whitish sand, which packs so tightly in the bottom of the bailer that it is difficult to dump. Where two pay streaks are present this sand occupies from two to five feet of the interval between them.

The dolomite or oil-bearing portion of the Trenton is 12 to 20 feet in thickness, darker and much more porous than that in the main field. A piece at hand weighing seven pounds is literally honeycombed with pores plainly visible to the naked eye. It has numerous cavities, the size of a hickory nut or smaller, opening on the surface, which are lined with small rhombohedric crystals of dolomite, so that the cavity resembles, on a small scale, that of the inside of a geode. Intermingled with these crystals are numerous small cubical crystals of pyrites or iron sulphide. These crystals of pyrites are also characteristic of the porous Trenton of the Broad Ripple field, and it is there claimed that only where they occur in numbers is petroleum found in paying quantities.

On account of the porosity of the oil-bearing rock and its proximity to the top of the Trenton but few wells in the Peru field were shot with nitro-glycerine. There was too much danger of shattering the overlying Utica shale and so causing it to fill up the bore into the porous reservoir, or of flooding the well with salt water from the underlying water-bearing portion of the Trenton. A saving of from $75 to $150 in cost was effected by omitting the shooting.

The great porosity of the oil-bearing stratum accounts for the richness of the pool, each pore being simply a small reservoir where a stock of petroleum has been stored for thousands of years. With 200 pumps constantly drawing on this stock within an area of a mile and a half square it is no wonder that the output gradually lessens, and unless the pool is larger than it now seems the stock will soon be exhausted. No gas is found with the oil, and it is forced upward in the bore or to the surface by water pressure alone. As the stock of oil lessens the water is slowly rising and in time will fill the pores and take forever the place of the more valuable fluid.

The oil from the vicinity of Peru is darker and more viscid or sticky, owing to its containing a greater percentage of tarry matter or solid bitumens, than that from the main Indiana field. For this reason it is more difficult to separate from the water and more expensive to handle. Being wholly free from gas, it is heavier and has not the life or sparkle of the eastern oil. Up to the present the price paid for the two has been the same, though that at Peru requires a longer steaming to prepare it for the market and a greater percentage of residue is left in the tanks.

The average cost of the first productive well on a lease in the Peru field in 1897 was about as follows:

Rig	$250.00
Drilling	400.00
Drive pipe	25.00
Casing	125.00
Pumping and tubing	130.00
Two tanks	150.00
Receiving tank	40.00
Engine and boiler for pumping	450.00
Total	$1,570.00

The second well cost $450 less, as the one engine and boiler served to pump both. In many cases, however, the lease consisted of a town lot, where but one well could be put down. Adding to the $1,570 invested, $94, the interest at 6 per cent. for one year, and $480, the wages of a pumper, we have $2,144, the amount necessary to put down and operate a town-lot well for one year.

The average well on December 1st was making but 18 barrels a day, or 15 barrels aside from the royalty. Of this four barrels were used as fuel, leaving 11 barrels for sale, which, at the prevailing price of oil—41 cents—would be $4.51 for the income of the operator. If the well should hold up to an eighteen-barrel output for a year, which there is one chance in a thousand of its doing, the operator would receive, at the prevailing price of oil, $1,646, showing a loss of $498 on his venture. The chances are that in 1898 the town-lot wells will average less than eight barrels each per day and that but few of them will ever pay out. Where the leases are in tracts of from 20 to 80 acres and four to ten wells have been put down on them some money will doubtless be made. There is room inside of the productive area for but few companies to operate such leases, and for that reason much more money has been sunk in the field than will ever be gotten from it, unless its area is greatly increased. The following statistics of the field, brought up to January the first, 1898, will aid in showing the truth of the last statement:

STATISTICS OF THE PERU OIL FIELD FOR 1897.*

No. of wells drilled	229	
No. of wells producing Jan. 1st 1898	178	
No. of wells abandoned after producing	25	
No. of wells, dry holes	26	
Daily production Jan. 1st, 1898	2,264	barrels.
Average production per well Jan. 1st, 1898	12.7	barrels.

PRODUCTION SOLD.

September	10,257	barrels.
October	55,376	barrels.
November	88,725	barrels.
December	67,918	barrels.
Total	222,276	barrels at 41c—$91,133

APPROXIMATE EXPENDITURES IN THE PERU FIELD.

204 producing wells @ $1,300	$265,200
25 dry holes @ $700	17,500
Bonuses paid for leases	15,000
Capital invested by Buckeye Pipe Line	100,000
Salaries paid 50 pumpers for three months	7,500
Interest on above amount at 6 per cent. for two months.	4,052
Total amount invested Jan. 1st, 1898	$409,252

THE BROAD RIPPLE OIL FIELD.†

During the year 1897 petroleum in commercial quantities was produced from a number of wells in the vicinity of Broad Ripple, Marion County, five miles northwest of Indianapolis. The developments of the year were such that the field promises much for the future and will doubtless be the scene of active operations during 1898.

* This table includes 11 wells located at Bunker Hill, Denver, Fulton, Mexico, Santa Fe, Rich Valley, Walton and Waverly. The production does not include the amount used for fuel or other purposes in the field.

† Much of the data relative to the Broad Ripple field was furnished by Edward Kirkpatrick, of Indianapolis, an experienced operator, who has made a careful study of the conditions within its present bounds.

The first deep bore put down in this field was sunk for gas in the village of Broad Ripple, southwest quarter of section 36 (17 north, 3 east), in 1888. A record of the strata pierced by that bore is as follows:

Drift	55 feet.
Corniferous limestone	48 feet.
Niagara limestone	257 feet.
Hudson River and Utica shale	504 feet.
Top of Trenton	864 feet.
Total depth	888 feet.
Surface of bore above sea level	755 feet.
Top of Trenton below sea level	109 feet.

This bore yielded a small amount of gas and a good showing of oil, but neither in sufficient quantities for commercial use, and as gas was the object sought, no attempt was made to develop the petroleum industry.

Three other bores were put down for gas in the vicinity of Broad Ripple about the same time, one on the Jas. Huffman farm, one-half mile west of the town, northwest quarter of southeast quarter of section 35 (17 north, 3 east), which proved dry; a second in Fairview Park, west half of section 11 (16 north, 3 east), two miles southwest of Broad Ripple, and the third on the Boardman farm, three-quarters of a mile northeast of the town, the last two with a fair showing of oil. As the prospectors were at that time also in search of gas but little attention was paid to the presence of petroleum, and drilling was stopped until March, 1896.

At the latter date Mr. Alex. McKnight, an experienced operator from the Pennsylvania field, learned of the presence of oil in the former bores put down near Broad Ripple, and visiting the vicinity, secured leases on about 3,500 acres of land in Washington Township, west and northwest of the town. In company with W. J. Murphy and other citizens of Indianapolis he organized the Keystone Oil Company, and a bore was started on the Wm. H. Sharp farm in the southwest quarter of the northeast quarter of section 34 (17 north, 3 east), one and a half miles a little north of west of Broad Ripple. The elevation of the surface at this bore is about 60 feet above Broad Ripple, or 810 feet above tide. The following is a record of the well as furnished by Mr. Kirkpatrick:

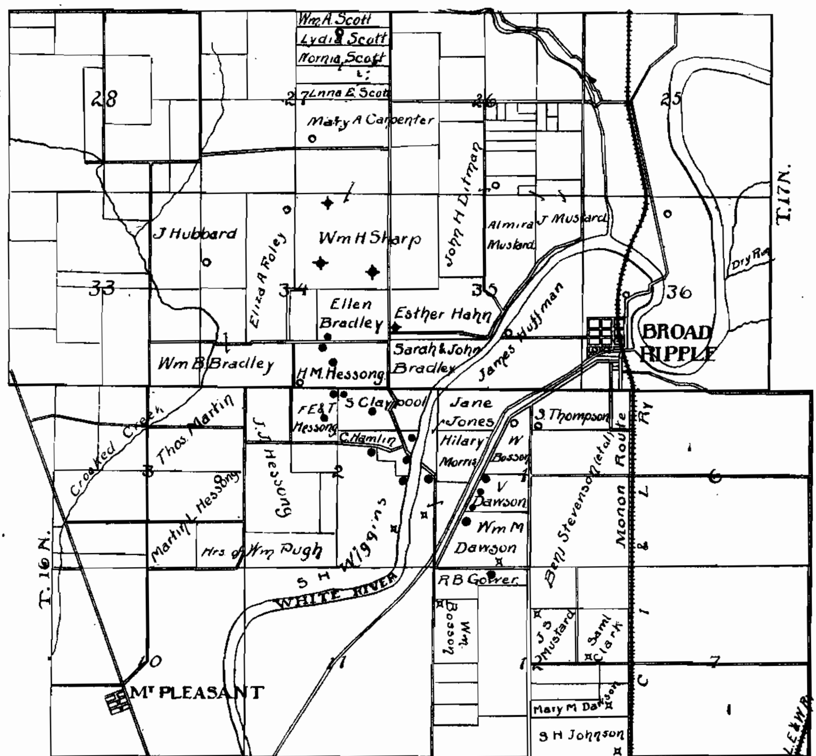
Drive pipe	90 feet.
Casing	425 feet.
Trenton struck at	930 feet.
Total depth	942 feet.
Top of Trenton below tide	120 feet.

The Trenton was found to be a dark, porous rock and yielded a large amount of gas, the pressure being 315 pounds per square inch and the output estimated at 1,500,000 cubic feet per day. A second bore was put down one mile northwest of Broad Ripple on the Jno. H. Ditman farm, southwest quarter of southeast quarter of section 26 (17 north, 3 east), which proved dry, the Trenton being a close-grained, white, hard rock. Dry holes were also drilled by the same company on the James Hubbard farm, northwest quarter of section 34, and on the Mary A. Carpenter farm, southeast quarter of section 27 (17 north, 3 east), and a second gas well was developed on the W. H. Sharp farm.

In May, 1896, Dr. R. C. Light organized the Broad Ripple Gas Company and secured a lease on the E. A. Foley and H. M. Hessong farms, in section 34, for the purpose of producing natural gas for consumption at Broad Ripple. A bore was sunk on the Foley farm, directly west of the Sharp No. 2 gas well, which developed gas, oil and salt water. The gas was sufficient in quantity to furnish fuel to drill a well on the northwest corner of the Hessong farm. This was finished the latter part of May, 1896, and was the first well producing oil in any quantity in the Broad Ripple field, yielding about 50 barrels the first 24 hours. The owners were, however, seeking gas instead of oil, and though the well was tubed, no pumping attachment was affixed. It continued to flow oil in small quantities, which was barreled on the spot. A second bore in the southwest corner of the Hessong farm resulted in a dry hole, as did also a third on the Scott farm, in the northeast quarter of section 27 (17 north, 3 east). Meanwhile a small oil producer was drilled in by the Keystone Company on the Ellen Bradley farm, just north of the Hessong No. 1. This well was shot once, then drilled deeper and a second shot put in, which in part lodged above the Trenton, and as yet has never been exploded.

The Broad Ripple Company gave up its search for gas and surrendered its leases to the Keystone, after making arrangements with the latter company to furnish gas from the wells on the Sharp farm to consumers at Broad Ripple. The developments of 1896 resulted, therefore, in two small oil wells, three gas wells and six dry holes.

In 1897 no developments were made in the Broad Ripple field until August, when a bore was finished by the White River Company on the H. M. Hesssong farm about 800 feet southeast of the No. 1 well. When the Trenton was pierced at 929 feet oil began to fill the hole and soon ran over the top, and when the well was shot and put to pumping it yielded 125 barrels per day for a week. In a month the production had dropped to 75 barrels, and by January 1, 1898, was down to 15 barrels.



SKETCH MAP OF

BROAD RIPPLE GAS & OIL FIELD

LEGEND: ✦ Gas well ● Productive oil well o Dry well
¤ Rigs up January 13, 1898.

C.H.A. Del

Several companies now entered the field and scoured the surrounding country for leases, which were hard to obtain, as the White River and Keystone companies had most of the land under contract.

The second bore sunk in 1897 was 1,000 feet southeast of Hessong No. 2, on the Claypool farm. It also started at 125 barrels, but trouble occurred by the caving of the Utica shale, the shot having been too high, and the production soon dropped to 70, and by January 1st, 1898, to 20 barrels. A second well on the same farm, 700 feet southeast of No. 1, was finished on November 23d, and proved the best producer drilled in 1897, flowing 150 barrels per day for ten days, and on January 1st was pumping 50 barrels.

The Ohio Oil Company (an adjunct of the Standard) secured a lease and put down two wells on the F. E. & T. Hessong farm, east half of northwest quarter of section 2 (16 north, 3 east), just west of Claypool's. One of these was drilled 80 feet into the Trenton and shot with 200 quarts of nitro-glycerine. It started at 90 barrels; the other, 700 feet south and 100 west, was a very light well, and is yielding at present but five barrels daily.

At "Crow's Nest," near the bridge across White River, one mile southwest of Broad Ripple and nearly one mile southeast of H. M. Hessong No. 1, two wells were drilled on the Hamlin farm, one of which started at 40 and the other at 100 barrels daily. Forty rods south of the wagon bridge, on the west side of White River, is the No. 2 well on the Wiggins farm. In it Trenton was struck at 850 feet, and the bore filled to within 50 feet of the surface before being shot. After shooting it began to yield 150 barrels daily, and is probably the second best well in the field. The Wiggins No. 1, 1,500 feet northwest on the same farm, is a light producer, yielding about eight barrels on January 1st. A dry hole was sunk by the Ohio Oil Company on the M. L. Hessong farm, in the northeast quarter of the southeast quarter of section 3 (16 north, 3 east), which is one-half mile farther southwest than any other bore in the field. The Trenton was found 15 feet lower than on the E. & T. Hessong farm, and was pierced 207 feet. Between 170 and 190 feet in Trenton the rock became dark and porous, but yielded blue lick water instead of gas or oil.

East of White River are two producing wells, one on the M. Garver farm, close to the east line of section 2, and the other one-third of a mile northeast on the V. Dawson farm. These are the most southeasterly wells in the field, and started at about 40 barrels each.

Two dry holes were drilled in Broad Ripple in November, the Trenton being struck at 850 and pierced to a depth of 40 feet. Bores which produced only a showing of oil were also put down on the Wm. Bosson and S. Thompson farms on the line between Broad Ripple and the V. Dawson well.

The statistics of the Broad Ripple field from March, 1896, to January, 1898, are as follows:

STATISTICS OF THE BROAD RIPPLE OIL FIELD TO JANUARY 1, 1898.

Total number of bores	29	
Bores producing oil in commercial quantities	12	
Bores producing gas in commercial quantities	4	
Dry holes	13	
Wells drilling	4	
Total daily production Jan. 1st, 1898	230	barrels.
Average production per well, Jan. 1st, 1898	19	barrels.

PRODUCTION OF THE BROAD RIPPLE FIELD BY MONTHS IN 1897.*

August	188	barrels.
September	1,886	barrels.
October	1,070	barrels.
November	1,660	barrels.
December	2,892	barrels.
Total	7,696	barrels.

The productive oil wells are found in a strip of territory three-fourths of a mile wide and a mile and a half long, extending in a northwest and southeast direction from the Bradley farm, in the southeast quarter of section 34 (17 north, 3 east) to the V. Dawson farm in the northeast quarter of the southwest quarter of section 1 (16 north, 3 east). The porous oil-bearing stratum lies very near the top of the Trenton, and in the productive wells is found from 10 to 15 feet higher than in the non-productive bores to the northeast and southwest. Salt water in quantity has not been found in any of the wells yet drilled, either productive or dry. The flow of gas in large amounts from some of the wells bored would indicate the presence of a good-sized area of oil-producing territory in the immediate vicinity of the field as developed. There are no indications as yet to prove that the Broad Ripple oil field is connected with the main oil field in Grant and Blackford counties. As already noted, oil is liable to be found in commercial quantities in isolated areas anywhere within 15 to 25 miles of the margins of the main gas field, and will eventually be found over the greater portion of that field. The Broad Ripple field lies on the southwestern slope of the gas field within the distance named. It is most probably an isolated area of porous Trenton rock, formed in the manner previously mentioned†, and its area can only be circumscribed by the future use of the drill. Since wells with a showing of oil have, in the past, been drilled at the Atlas Engine Works, within the limits of Indianapolis; at Brightwood, in section 29 (16 north, 4 east); on the Mary J. Wolf farm, in the northeast quarter

* Not including the amount used for fuel and other purposes in the field.

† See p. 156 of the present volume.

of the southeast quarter of section 21 (16 north, 4 east), and on the Hezekial Smart farm in the northeast quarter of section 6 (16 north, 5 east), two miles northeast of the station of Lawrence, the field may expand into one of large size. At any rate, it at present offers good attractions to the speculative operator, and it is to be hoped that the season of 1898 will bring him a fair degree of success.

* * *

Up to the present, much more money has been put into the Indiana oil field than has been gotten from it. The reason for this lies with the operators themselves, and not with the field. They come in from other States and lease a large amount of territory, which they fail to properly develop. They expect to get rich from the leases and not from the oil which they develop from them. If, within the productive area of each of the fields, a well had been sunk on every eight acres, and those on each lease of 40 to 160 acres connected with one power, and then managed as other successful business interests are managed, the success would have been much greater, and the balance on the ledger of the Indiana field would have been on the opposite side from where it is at present. There is no doubt but that the oil is there, but different methods of development will have to be inaugurated before the field becomes as productive, proportionally, as those of Ohio, Pennsylvania and West Virginia.

ON THE ADVANTAGES OF PRODUCING BEET SUGAR IN NORTHWESTERN INDIANA.

BY E. L. FURNESS, FURNESSVILLE, PORTER COUNTY, INDIANA.

The subject of growing beets, for the purpose of making sugar, to supply the demands of commerce, is attracting much attention in the United States, and it now seems quite probable that the sugar consumed in this country will be produced within it before many years.

A careful study of the subject, makes it appear to be entirely desirable and feasible to do so. It has been proved by actual experience, that it may be done profitably—in itself considered—but that it will also greatly benefit incidentally and directly many other industries.

There are already ten or twelve large sugar factories, located in different parts of the country, east and west, profitably at work, turning out refined sugar, of the best quality, from sugar beets grown in their respective vicinities, and others are now being built. It is said by the Hon. James Wilson, Secretary of Agriculture, "that at least nineteen sugar beet factories will be at work in the United States in the year 1898."

And Hon. Aaron Jones, Worthy Master of the National Grange, in his annual address to the Indiana State Grange, says that he is proud to say, "that at least one, if not two, of these factories will be in Indiana, and that probably they will be in the Kankakee valley of northwestern Indiana."

It seems reasonable to believe, that if a part of the sugar used in this country can be profitably produced in it, that the whole might be, and that it should be; and it is proper that intelligent investigation should be given the subject to discover its requirements, and that whatever may be needed in the way of private effort to bring about this result, should be given it by individuals; but as an essentially wise and economic policy it should also have the encouragement and fostering help of both State and Nation.

More than two million tons of sugar (with 2,240 pounds to the ton) are consumed annually in the United States, and less than one-sixth of it (315,000 tons) is produced at home. One hundred million dollars—more or less—go out regularly year after year to pay for this sugar. It is bought of nearly every other nation in the world (the countries of Europe, Asia and Africa, South America and the Islands of the Sea—West Indies, East Indies, Phillipine Islands and Hawaii, etc.).

We thus buy what we can, and, with great advantage, should make ourselves. If we were producers, as well as consumers, of this immensely large and indispensable commodity, we should become more independent as a nation, and give needed employment to our own people, thus adding greatly to their comfort and prosperity.

We have here, therefore, not only an important economic question, but an important social one as well.

It is deserving, certainly, of much painstaking study and investigation, from a broad and high plane of patriotic and philanthropic statesmanship, entirely freed from any taint of the prejudice of partisanship.

Sugar beets in large quantity, of proper quality and rich in saccharine, can be profitably grown throughout the State of Indiana, but especially so in the northwestern part of the State. Beets for sugar are said to do best in north temperate latitudes, and in friable soils. There is a large area of sandy, sandy-loam and alluvial soil, in northwestern Indiana, which is particularly favorable for growth of vegetables, as has been demonstrated by actual performance. This soil is easy to cultivate, it is warm and fertile, and there is in this part of the State the proper degree of sunshine, and an especially requisite and favorable amount and time of rainfall, for the growth and ripening of sugar beets, as well as the developing in them of the quantity and purity of saccharine to fit them for profitable sugar making. The price of the land is low, and taxes are nominal. The numerous farmers who occupy this land, in moderate-sized holdings, have the energy, the intelligence and the willingness to make a success of beet raising, and will gladly furnish to factories all that can be used. The facilities for transportation are all that can be needed, and greatly excel those of other parts of the country.

Railroads interlace the land, and shipping stations can be had at any point where freight offers in reasonable quantity. Water carriage can also be surprisingly developed, when the necessity for it is presented.

Northwestern Indiana borders on Lake Michigan, and has several rivers ~~that~~ can be used for freight highways, for taking beets to factories at low cost, and can be used for other freight. Again, the close proximity to Chicago—a great distributing point, and mart of trade, with its immense consumption—is an argument in and of itself of the favorable location of northwestern Indiana. All the conditions for an economical and prosperous manufacture and marketing of sugar, from sugar beets, seem assured beyond peradventure for this peculiarly favored locality.

All that now seems to be lacking for this consummation is a recognition of the chance, and the determination to do that which should be done, and the accomplishment of making sugar under these favorable circumstances, is so logical and legitimate as to go without saying. Here is the land, waiting as a fair bride; here is the energy of labor and capital, with the opportunity; here is the urgent demand to be supplied, and a great commercial enterprise of incalculable value should legitimately spring into life, to cheer and bless the community.

It is known from experience, that beets rich in sugar, will grow here readily, and satisfactorily, but to place the matter beyond conjecture, scientific tests have been made, for the past ten years, at the Indiana State Agricultural Experiment Station, at Purdue University, Lafayette, by chemical analysis, by the State Chemist, Dr. H. A. Huston, and he reports that his investigations show entirely satisfactory results. He sees no reason to doubt, that from the large per cent. of sugar contained in the beets grown in northwestern Indiana, and the high per cent. of its purity, that they fully meet commercial and manufacturing requirements, for the purpose of making sugar. His tabulated report of analyses of sugar beets grown in 1897, in this section, will soon be made public, and will be found to be assuring as to the richness and good quality of northern Indiana grown beets.

Tests of the sugar value of beets grown in northwestern Indiana are also being made by the Chemist of the United States Agricultural Department at Washington, and will be found to be favorable. There is consequently definite knowledge of the sugar value of beets grown in this part of the State; and the reader is recommended to consult these statistics.

It may not be necessary to draw with minute definiteness the exact border line of what is here spoken of as northwestern Indiana—the line may be considered as quite elastic—and there is no need of naming hard and fast, the many grand counties that are within its boundaries, nor is it essential to figure up precisely its area of square miles, or thousands of fertile acres, well adapted to sugar beet growing, or to enumerate with the exactness of a census its host of intelligent people. It is a vast area, a magnificent territory, a principality, an empire of possibilities, the future home of many people, more millions than now live in the entire State.

The advent of its prosperity depends upon its people coming to the recognition of their opportunities, and in making energetic efforts to realize and to materialize them. Its close proximity, as has already been said, to the large and progressive city of Chicago, makes its domain a source of supply, from a sure vantage ground, of a large portion of that city's great and increasing wants. It has also many large cities within its own borders, and a large and rapidly increasing surplus of cash capital that very unnecessarily and mistakenly too often seeks investment outside, instead of within its own borders. A home investment would be not only safe and profitable, but would immensely increase the value of all home property.

The same kind and degree of energy, and work and faith, that have built Chicago, that raised it from the quagmire, is needed to develop the latent possibilities of northwestern Indiana. The many travelers passing on their way to and from Chicago, through northwestern Indiana, see on the face of things, much that may be unthinkingly, and perhaps freely criticised. They would have seen much to criticise also in the early Chicago.

He who foresees the great transformation that is inevitably to take place in this favored part of Indiana, wonders that it should be so long delayed.

He who has lived to see the evolution of Chicago, is prepared to believe unhesitatingly in the coming development of northwestern Indiana.

The introduction of sugar making, from sugar beets, promises to hasten this development and prosperity—for this region. The men who are actively working for this cause, are benefactors to this part of the State, and to the whole State, and to the American people. The thing to be accomplished is not a light one. It requires work and money, and time, with many discouragements, and all that is implied in awakening dormant energy from its lethargy and unbelief, and to overcome the active hostility of prejudiced opposition, but success is bound to come, slowly probably, but steadily, and then the whole thing will carry itself forcefully forward, and the wonder will be that it was not all done sooner. Sugar making here means improving all the general conditions of society, by introducing a new and successful industry that will put large sums of money into general circulation—it means improving the land, and improved culture of land, planting larger areas, the introduction of a new crop, that will not compete with present crops, but will make added market for them, and one that has the exceptional advantage to its merit, of having the price which is to be paid for it, agreed upon even before it is planted. This last fact means much to the farmer who has toiled through heat and cold, to raise a crop, and has then found the market over-supplied, and that it could not be sold for cost of production. It means employment of a great number of beet growers, and light, healthful, and profitable employment for women and children, who can thus have the pleasure and benefit of having money of their own earning.

It means the building of factories, and consequent demand for building material (brick, lumber, etc.), and the equipment with machinery—work for mechanics and factory hands—increase of railroad business, which of itself affects all the industries of the country favorably. It means too, a greatly increased demand upon the farmer, for other farm products, to supply the increased population of his neighborhood, a demand too, right at the farmer's own door, which he will find of much more worth to him, than a distant foreign market, and one that will include many articles that could not be shipped away. New houses will be needed, greater sales of merchandise will follow, both of necessities and luxuries, as is always the case with the ability to purchase, consequent upon regular employment, with paying wages. This increase of activity would put money into active circulation and new enterprises would naturally follow, resting upon this basis of prosperity. There would necessarily be a very decided improvement of the highways—live people must move about—and good roads are a necessity to advancing civilization. It would not do to haul a small load of beets ten or twelve miles to factory, when with good roads, two or three times as much might be taken in less time, and with the same team.

All these things, high in color as they may seem, have come to pass at other points, where sugar is being made, from home-grown beets, and with so many favoring conditions, as prevail here in northwestern Indiana, there is no reason to expect anything less, but rather more.

Beets rich in sugar, of high degree of purity, will grow here—that is the foundation fact which can be made strong by a formidable array of statistics. There are here, too, good locations, for factories, with abundant supply of good water, which is needed in large quantity, and there must be ready chance for proper drainage, to take away freely, without discommoding any one, the fouled water used in washing and treating the beets.

There is here also an abundant and cheap supply of fuel, and the same can be said of the lime needed, also in large quantity, in manufacturing. And there can be found the needed number of workmen. With assurance of a full supply of beets, it would seem to be an inviting field for the investment of the requisite capital. One successful beet-sugar factory established in northwestern Indiana, would demonstrate the truth of the positions herein taken, and would lead to the building of many more. It matters little where this first factory shall be started, it should have the support of the whole district, and of the whole State.

It takes a large sum of money—probably from two hundred to five hundred thousand dollars—to build and operate a modern sugar factory, with its new methods and improved and costly machinery. Prudent and cautious men who have money must naturally be convinced, before investing their money in a beet factory in northwestern Indiana, that all the conditions are correct, and can be depended upon to make the investment a safe and paying one. Confidence is a plant of slow growth, and new ventures, even where the promises are so favorable as in the present case, are apt to be looked upon with doubt. There must be first the sure thing, that the beets, in quantity and quality, will be forthcoming as needed, from 300 to 500 tons, each and every day, for one hundred or more days. This is a large quantity—from 30,000 to 60,000 or more tons; requiring an acreage to produce, in direct use, or to be planted each year, of five or six thousand acres. To keep the land in proper rotation, so that one crop of beets shall not follow too quickly another crop of beets, on the same land, will require a total of twenty or thirty thousand or more acres, within say a radius of ten miles of a factory.

Fifty thousand tons of beets, at four dollars per ton (and five dollars are paid in some localities), would make a health-giving sum of two hundred thousand dollars to be paid out yearly in a comparatively small farming community directly to the beet growers. Multiply the factories to the number of 500, to absorb the one hundred million dollars paid for foreign made sugar brought into the country annually, and there would be a wave of prosperity sweep over the entire land, which would banish all thought of hard times.

The beet tops, and refuse beets, have also value to the grower, for feeding farm animals, and the improved condition in which land is put by beet culture, for better and larger yields to the crops which follow the beets, is an advantage to be considered as additional money value.

The profits of successful beet sugar factories are said to be large, and rightfully they should be, for they cost much money to build and maintain. Insurance, interest and taxes are large items, and the factories run only a small part of the year, perhaps four to five months, and the costly machinery suffers while idle. The larger the capacity of the plant for using beets, and the longer the time it can be kept running, the cheaper per pound can sugar be made. The fraction of a cent may make a large figure in the profit.

In less than twelve hours after the raw beet enters the factory, the refined sugar from it, may leave in bag or barrel ready for market.

This quick realization on the manufacture is a very big item in favor of the industry of sugar making. There is a large and growing demand for sugar in the United States. It is the largest and best market for it in the world. The consumption of sugar is rapidly increasing in the world; it has more than doubled in the past few years. Sixty-five pounds each, annually, is the average amount used, for every man, woman and child in the United States—not that every person uses directly in the form of sugar, that large amount, but it is used in distilling, brewing, preserving fruits, making jellies and jams, confectionery, chocolate, varnishes, blacking, etc., etc. There are also large quantities of foreign substances, adulterants, added to sugars, such as starch, chalk, white earth (terra alba), glucose, etc. The people should protect themselves from such fraud since it is not wise to be imposed upon in any such way. There are immense quantities of glucose, made from Indian corn, and used in the United States as well as exported. It seems to be a legitimate industry, and the time may come suddenly, when the art will be discovered of turning glucose to sucrose, and we shall have sweet sugar made from corn and other grains. There are tons of maple sugar, and maple syrup, and sorghum, and a large quantity of honey is gathered annually.

These sweets are all in eager demand, and enter largely into the food of the people of this country, and are influencing more largely perhaps, than is realized, the character of the nation. It has been said by some physiologists: "Tell me what you eat, and I will tell you what you are."

The Japanese have lived quite exclusively for centuries on rice. They are small in stature, presumably as a result of this diet, and the Japanese Government is now seeking to introduce the general use of wheat among the people, hoping from its bone and muscle making elements to induce a larger stature. The beef-eaters of merry England, are noted for a robustness and an energy, that continually reshapes the maps of the world.

The great consumption, and demand for sweets, requires an immense production, and calls for the employment of large amounts of capital, and of labor, and warrants the investment of money in the industry, so far as demand for the product goes. The question presents itself pointedly then, whether we shall continue to buy our sugars of other nations, or shall we make them ourselves. If all the conditions are as favorable as assumed in this paper, all that seems necessary is to build the factories, and that is a question of much money. The question of investing money in sugar making in the United States, waits upon, and is dependent upon the will of the people, to be expressed in national legislation, for there must be legislative protection, to this industry, until, at least, it is substantially established, to keep it from disastrous competition of foreign made sugar. This legislation must be without fluctuation, and so reliable in constancy as to command confidence in its stability, as being the settled policy of the nation to effectually encourage and protect home made sugar. This policy would end all doubt as to the ability of the American people to advantageously make their own sugar. This matter of protection to home industries should cease to be a thing of partisan politics, and be recognized as the policy of loyal statesmanship. The experience and practice of other highly civilized, enlightened and prosperous countries, is in direct and positive evidence upon this very question of legislation in favor, and protection of making sugar by their own people. The recent experience of the United States in fostering its iron and steel, and tin, and textile industries is happily directly in point, and is convincing as to its wisdom.

Large sums of money were formerly, continually being sent out of the country to purchase manufactured articles, while the raw material was lying unused in abundance at home, and workmen lying idle, needing work. By simply invoking the aid of the necessary and sensible tariff protection, we now make at home what we formerly bought of other people, and are fully able to supply our own wants in these lines with not only better goods, but at cheaper prices. We also ship such goods profitably abroad. With such eminently and plainly practical good results, so conspicuous that "He who runs may read, and the wayfaring man tho' a fool need not err therein," all the theories that are arrayed against it, seem to be knocked silly, and have no foot, or ground to stand upon.

It is said by making our own sugar, we should prejudice a profitable trade with countries from which we now buy sugar, and this is held as valid argument why we should export wheat to pay for sugar. It is said to take all the wheat, and wheat-flour shipped from the United States to pay for the sugar brought into it. Why is there any advantage in trading, just for the sake of trading? With the yield of one acre of wheat, the American farmer might buy, say 200, or 300 pounds of sugar. That same acre planted with sugar-beets might yield, say 2,000 or 3,000 pounds of sugar, a difference in figures, and real values, that shows big loss, in the way of friction, or manipulation, or trade, somewhere on the road from wheat to sugar. And it is probably quite true that there is really more sugar in the wheat, that the farmer trades for the sugar, than there is in the sugar he gets for it. It may be worth the while of the American farmer to look sharply into this matter.

If we should make our own sugar, the sugar workmen might consume in this country, all the surplus wheat which is now shipped abroad, making a home market for it, much better than a foreign one, and paying better prices. The farmer has very good reasons for being dissatisfied with present prices of wheat, and would be justified in attempting to create a better market for it, and there would consequently be an added new market for butter, eggs, milk, meat, clothing, and the whole thing of sugar and wheat would be of home, and for home. There is very much that might be said as to the questionable policy of shipping wheat from this country. Whatever will contribute to the healthful growth and independence of this country, whatever will improve the character and condition of our people, is desirable. A study of the promises to these ends, held out, by making at home, all the sugar needed, makes it seem to be the right thing to do. Beet raising requires a more thorough and systematic method of farming, than is usually given to the growing of wheat and corn—and it is more profitable. It is certainly desirable, and quite possible, to improve the manner and method of farming. There is much said enthusiastically about large yields of sugar-beets and of extra high per cent. of sugar value, etc., but 12 tons of beets to the acre, with sugar value of 12 per cent., with proper purity of the juice, say 70 per cent., may be considered as a standard yield, and this will require a good deal of effort to attain, although it may fortunately be quite possible to excel in this region. To make 12 pounds of beets, yield one pound of sugar, will require great skill in manufacture.

Great improvements have been made in the whole art of sugar making—in growing the beets, in the process of extracting and refining, and much more in this direction is yet possible. The horticulturist, the inventor and the chemist have united forces in the problems involved, and the State has protected and encouraged by bounties and privileges, and the battle royal between cane sugar and beet sugar is won in favor of art over crude nature. This paper might be lengthened indefinitely upon the interesting subject of the history of sugar making, and of the disturbing and agitating conditions surrounding it to-day. The subject grows with study, in magnitude and importance, but the paramount question in this subject, even at the risk of repetition, is, Shall the people of this country make their own sugar? There is of course much chance for the play of sentiment and emotion, in weighing up or adjusting the seeming rights and wrongs which float on the surface of many great and grave questions, but the law of self interest, or apparent self interest, will, and should control in the actions of those who are affected by any given policy. How other lands, and other peoples, may be effected by the people of the United States striking directly for their own advancement and prosperity, is involved in too great and uncertain obscurity to be considered.

There can hardly be a question as to the good policy of having the people of this country fully and profitably employed. It appears so entirely self evident, that no argument of words is needed to support it. It is an unpleasant fact, that there are now, and have been for several years past, many unemployed people—who would gladly work, and their material and moral condition would be greatly benefited by doing so. There has been and still is the general complaint of hard times, and there exists a spirit of unrest and dissatisfaction, which surely constitute a serious menace to the safety of the community. This condition costs immensely in the way of self denials, of suffering and misery, and of stagnation of industry and business, and a retrogression of all material interests. The aggregate cannot be computed in money. It costs much in direct public taxation, and for an unusual support of the needy, and for prosecuting an increased growth of crime.

There is too a great tax upon the charitable, for voluntary contributions to the poor, a tax that in equity should be borne by the State, so that all citizens might bear their proper share of it. In the form of charity it has a very demoralizing effect. It is desirable to have all the people of this country self sustaining and self respecting, even if to furnish requisite employment, enterprises are instituted requiring governmental aid and protection. This means simply, when analyzed, the very proper co-operation of the whole people in the performance of a self protective duty, by enabling all to support themselves by their own labor, without any sacrifice of self respect, and to contribute to the support of the Government. A portion of the community cannot be benefited without the whole community sharing the benefit. Whatever it might seem to cost there would be equivalent value received for it. Whatever is really worth much more than it costs, and is entirely beneficial in its results, is not dear, but is cheap. As George Washington expressed it, "The aggregate happiness of society is, or ought to be, the end of all government."

There seems to be prophecy, shaping into fulfillment, in the general expectancy that sugar making on such a scale as to fully supply our own market will soon be an accomplished fact in the United States of America. It is in the thought and in the purpose of the people.

REPORT OF THE STATE NATURAL GAS SUPERVISOR.

LETTER OF TRANSMITTAL.

OFFICE OF THE NATURAL GAS SUPERVISOR,
KOKOMO, IND., Jan. 25, 1898.

PROF. W. S. BLATCHLEY,
State Geologist:

Sir—I transmit herewith to you my third annual report. It is made in obedience to section 7,504 of the Revised Statutes of the State of Indiana, and is for the year ending December 31, 1897. It is the sixth annual report from this department.

It is due for me to say at this time that during the past year I have had frequent occasion to ask your aid and counsel, and for the same I beg to tender my grateful acknowledgment.

Yours respectfully,
J. C. LEACH,
State Natural Gas Supervisor.

INTRODUCTORY.

A brief outline of the subjects discussed in the body of this report and such other matters as have not a logical connection with the same, but merit a passing notice, are given in this introductory chapter.

For reasons patent to every person acquainted with the condition of the gas field and the character of the work occasioned thereby, the time that I have had to devote to this report has been very limited. As the natural gas industry in this State becomes older the developed area increases by the drilling of wells and extension of pipe lines, and in further consequence of the extraordinary activity in the oil industry in high-pressure gas territory during the past year, it has been necessary for me to devote all of my time to the work in the field. At this time the importance of aggressive field work can not be overestimated. Every working day in the year is needed for this work, and while I do not wish to undervalue the history of the progress of this or any other natural gas field of any importance, the doing of the work, especially the efforts to stop the vandal-like waste that has characterized some sections of this field during the past, is more important than a record of the same.

Regarding the purpose of the reports from this department, I quote from my first annual report:*

"The reports from this department, to be of value, should contain such information as the public desires to know, and discuss such subjects as demand the attention of those engaged in the natural gas industry in Indiana. They should contain an accurate history of the gas field; a history in which all phases of the subject are discussed and in which the condition of the field has been noted from time to time."

A discussion of the scientific questions suggested by the generation, storage, pressure, etc., of natural gas would be a reiteration of portions of former reports. This would not be profitable, even if practicable, at this time.

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*Twentieth Annual Report of the Department of Geology and Natural Resources, Indiana. 1895.

Soon after the discovery of natural gas in Indiana, and even before this, during the time that the Findlay, Ohio, field lasted, the scientific phases of the natural gas question were considered by the ablest scientists in America, especially geologists. Nor were they alone. Manufacturers and persons variously interested in this new industry, not only watched the progress and development of the field, but were anxious to find a logical answer to the numerous questions suggested by the developing of this field. The same cause was not responsible for the interest manifested by the two classes of people. With the former a logical solution of a question in nature was the reward, while with the latter these questions were interesting because of their relation to the future of the natural gas industry. Not a few reached the happy conclusion that the life of this gaseous fuel would be equal to all time. This to a majority, including all geologists, was not a sound conclusion, nor one that the facts involved would substantiate. The latter said that the stock of natural gas is practically fixed, and when once exhausted there is no provision in nature for its renewal. The history of the field during the past ten years and its present condition attest the truthfulness of this conclusion. The exhaustion of territory once productive; the decrease in the rock pressure; the advance of the salt water horizon, and, in fact, all the conditions surrounding the field point to the final exhaustion of the supply. With this in mind it is apparent why consumers and persons variously interested in the natural gas industry, who are acquainted with these conditions, are so anxious about the ever-changing condition of the field. Information as to progress and development of the field, the advance of the salt water horizon, the decline in the rock pressure, and everything that tends to diminish the productiveness of the field is most sought now.

It is not, how is it generated? Under what conditions is it stored, or, what causes its pressure? but, what is its rock pressure? What is the rate of decrease of the same? What can be done to effectually combat the effects of the salt water, or what appliances are most economical; produce the most heat with the least amount of gas?

As has been said, the condition of this field is continually changing. New limitations are encountered and unforeseen difficulties arise, which those engaged in the natural gas industry should be prepared to meet. In one section the salt water is found in the upper strata of the natural gas rock; in another petroleum deposits are found, while in some localities the limestone is very hard, lacks porosity, and consequently the wells are very unproductive at first, and soon fail, owing to a stoppage of the rock. These difficulties are dealt with differently in the various localities of the gas field; sometimes successfully and sometimes not. A careful study of these questions and prompt action always does some good, and frequently prolongs the life of the well for many months, or even years. Being guided by observation in the field and experience, I have tried to make this report along the lines indicated above as practical as possible, endeavoring to answer those questions most frequently asked, and to give such advice and such recommendations as will, in my judgment, do most to preserve the present supply of this valuable fuel. The chapters on the "Condition of the Field," found in the successive annual reports from this department, are a history of the field from its beginning, and for the reason, with others stated above, that a majority of the people interested in the natural gas industry care more for present condition than "theories," first consideration is given to the former in this report.

MAP OF THE GAS FIELD.

The map of the Indiana Natural Gas Field accompanying this report will, it is thought, be a valuable aid to those who are studying the field. The original gas area is shown, and by the pipe lines and wells both the developed and undeveloped territory can be located. Owing to the limited space only about 17 per cent. of the wells are marked. The principal pipe lines, not service lines, are located. The general direction of the pipe lines are given, the frequent angles found in some being omitted. The location of tributary pipe lines are not shown.

OIL FIELD.

The oil industry has been very active during the past year, and while a report on this subject is not included in the duties of this department, because of its close relation to the gas industry in some sections of the field, the location of oil territory is shown on the map, and reference is made to the subject in its appropriate connection.

STATISTICAL INFORMATION.

The statistical information specified by the law authorizing reports from this department, has been very fully given in former reports, and in the reports of the State Geologist and Bureau of Statistics. They are not repeated here.

ACKNOWLEDGMENTS.

In performing the work of this office during the past year gas companies, manufacturers, farmers and drillers have rendered me much assistance, without which my work would have been much more arduous and less effective. To all these and others who have aided me, I desire to return my grateful acknowledgments.

THE INDIANA NATURAL GAS FIELD.

A BRIEF REFERENCE TO ITS HISTORY AND DEVELOPMENT, AND ITS PRESENT CONDITION.

Natural gas was found in Trenton limestone, near Portland, Indiana, March 14, 1886. This was the beginning of an era of exploration, the most important result of which was the location of the Indiana natural gas field. The first well was small compared with the average since drilled in this field. The eastern edge only of the gas rock had been penetrated. The second well was drilled at Eaton, Delaware County, the following September, and the third at Kokomo, Howard County, in October of the same year. Though the well at Kokomo was as near the western edge of the field as was the well at Portland the eastern edge, it was much more productive, discharging at least 3,000,000 cubic feet of gas daily for four years. This well, with others in that territory, succumbed to the invasion of the salt water before the rock pressure of the field showed a material decrease. The well at Eaton produced more gas daily and for a longer period than either of the above wells. Kokomo is sixty-two miles west of Portland. Eaton is eight miles south of a straight line connecting Portland and Kokomo. The drilling of numerous wells between these two points soon demonstrated that the territory intervening was gas-producing. Incited by the nearly universal success of the drill in this region, companies were organized in almost every county in the State, and the drill started on its mission of exploration.

At that time but little was known of the formation in which the gas is stored, nor was more known of the origin of this hydrocarbon. The relation that the textural and structural conditions of a rock, in which the lighter hydrocarbons are stored, bears to the production of the same had not been considered by the local geologists. The great value of natural gas as a heat-producing power and the fact that the first wells indicated a very large if not an inexhaustible supply of it, were incentives sufficient to develop the field, and finally to locate its boundaries. However convenient and valuable the new fuel was thought to be, but few, if any, imagined the great change to be wrought in this section of the State within the next decade on its account.

Natural gas had been found in Trenton limestone, a universal formation in this State. Was it a universal gas-producing rock? If not, why not? Answers to these questions were reserved for the future. All theories had to conform to the story of the drill.

The Trenton limestone in this State is a reservoir for natural gas over a limited area only. From Portland west to Kokomo; from Greensburg, Decatur County, north to LaFontaine, Wabash County, an area of about 2,500 square miles. It must not be understood that this entire area is gas-producing at present, for nearly, if not quite, one-half of it has been practically abandoned; has been overrun with salt water. Outside of the original gas area the Trenton limestone is, with a few exceptions, barren, while within, with similar exceptions, it is the most productive gas rock in the United States.

As would be expected, there were many failures in the search for gas in the State of Indiana and an immense expenditure of money, but the "gas belt" was located and in addition the large number of deep wells drilled in the various sections of the State revealed the character and condition of the underlying strata; increased the knowledge of geology of the State and the popular respect for the same.

Now that it was possible to obtain definite knowledge of the geological structure of the State, scientists soon began to investigate the conditions that controlled the origin, accumulation, etc., of natural gas and oil, and the result was that reasonable theories accounting for the same were presented, discussed and accepted by the leading geologists of the country. Nothing has been added to these conclusions recently. Time confirms their truthfulness. A discussion of the subject, or even a statement of the commonly accepted theories regarding the same, would simply be a reiteration of what has been said in former reports from this department. However, it may be said that the data obtained by scientific investigation or practical observation did not warrant the conclusion that natural gas would last forever, but quite the reverse.

The geologists of the State were the first to warn the people of the gas belt against the vandal-like waste that was so often seen during the early history of the field, and I am sorry to say can be seen in some localities yet. But little attention was given to the subject at that time, and the statements made that the supply of natural gas was limited, was being diminished each day by the amount of gas used and wasted, were labeled as idle assertions, made in the interest of gas companies. The difference of opinion on the subject is not so marked now as it was in the past, nor are the commonly accepted views based on theories. The evidence is present everywhere in the field that the supply of this valuable fuel is being rapidly exhausted.

The people of Indiana knew of the value, as a heating power, of natural gas even before they knew that within the borders of their own State was the largest, as well as most productive gas area of the world. They knew of the Pennsylvania and Ohio fields. They had heard of the wonderful growth of Findlay and other towns in Ohio; how they had grown from villages to cities in a short time; how small agricultural towns had been transformed into thriving manufacturing cities. This was the kind of prosperity the Indiana towns hoped to see. As we shall see hereafter they began to advertise their fuel resources and other advantages far and wide. To many this was not in vain. Small country villages soon became prosperous manufacturing towns, with the conveniences of cities, and the large cities can boast of twice their former population. The gas belt is the manufacturing center of the State. The discovery and utilization of natural gas as a fuel has caused this almost miraculous change within the last ten years. When the supply of natural gas is exhausted other changes will be necessary. There is little doubt but that, in most instances, other fuels will be successfully used.

It is certain that the time will come when the supply of natural gas will not be sufficient for manufacturing purposes, and it is equally true that a large per cent. of the factories in this section located on account of its fuel privileges. I am glad to know that the indications are that the gas belt will remain the manufacturing center of the State after the natural gas supply has been exhausted. A majority of the factories using gas are substantially built and are doing a prosperous business. They are advantageously located with regard to the great jobbing centers and transportation facilities to the same. Referring to the condition of the manufacturing industries in the gas field, I quote from my last annual report:*

*Twenty-first Annual Report of the Department of Geology and Natural Resources, Indiana. 1896.

"While a change of fuel will be necessary in the future, and no person knows this better than the manufacturers, there is no cause for immediate alarm. Manufacturers know and appreciate the value of natural gas, and are providing for the future as far as possible. The larger factories, located near cities where the field shows signs of exhaustion, have pipe lines and sufficient territory to protect their interests. Others located where the consumption for other purpose is light, are drawing from wells in the vicinity of the factory, two hundred feet of pipe in some instances being sufficient. True, a majority of the first wells drilled show signs of exhaustion, but in many cases the territory is only partially developed, and the new wells are usually productive. Any signs of a shortage in the fuel supply causes much anxiety regarding its future on the part of the manufacturers, and this is usually followed by more care and economy in its use.

"Further inquiry shows that other fuels can be used without serious inconvenience to supplement the supply of gas where it fails to come to the full requirement of the manufacturing plants.

"Of course, the chief reason for the location of factories in this section of the State during the last nine years are the advantages possessed by this fuel, but evidence is present that the proximity to the markets of the country and the splendid railroad facilities possessed were considered, and, while it is true that some manufacturers who have outlived a less productive gas field are apprehensive concerning the future, they are disposed to find another fuel, if it is necessary, rather than a new location. Taking into consideration the present condition of the field, the proximity to the Indiana coal field and its railroad connection with the gas field, it seems that a majority of the industries of the Indiana gas belt are permanently located."

The conditions have changed but little since the above was written. The draught upon the field for manufacturing purposes has been extraordinarily light for the past two years. A few factories have been compelled to change their plan for fuel supply, and in a very few instances, factories located near the edge of the field or in localities remote from pipe lines, have either changed to other fuel or are supplementing their supply of gas with wood or coal. It is reasonable to suppose that this will continue where necessary in the future. I do not know of a single instance where a factory has left the gas belt on account of the fuel item.

It is in the progress and present condition of the natural gas industry that we are most interested. We have been enjoying its use, both as a manufacturing and domestic fuel, since 1886. In the light of the past history of the field and its present condition, how long will it continue? Is this gaseous fuel being generated as we use it, or is there a fixed stock, upon which we are drawing? I will leave the first question until the condition of the field is given. The other question need hardly be mentioned at this late day. While it is probably true that natural gas is being generated daily, and will so continue as long as material out of which it may be, is in the earth's crust, it is equally true that the amount generated daily is not more than a small percent. of the amount wasted under ordinary conditions. Practically the stock of natural gas is complete, and every cubic foot either consumed or wasted, reduces the supply by that amount, and brings us that much nearer to the time when the supply will cease to honor the draught that is being made upon it from dav to day.

When the gas field was located and the boundary of the gas-producing area established, it was not known that the Trenton limestone was a productive rock over the entire field, until wells were drilled in every town and hamlet and every township over the entire area. The wells drilled for exploring purposes were quite sufficient to supply the domestic consumption the first year of the history of the field.

At first but few people knew how to control or use the new fuel. From the larger cities and towns committees were sent to the older fields to investigate safety appliances and methods of consumption.

Gas companies in the smaller towns and country took advantage of the information thus obtained, and it was a very short time after the discovery of gas until it was possible for every resident within the confines of the field to use gas for fuel and light. While, as I have said, the people in the gas belt soon became acquainted with methods of consumption, I am sorry to say that but few have learned how to use this fuel as economically as its value warrants, nor is it probable that much attention will ever be given to this very important phase of the subject as long as gas is sold by the "contract system."

Doubtless natural gas is most valuable as a domestic fuel, yet this fact does not attract from its value as a manufacturing fuel, as a heat-producing power. Manufacturers were not slow to learn this, and were soon investigating the new field. The advantages that a city and the surrounding country would derive from large manufacturing industries were apparent. Many factories were anxious to locate in the gas belt, and to secure these a sharp competition arose between the cities and towns seeking to locate them. Most of the towns offered subsidies in the shape of land, free fuel or cash subscriptions. While inducements in the way of cash to cover the expense of moving a manufacturing plant, or land for building purposes may be proper, nothing can be said in favor of giving "free gas," as was done in many instances. The result is invariably a lack of business-like economy in its use. I am confident that if free gas had never been included in the subsidies offered manufacturing establishments, and if they had been compelled to pay a reasonable price for their fuel, that its value would have been appreciated more highly, and as a consequence an economy commensurate with this would have been practiced. "Free fuel" has been used too freely in most instances for the highest good of the natural gas industry.

NATURAL GAS AND OIL.

Natural gas and oil are usually referred to as associated products of the earth's crust. They unquestionably have the same general history, and the fact that their origin and the conditions under which they are stored are practically the same, are sufficient reasons for this. Then, with all the facts in mind regarding the origin and nature of these hydrocarbons, it is not unreasonable to search for both in the same locality, though the idea that "oil follows gas," as is so frequently stated, is erroneous. That has not been the history of gas and oil fields in other States, nor has it been found true in this State. Reference will be made to this subject in another section of this report, and it is only mentioned here incidentally to show the apparent reason for the presence in this field of oil operators soon after its discovery.

It was not long after it became known that Indiana contained a large and productive gas field until large tracts of land were leased for both gas and oil, and a few test wells drilled. So far as I know nothing was found to encourage further development for oil. The territory leased was in the heart of a productive gas field, and it seems true that it was with these oil operators in possession of large tracts of gas territory, that the pipe-line idea in this State originated. The organization of a company to construct a pipe line from the Indiana gas field to Chicago stimulated the Indiana towns near the field to investigate the subject. The result is known. Indianapolis, Crawfordsville, Lebanon, Frankfort, Lafayette, Logansport, Peru, Wabash, Huntington, Bluffton, Ft. Wayne, Decatur, Union City, Richmond, Connersville, Shelbyville, Chicago and western Ohio are connected with the most productive portion of the field, each by one or more pipe lines. Prior to the construction of these lines no systematic drilling had been done. It was not necessary for factories to go outside of their own yard, or cities beyond their limits for fuel. A few wells were drilled in the country, and "farmer lines" could be found along the principal highways. With the pipe lines came a more systematic and complete development of the territory. The various lines entered the field at the nearest point and have been extending toward the center of the field from year to year. A uniform extension of the principal pipe lines would find the center of the field between Fairmount, Grant County, and the northwest corner of Delaware County. With the exception of the Indianapolis lines, but slight extensions toward the center of the field have been made this year. Wells have been drilled mainly to supply lateral extensions. An examination of the map accompanying this report will give the reader accurate information regarding the location of the various pipe lines, pumping stations, etc.

The territory occupied by the various pipe lines at present is practically "drilled out." The drilling of any considerable number of wells in the future will involve main-line extensions.

For a number of years cities were supplied with fuel for both domestic and manufacturing purposes from wells within their corporate limits. While this is true yet in a few instances, it will soon be a thing of the past. Pipe lines are becoming a necessity. As a rule the larger manufacturing institutions maintain their own independent pipe lines, while the smaller factories are supplied by gas companies. The map indicates cities and towns in the field that pipe gas for any considerable distance for either domestic or manufacturing purposes, also those that obtain gas from the immediate vicinity. Of the larger towns, Elwood, Alexandria and Hartford City are still depending largely on the first wells drilled for their fuel supply. While the wells at these places remain productive, their closed pressure has decreased uniformly with the field.

At present there are about 250 square miles of territory that has not been invaded by pipe lines. In this section, which includes parts of Grant, Madison and Delaware counties, enough wells have been drilled to supply the local consumption only.

I am often questioned as to the miles of pipe line in the State. If by pipe line is meant all gas pipe, regardless of size, that is used to convey gas, then the question becomes exceedingly difficult to answer. If, however, by pipe line is meant the larger lines, those usually termed pipe lines by gas companies, then a fairly accurate estimate can be made. Taking into consideration all lines four inches and over in diameter, there are near 1,300 miles in the State.

While all the territory within the confines of the natural gas field, as shown on the map accompanying this report, either is at present or has been gas producing, all parts are not alike productive. With the fact in mind that the productiveness of a gas rock is governed entirely by its structural and textural condition, the above does not seem unnatural. If the Trenton limestone is very porous and the gas passes freely from the rock to the well, thereby permitting a heavy draught without materially lowering the density of the gas in the rock, wells drilled in the same will be productive, while if there is a lack of porosity in the rock, and the gas passes through it slowly, the reverse will be true.

The structural condition of a gas rock may be such that the wells can not withstand a heavy draught, even for a short time, without inviting the salt water. In some sections of the field strong wells, with a rock pressure of over 250 pounds, have been overcome by this agent, while in other sections wells with less than 100 pounds rock pressure continue serviceable. Then, the number of wells drilled in any locality to supply a given consumption, is controlled largely by natural conditions. In one section the rock is very hard, the wells are small and a large number are necessary to supply the domestic consumption. However, it may be said that wells of small capacity, because of the uniform and close texture of the gas rock in a given locality, maintain a higher rock pressure and are longer lived than wells in more porous rock. This can be demonstrated in the extreme southern part of the field. For a detailed account of the conditions necessary for gas accumulation, as well as those present in the Indiana field, the reader is referred to the Twentieth Annual Report of the Department of Geology and Natural Resources of Indiana, 1895, pp. 383-5. That the conditions in the southern part of the field may be understood the above is briefly referred to here.

The reservoir in which the supply of natural gas in this State is stored, is a low, broad elevation or arch, the Cincinnati arch, that crosses the eastern boundary of the State between Lawrenceburg and Liberty, and extends in a northwestern direction across the State. This arch is found at a depth of 349 feet below the surface, 158 feet above sea level, where it enters the State, and 1,300 feet below the surface at Valparaiso, or 602 feet below sea level. It is found at sea level between Elwood and Kokomo. The incline to the northwest is not uniform and the surface is very uneven in some places, consisting of numerous small ridges or folds, with occasional spurs extending at various angles from the main elevation. The Cincinnati arch acts as a trap, in which the gas in this field accumulates. It is held in this gas-holder under an enormous pressure, due to the weight of a column of water back of it. The gas is prevented from escaping by a covering of Utica shale, which is impervious to water and gas, and forms a perfect cover for the Trenton limestone.

"Wherever the Trenton limestone is a gas or oil rock, it is always substantially a pure dolomite, highly crystalline and of a sufficient porosity to contain large quantities of these hydrocarbons. Its storage capacity is much greater than that of sandstones. Outside of the gas area the conditions are different. There the limestone is nearly pure and non-porous. The dolomitic change has not taken place. From the above it is plain that the porosity of the Trenton limestone is due to its chemical composition, or at least connected with it. In the oil and gas area this limestone has been transformed in its upper beds; the carbonate of lime giving way in part to carbonate of magnesia."*

With what has been said regarding the geological structure of the gas field and the general limitations surrounding the same in mind, a specific mention of the general condition of the various sections of the field will be better understood.

THE CONDITION OF THE FIELD.

The southern extremity of the Indiana natural gas field is in Decatur County. But little gas has been found south of Greensburg. The productive portion of the Trenton limestone in this county is very thin, varying from five to ten feet thick. It is very hard and lacks the porosity found in the northern part of the field. The gas passes very slowly from the rock to the well, and consequently the wells are very small, the average not supplying over twenty families with domestic fuel. With all this, the indications are that the gas supply will last longer here than in the more productive parts of the field. The texture of the rock nearly precludes the possibility of overworking the wells. Salt water is not present to a dangerous extent, and it seems almost incredible, nevertheless it is true, that the rock pressure in this section at this late day is 300 pounds. That part of Decatur County, north and west of Greensburg is gas-producing. The territory in the vicinity of St. Paul and the southwestern part of Rush County are similar to the territory just mentioned, except that the rock pressure decreases toward the north. Nine miles northwest of Rushville it is 255 pounds. About one-half of Rush County is gas territory. The northwest part of the county in the vicinity of Carthage has to combat the influence of the salt water more than the territory farther south, and consequently has a lower rock pressure.

*Twentieth Annual Report of the Department of Geology and Natural Resources, Indiana, p. 383.

That part of the original gas area in Shelby County is producing but little gas at present. All of Hancock County, except the southwest part, is in the gas field. While it is not as productive as some portions of the field, many good wells have been drilled. The rock pressure varies from 150 to 200 pounds, owing to the age and condition of the well. Greenfield and Shelbyville are supplied from this county. Every section of Henry County has been tested for natural gas. A number of failures have been recorded in the southeast part of the county. The west half of the county is most productive. Knightstown has an ample supply of gas from territory six miles northwest of the city. Shirley, on the boundary between Hancock and Henry counties, has some good wells, and the territory in the northwest part of the county is still producing some gas, though the salt water is very intrusive.

But a small area in the northwest part of Wayne County has produced any gas, and it is practically exhausted. Though the northern part of Marion County has been thoroughly tested for gas, not enough has been found to place the county in the gas field. A few wells drilled at Broad Ripple during the past year are producing some gas. Hamilton County, with the exception of a small area in the southwest corner, is gas territory. This county claimed some monster wells during the early history of the field. The three pipe lines from Indianapolis pass through the eastern part of this county, and have drawn heavily upon its gas resources. At present the salt water is very troublesome, and the rock pressure of the eastern half of the county is not above 190 pounds.

Crawfordsville and Lebanon are being supplied from territory north and east of Sheridan. The rock pressure there is higher than in the eastern part of the county.

All of Tipton County, except a small area in the northwest corner, is in the gas field. Early in the history of the field a few test wells drilled at Tipton, the county seat, were failures, from what cause it is not known; for in 1896 a well showing a rock pressure of 270 pounds and a daily capacity of 1,500,000 cubic feet was drilled one-half mile east of the city. The Lafayette and Frankfort pipe lines pass through this county, and until recently were supplied from its territory. That part of the county west of Tipton is practically exhausted. The rock pressure of the eastern part of the county is not above 210 pounds.

Randolph County west of Winchester is in the original gas field. The east one-half of this area has been abandoned. Wells in the vicinity of Parker show oil. The best wells show a closed pressure of 190 pounds. The western part of Jay County has proven to be a valuable gas field. Though the wells drilled in the vicinity of Portland have long since been abandoned, wells in the extreme western part of the county, with a rock pressure of 125 pounds, are still producing gas in valuable quantities. The wells in the vicinity of Dunkirk show a rock pressure of 195 pounds.

Of a number of test wells drilled in Wabash County a few in the vicinity of LaFontaine produce gas in small quantities. The wells in Miami County, with a few exceptions in the vicinity of Converse, have been abandoned.

The eastern part of Howard County, though on the edge of the field, contains much valuable gas territory. Kokomo was one of the first, if not the first, city in the gas belt to use the new fuel. Nearly every well drilled in the vicinity of Kokomo was a "gusher." The structure of the rock is such, however, that the salt water soon overrun the territory, and now this city is piping gas from the eastern part of the county, a distance of twelve miles. The rock pressure in this part of the field is 210 pounds.

For convenience, Grant, Madison, Blackford and Delaware counties will be considered together. They are all in the original and present gas-producing area, except a narrow strip of territory along the northern edge of Grant and Blackford counties. The principal pipe lines draw largely from these counties, and Grant, Madison and Delaware contain the only territory in the field not threaded by pipe lines.* Southeastern Grant, northeastern Madison and northwestern Delaware County have not been touched by pipe lines, and have had only enough wells drilled to supply the local consumption and thoroughly test the territory. This territory is certainly the "heart" of the field. It contains about 250 square miles. Its average rock pressure is 215 pounds. This is a decrease of 30 pounds during the past year. The average rock pressure of the four counties under consideration, not considering the territory in the vicinity of Alexandria, is not far from 200 pounds.

In the vicinity of Alexandria the decrease in both the rock pressure and volume of flow of wells has been greater than in any other part of the field. This is attributed to the heavy draught upon this section by the oil industry.

In speaking of the condition of a field I have referred to the rock pressure only, for the reason that it is the popular way of indicating its productiveness, many believing that accordingly as this is high or low, so is the productiveness of the field great or small. This in a

*See map accompanying this Report.

great measure is a mistake. While a decrease in the rock pressure indicates a general diminution in the supply of the field, it does not indicate the volume of flow when applied to a particular well, or the permanence of its supply. Wells in a given territory registering the same rock pressure, usually vary in capacity. A well with a rock pressure of 210 pounds shows a daily capacity of 4,000,000 cubic feet, while another on the same farm, showing the same rock pressure, will only flow 1,000,000 cubic feet daily, or less. The reasons for this are found in the difference in the draught on certain areas, and in the texture of the rock. When a well is closed it becomes a part of the main reservoir, and if all the wells in the field should be closed, each in a short time would show the same rock pressure; the normal pressure of the field. That is to say, the gas in each well would register the maximum rock pressure of the field, because the gas in the wells would be of the same density as the gas in the rock. The time required to obtain this varies in different localities. Where the gas rock is very porous, permitting the gas to pass through it freely into the well, the maximum rock pressure is reached quickly when the well is closed. When the well is open into the line, the density of the gas in the well does not show a marked change, and the volume of flow is large. If the conditions are changed a change in the result will follow. That is to say, if there is a lack of porosity in the rock, the gas thereby passing through it slowly, the capacity of the well will be small, and when the well is closed, the gas will reach its maximum density slowly, though finally showing the normal rock pressure of the field. Then, on account of the difference in the porosity of the rock, one well may produce but little gas, and another in the same locality be of greater capacity; yet whether large or small, they will, if closed, eventually reach the same rock pressure. This may require days, for, on account of the small difference in the pressure of different sections of the field, it equalizes slowly. A well that will produce 6,000,000 cubic feet of gas in twenty-four hours shows no greater rock pressure than one that produces only 500,000 cubic feet, though the first reaches its maximum rock pressure in a few seconds, while the latter may require hours. Rock pressure does not indicate the productiveness of a field.

Referring to this subject, Prof. Edward Orton says:* "The rock pressure of gas may perhaps be continued with little abatement of force until the end of the production of a field is near. The maintenance of pressure is no proof whatever of the maintenance of the

*Eighth Annual Report of the United States Geological Survey, 1889, p. 598.

supply. The last 1,000 feet of gas come out from the gas-holder with as much force as the first 1,000. In a field that contains both gas and oil, but in which the reservoirs of these is differentiated, the first sign of approaching failure will be the invasion of either level by the contents of the division next below."

GAS WELLS.

Generally speaking, the condition of a gas field must be judged by the condition of the wells. They are an index to the field, provided they have received proper care. It is a mistake to turn wells into a line and give them no further attention until a shortage of gas renders it necessary. Gas companies and owners of gas wells are fast learning this. The care should begin when the well is being drilled. First, none but experienced and responsible drillers should be employed. The location of the salt water horizon should be ascertained and the drill stopped before it is reached. Usually a small gas well is more valuable to a gas company than a large salt-water well. When the well is finished care should be exercised in tubing and packing. Only tubing perfect in every detail and not larger than is necessary, should be used. It is much easier to properly pack a well at first, even if the tubing has to be drawn and the packer reset, than it is to repack after the well has been closed a year or more. All gates, valves, etc., should be examined frequently, that they may be in working order when it is necessary to use them. At this time in the history of the field there are but few localities in which salt water does not appear within a comparatively short time after the well is turned into the line, even if the drill has stopped above it. This must be cared for, or the well will soon be useless. If the pressure of the gas is strong enough to bring it to the surface, through the well tubing, it can be separated from the gas be means of an automatic separator. Any water that may be in the line can be caught in properly arranged drips attached to it. The latter can be constructed and connected to the line without any particular skill or much expense.

If the pressure of the gas is not strong enough to lift the water through the well tubing, then the only practical thing to do is to place a small tube, say three-fourths of an inch in diameter, to the bottom of the well. Properly arranged, a small amount of gas will lift the water through this tube, thereby cleaning the well, and the gas will pass into the line comparatively dry. The tube need not be left open all the time, but opened at intervals, as often as necessary, to relieve the well of the salt water.

Where it is not practical to use either separator referred to above, and the rock pressure is sufficient, the well should be opened often enough to allow it to relieve itself of the accumulated water. This will waste a small amount of gas, but the damage to the field will not be as great as it is when the water is allowed to accumulate until it overpowers the pressure of the gas and hermetically seals it in the rock. Ordinarily the small inner tube is altogether practical, and with it the salt water can be successfully resisted, for a time at least, and the life of the well prolonged. The pressure of the gas will raise the water in the small tube long after it fails to lift it in the larger well tubing.

As to the number of wells in the gas field, either abandoned or productive, I do not attach much importance, except for statistical purposes. To get exact figures is almost an impossible task. Some gas companies have kept accurate records of all wells drilled and a history of the same from the beginning. Based upon the most reliable data obtainable, I submit the following estimate:

First—Number of wells drilled for gas since March 14th, 1886	5,400*
Second—Number of wells abandoned since March 14th, 1886	2,800
Third—Number of wells producing gas January 1st, 1898.	2,600

WASTE OF NATURAL GAS.

So much is being said about the waste of natural gas at this time that a reference to the subject in this paper is hardly necessary. At most the condition, at present only, will be noticed. The extravagant use and vandal-like waste of natural gas in the past is common history. That the future of the natural gas industry depends much upon how this fuel is used from this time on; upon whether it is used economically or otherwise, no one will deny. In the past the public has given but little heed to the warnings given either from this department or other sources, regarding the magnitude of the gas waste, and the certain results of the same.

On account of some extraordinary wastes this year, the public has become aroused. I refer to the waste of gas occasioned by the efforts that are being made in high-pressure gas territory to develop an oil field. Oil has been found in many localities on the northern and eastern border of the gas area since 1886. Though the oil production

*This does not include wells in which no gas was found.

in that section has involved the waste of some gas, owing to the proximity of the two fields, the amount has been insignificant compared with the waste in the gas field. The gas from the oil wells in the vicinity of Montpelier, Van Buren, Pennville and Geneva is not sufficient for drilling and pumping purposes. Pipe lines are necessary to procure fuel to develop the oil territory.

Indications of oil have been noticed in a number of localities in the gas field since its discovery. The first attempt to develop an oil field in the "heart" of the gas field was last spring, at Alexandria. A well completed on the Nimrod Carver farm, two and one-half miles northeast of Alexandria, April 23d, proved not only to be a good oil well, but a very large gas well. The result of that "find" can not be given now. Since that time 69 wells have been drilled for oil in that section of the field. Of these, 30 produce both gas and oil, the remainder being either "dry holes" or gas wells only. The waste of gas from the beginning has been enormous; increasing, of course, with each new well. The oil operators, as a class, while pretending to be opposed to the waste of gas, have shown no disposition to save it.

The manufacturers of Alexandria and the surrounding cities became alarmed about the future of their fuel supply as soon as the first oil well was drilled, but curious as it may seem, merchants, business men, etc., of Alexandria have from the first until quite lately seemed indifferent to the waste of the product that caused their city to grow from a small village to a modern city. At one time not fewer than 25,000,000 cubic feet of this valuable fuel escaped into the air every day, and the rock pressure of the gas in the immediate vicinity of Alexandria decreased during the summer from 200 to 125 pounds, and yet the public generally seemed to think that the oil industry was an advantage to the town. It is very difficult to enforce the law under the conditions above stated. Any attempt made to enforce a law which interfered with the oil industry in the least was at once branded as an improper interference on the part of the State with the rights of the people. Soon after the oil development began at that place I filed a number of affidavits against oil-well drillers for burning large natural gas torches for drilling purposes. The first case was tried at Alexandria. The defendant did not deny burning the flambeau, claiming that it was necessary to light the derrick. The law violated by burning the flambeau had been declared constitutional by the highest court in the State but a few weeks previous, and yet a jury, composed of merchants, business men and farmers, after deliberating five minutes, brought in a verdict of "not guilty." I relate this to show the sentiment with which we have had to contend at that place.

However, I am glad to say that a change has been wrought. From some cause or other the people have become aroused to the importance of the subject and are aiding me now in every way possible to suppress the waste of natural gas. Parties who drilled for oil during the early excitement are now the most enthusiastic supporters of the law and the efforts to suppress the waste of gas.

THE NATURAL GAS LAW.

The law enacted in 1893 to prohibit the waste of gas from wells provides, in Section 1, "That it shall be unlawful for any person, firm or corporation having possession 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 in 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. And thereafter all such gas or oil shall be safely and securely confined in such well, pipes or other safe and proper receptacles."

The penalty for the violation of this section, as specified in Section three (3) of the same Act, is as follows: "Any person or corporation violating any provision of this act shall be liable to a penalty of two hundred dollars ($200.00) for each and every such violation, and to the further penalty of two hundred dollars ($200.00) for each ten days during which such violation shall continue; and all such penalties shall be recoverable in a civil action or actions in the name of the State of Indiana, for the use of the county in which such wells shall be located, together with reasonable attorney's fees and cost of suit."

It also provides in Section four (4) of the same Act, that "Whenever any person or corporation in possession or control of any well in which natural gas or oil has been found shall fail to comply with the provisions of this act, any person or corporation lawfully in possession of lands, situate adjacent to or in the vicinity or neighborhood of such well, may enter upon the lands upon which such well is situate and take possession of such well from which gas or oil is allowed to escape in violation of the provision of Section 1 of this Act, and pack and tube such well and shut in and secure the flow of gas or oil, and maintain a civil action in any court of competent jurisdiction in this State against the owner, lessee, agent or manager of said well, and each of them, jointly and severally, to recover the cost and expense of such tubing and packing, together with attorney's fees and costs of suit. This shall be in addition to the penalties provided in Section three (3) of this Act."*

*See Acts 1893, p. 300.

It will be noticed that the law is not criminal, but involves the infliction of a penalty for its violation, the same being recoverable in a civil action in the name of the State of Indiana for the use of the county in which the well is located. Every violation of this law during the past year has been reported to the prosecuting attorney of the county in which the law is violated, with the necessary information for a civil complaint, which always includes the location of a well, the date when completed, the kind of a well and the estimated capacity, together with the name of its owner, lessee or manager. Information for 34 complaints have been filed since the 1st of last May. The first case to come to trial was the "State of Indiana, for the use of Madison County *vs.* The Ohio Oil Company." In this case, as in all others where the State is endeavoring to prevent the waste of natural gas or oil, it is contended by the State that gas and oil are the property of the State, and as such the State has a right to prevent their waste and control their use. In the above case, the only one that has come to trial, the State obtained judgment in the Circuit Court for the full amount asked in the complaint and attorney's fees. The case was promptly appealed to the Supreme Court of Indiana, and a decision from that tribunal is soon expected.

As to the adequacy of the present statute to prevent the waste of gas from oil wells, it is hardly necessary to speak now. If its provision can be enforced, I believe it to be an adequate remedy. With the certain infliction of a penalty of two hundred dollars ($200.00) for the first offense, and two hundred dollars ($200.00) for each ten days thereafter, so long as gas is allowed to escape from the well, oil operating in Indiana can not be a very profitable business. The greatest objection to the law as it now is, is that it involves the tedious delay of a civil action. This means much, when millions of feet of gas are escaping into the air daily.

I am inclined to believe that the provision for tubing and closing wells as provided in Section four (4) of the Act will never be a practical remedy. While its application would be a quick and effectual remedy, citizens dislike very much to attempt to interfere with their neighbors' business, which would doubtless in some cases invite a breach of peace and possible litigation.

The question as to whether injunctive relief can be had to stop the waste of gas is now before the Supreme Court of the State in two cases. One, the Lippincott Glass Company *vs.* the Ohio Oil Company, is an action brought in the Madison Circuit Court to enjoin the defendant, the Ohio Oil Company, from allowing natural gas to escape into the open air from an oil well. In this case the defendant demurred to the complaint, and the court sustained the demurrer. Judgment was rendered against the plaintiff for costs.

The other case is similar to the one above, except that the plaintiff is the State of Indiana. It was brought in the same court. Three cases, then—The State of Indiana *vs.* the Ohio Oil Company, to decide the constitutionality of the "penalty law;" The Lippincott Glass Company *vs.* the Ohio Oil Company, to decide the right of an individual to enjoin persons owning gas or oil wells from permitting the flow of gas or oil from such well to escape into the open air, and a similar action brought in the name of the State of Indiana for the same purpose—are now before the Supreme Court. Briefs have been submitted in each case, and oral argument will be heard by the court the 25th of this month. Much depends upon the results of these cases. The State has, and will use, every means at her command to stop the unlawful waste of one of its most valuable resources.

The people living in eastern central Indiana and the surrounding cities have been privileged to use for the past ten years the cheapest, cleanest and most satisfactory fuel known to man. The supply is limited. Its life depends upon how it is used in the future. With these facts in mind, and the history of other fields, and the past of this field an open book, how much longer will the people living in the gas belt remain indifferent to the present extravagant use and waste of this fuel?

So great has been the waste from oil wells during the past year that other classes of waste seem comparatively insignificant. In some cases this extraordinary waste, which we hope to suppress soon, has been used as an excuse for the extravagant use and waste in other localities; while in other instances it has served to arouse gas consumers to the true situation, and the necessity for a combined exertion toward husbanding the gas supply.

I think it will be conceded that no one is more vitally interested in the future of the natural gas industry than are the manufacturers of the gas belt. Its fuel resources were the principal incentives for the location of a majority of the gas belt factories. Numerous manufacturing institutions are enjoying an unexampled prosperity on account of the small fuel expense. Considering all the conditions, we have a right to expect them to set the example and to practice all the economy possible in the use of one of the chief agents of their prosperity, and yet, in not a few instances, quite the reverse is found to be true. To charge all manufacturers with wasting gas or even using it extravagantly would not be just, but an examination will convince any one that a majority use more for both fuel and light than is necessary.

It can not be said that manufacturers do not know and appreciate the value of gas as a heat-producing power. This extravagant use of fuel can not be charged to a lack of knowledge of conditions, except, probably, in a very few instances, but to a number of causes. As I have said before, the "free gas" idea that was held before manufacturers so long has had a bad influence. The seeming abundance at the point of consumption, the heavy draught that some wells have honored for years, and the small cost of the same, if not free, is responsible in no small degree for the prodigality in the use of gas in some localities. To refer to the mistakes in the past, however, is of little use, unless the future is profited thereby.

One of the chief avenues of waste in the factories of the gas belt is the lighting system in general use. Most of the factories are lighted with natural gas, and the burner used in many instances is simply the open end of a small pipe. Natural gas as an illuminant is not a success. It produces a very poor light, and when its value as a fuel is considered, it is expensive. That it is convenient for this purpose when used as a fuel is the most that can be said in its favor. Some of the larger manufacturing institutions have substituted electric lights for it. I realize that this is not practicable in some of the smaller factories, nor is the use of domestic lights any more so. However convenient or necessary it is to use natural gas for lighting purposes, I am quite sure that it is entirely unnecessary to allow large and wasteful torches to burn night and day, in all departments of the factory, whether operating or not. It is not always the largest burner or the one that consumes the most gas that makes the best light. Economical burners should be used and all lights turned out when not in use.

Of the many factories that I have visited the past year, but few were securing perfect combustion. In some instances the burners, mixers, etc., were so unscientific and ill-arranged that perfect combustion was not possible. Even if the apparatus for consuming natural gas is scientific in its construction and properly arranged, it needs constant care to insure the best results. Then, what the natural gas industry needs most in this line, is that all fuel consumers ascertain the true condition of the supply and its value to them and the public and apply business principles to the question.

Before leaving this subject I desire to say that there are a few manufacturers in the gas belt, and the number is increasing, that fully appreciate the value of this fuel and use it accordingly. They exercise the same care in the use of their fuel that they do in the use of any other ingredient of their manufactured product. They would as soon waste one as the other.

The pipe lines within the gas area, including tributary and service lines, are in better condition than at any time during the history of the field. During the last two years most of the lines have been thoroughly overhauled. Pipe with the most approved joints has taken the place of the lead joint pipe that had been in service for a number of years, and where the pipe was not changed the joints have been carefully inspected, and air-tight clamps used where necessary. The repairs made have usually been of a permanent nature, and I anticipate but little trouble from pipe-line leaks in the future.

The chief trouble from this source has usually come from small lines, "farmer lines," service lines, etc. Hundreds of miles of this kind of pipe thread the "gas belt." Much of it belongs to small co-operative plants in the rural districts, and with these it is frequently very difficult to fix the responsibility for the bad condition of the lines. Natural-gas leaks along the highway are not only wasteful and dangerous to the public, but damaging to the pipe. The sulphuretted hydrogen contained in the gas is absorbed by the water and oxidized by contact with air to sulphuric acid, which readily attacks the pipe, forming sulphate of iron or copperas. The above acid attacks the pipe to such a degree that it is often eaten entirely through. These small lines have been the source of much trouble during the past, and I realize how difficult it is to keep small pipes lying on top of the ground, subject to a varying temperature, in repair. Watchfulness and prompt action is the only remedy. A number of gas companies keep men whose sole duty is to keep the lines in repair. This is advisable.

In the early history of the gas field one of the greatest avenues of waste was the hundreds of flambeaux permitted to burn throughout the gas belt night and day. There were sections of the field in which every village street, highway and farm yard were illuminated with natural gas torches. The amount of gas consumed by these lights was simply enormous. Not unfrequently was the gas allowed to burn at well pressure from the open end of a one-inch pipe; in fact, the volume of gas had to be strong enough to create a flame capable of resisting the wind and rain, or the flambeau would be of no value, and even the largest flambeau made a very unsatisfactory light. For most purposes a "jumbo" burner, enclosed in a glass globe, gives a better light, and does not consume over one-sixtieth of the gas consumed by an average flambeau. To prevent this great waste of the fuel resources of the State, the General Assembly of 1891 enacted a law prohibiting the use of natural gas in flambeaux, and prescribing how it may be used as an illuminant.* This law encountered much opposition from the beginning. Public sentiment was so opposed to it that it was almost impossible to successfully enforce it. When an effort was made to do the same, its constitutionality was questioned.

Soon after taking charge of this department I caused a suit to be brought in Blackford County to enforce this law. In the Circuit Court the defendants entered a motion to quash the affidavit, and thereby attacked the constitutionality of the law. The court overruled the motion to quash. The case was appealed to the Supreme Court, and in a very short time afterward that Court rendered a unanimous decision holding the law constitutional and enunciating the following propositions of law:

First—Natural gas, in its original state, is wild by nature, and, like game, fish and birds, belongs to the sovereign.

Second—When lawfully brought to the service and reduced to subjection and control, it becomes the property of him who produces it.

Third—Being the property of the sovereign, the Legislature, which is the representative of the sovereign people, may prescribe such regulations as it may choose, with reference to the development and production of natural gas, or may prohibit its production at all, as it may prohibit the taking of certain game, the preservation of which it deems important to the general welfare.

Fourth—Natural gas is an explosive and poisonous substance, and as such is subject to the police control of the State, under which the Legislature may, by law, surround its use and protection with such safeguards as may be deemed necessary to insure the safety of persons and property.

Fifth—Being within the police power, both in its character as property and in its quality as a dangerous element, the Legislature and not the courts, is the exclusive judge of what restrictions are necessary and reasonable in the premises.

Sixth—The Legislature has a right not only to prohibit waste, but to determine what acts shall constitute waste of natural gas, and the determination of such question is not an usurpation of judicial power, but is properly an exercise of legislative discretion.

Seventh—The right to regulate the use of natural gas, under its police power, exists not only because of its physical characteristics, and its primary ownership, but rests on the principle that whatever affects the general welfare of the people is a subject of police supervision.

* Acts 1891, p. 55.

Eighth—Nor is the operation of the police power confined, as has been frequently contended, to questions of public morals, public safety, or the public health, and kindred subjects; but it embraces equally everything that affects the general commercial welfare of the State.

Though the violation of this law has caused but little trouble since the decision of the Supreme Court, it is but just to say that even before the courts had decided the above case a change had been wrought in the public mind. The law had begun to be looked upon with more favor.

THE FUTURE OF THE GAS BELT.

What will be the future history of the Indiana natural gas field? How long will natural gas last? These have been the regulation questions for the last five years, and doubtless will be until the history of the field is completed. There are persons at this late day who believe that the supply of natural gas will be sufficient for this generation. That so many people in the past have been, or seemed to be, at least, wholly indifferent to the way natural gas has been used, is not surprising. A very small per cent. of all the consumers of this fuel have given any thought to either the theoretical or practical phases of the natural gas question. They have been gas consumers, and that is all. Few there are, indeed, that are prepared to defend any particular theory accounting for the generation, storage and pressure of this gaseous fuel. In most localities there has been plenty of gas to date. The service during the past two years has been better than at any time previous, owing, in most cases, of course, to the improved facilities for transporting, distributing and controlling the gas. Those that know nothing about natural gas, except what they learn at the point of consumption, are ill-prepared to judge of the future, and those who have a good knowledge of the field know but little except that the supply is failing. Occasionally some one will venture to inform you how long gas will last, but usually these persons are compelled to revise their opinions from year to year, as unforeseen conditions arise. Natural gas was first used as a fuel in the Indiana field in 1886. For eleven years it has stood an enormous draught. The field did not show any material signs of exhaustion until 1890. Since that time the evidence has been accumulating. Salt water is the most aggressive enemy with which the natural gas field has to contend. It made its appearance at the edge of the field, and is advancing towards the center. Where it has completely overrun the gas territory the wells are no longer productive. The heavier the draught, the more intrusive is the salt water. The area in the heart of the field in which wells free from this agent can be found is comparatively small, and is decreasing in size yearly. The time when the entire field will succumb to its influence can not be far distant. Eleven years ago the rock pressure of the entire field was 325 pounds. Now the average pressure of the productive area, which is very much less than the original gas field, is less than 200 pounds. The average yearly decrease during the past three years has been 20 pounds, the decrease for the past year being near 25 pounds. And in connection with the above it is safe to say that a majority of the wells of the field will cease to be serviceable when the rock pressure reaches 100 pounds. This estimate is too low rather than too high. As the supply decreases, and the price advances, the consumption will naturally become lighter. Factories will use gas only where it is absolutely necessary, and supplement with other fuel; and, finally, when natural gas is used only for domestic purposes, those that can afford it will use it for a considerable time after it has ceased to be a manufacturing fuel, or even a universal domestic fuel.

A LIST OF NATURAL GAS COMPANIES IN INDIANA JAN. 1, 1898.

ALLEN COUNTY.

Ft. Wayne Natural Gas Co., Ft. Wayne.

BLACKFORD COUNTY.

Baily Natural Gas Co., Hartford City.
Citizens' Natural Gas Co., Montpelier.
E. C. Storms Natural Gas Co., Roll.
Hartford City Natural Gas and Oil Co., Hartford City.
Linbark Gas and Oil Co., Dunkirk.
Marion Creek Natural Gas Co., Priam.
Millgrove Natural Gas Co., Millgrove.
Montpelier Natural Gas, Oil and Mining Co., Montpelier.
Peck Natural Gas Co., Hartford City.
People's Natural Gas Co., Hartford City.
Trenton Natural Gas Co., Priam.
Walnut Street Natural Gas Co., Hartford City.

CLINTON COUNTY.

Indiana Natural and Illuminating Gas Co., Indianapolis.
Terhune and Kirkland Natural Gas Co., Kirkland.

DECATUR COUNTY.

Citizens' Gas Co., Greensburg.
Consumers' Natural Gas Co., St. Paul.
Fourth Ward Natural Gas Co., Greensburg.
Greensburg Natural Gas, Oil and Water Co., Greensburg.
Hamilton Natural Gas Co., Greensburg.
Muddy Fork Natural Gas Co., Greensburg.
St. Paul Oil, Gas and Water Co., St. Paul.
Newton Natural Gas Co., Greensburg.

DELAWARE COUNTY.

Buck Creek Natural Gas Co., Muncie.
Cammack Natural Gas and Mining Co., Cammack.
Compromise Natural Gas Co., New Burlington.
Cleveland Gas Co., DeSoto.
Co-operative Gas, Light and Fuel Co., Yorktown.
Co-operative Fuel and Gas Light Co., Gaston.
Co-operative Natural Gas Co., Daleville.
Cowan Exploring and Gas Co., Cowan.
Delaware Natural Gas and Mining Co., Albany.
DeSoto Natural Gas and Mining Co., DeSoto.
Eaton Mining and Gas Co., Eaton.
Farmers' Natural Gas and Petroleum Oil Co., Yorktown.
Farmers' Natural Gas and Oil Co., Albany.
Granville Citizens' Natural Gas Co., Granville.
Gaston Gas and Mining Co., Gaston.
Manufacturers' Fuel Gas Co., Muncie.
Manufacturers' Natural Gas Co., Muncie.
Muncie Natural Gas Co., Muncie.
Niles Natural Gas Co., Dunkirk.
Oakville Natural Gas Co., Oakville.
Reed Station Natural Gas Co., Reed Station.
Ross & Fullheart Gas Co., Muncie.
Royerton Natural Gas Co., Royerton.
Selma Natural Gas Co., Selma.
Mutual Natural Gas Co., Gaston.
Walker Natural Gas and Oil Co., Gilman.
Yorktown Natural Gas and Oil Co., Yorktown.

FAYETTE COUNTY.

Connersville Natural Gas Co., Connersville.

GRANT COUNTY.

Arcana Gas Co., Arcana.
Barren Creek Gas Co., Fairmount.
Citizens' Gas Co., Gas City.
Citizens' Gas Co., Fairmount.
Citizens' Gas Co., Swayzee.

Citizens' Gas Co., Marion.
Deer Creek Mining Co., Hackleman.
Fairmount Mining Co., Fairmount.
Fowler Gas Co., Fowler.
Haw Run Gas Co., Roseburg.
Herbst Natural Gas and Mining Co., Herbst.
Jadden Gas Co., Jadden.
Jonesboro Mining Co., Jonesboro.
Lake Branch Mining Co., Upland.
Landessville Gas Co., Landessville.
Mississinewa Mining Co., Marion.
New Cumberland Mining and Gas Co., New Cumberland.
Pipe Creek Natural Gas Co., Roseburg.
Roseburg Natural Gas Co., Roseburg.
Swayzee Mining Co., Swayzee.
Triumph Gas Co., Fairmount.
Sweetser Natural Gas Co., Sweetser.
Upland Mining Co., Upland.

HANCOCK COUNTY.

California Natural Gas Co., Maxwell.
Citizens' Natural Gas Co., Greenfield.
Cushman Natural Gas Co., Fortville.
Don's Natural Gas Co., Fortville.
Farmers' Natural Gas Co., McCordsville.
Fortville Natural Gas Co., Fortville.
Gilboa Natural Gas Co., Cleveland.
Greenfield Natural Gas Co., Greenfield.
Independence Natural Gas Co., Greenfield.
McCordsville Natural Gas Co., McCordsville.
Mohawk Natural Gas Co., Mohawk.
Scrabbletown Natural Gas Co., Wilkinson.
Vernon Natural Gas Co., Fortville.
Westland Natural Gas Co., Westland.
Wilkinson Natural Gas Co., Wilkinson.
Willow Branch Natural Gas Co., Willow Branch.

HAMILTON COUNTY.

Atlanta Natural Gas Co., Atlanta.
Bethlehem Natural Gas and Oil Co., Cicero.
Big Springs Natural Gas Co., Big Springs.
Buffalo Corner Natural Gas Co., Arcadia.
Carmel Natural Gas Co., Carmel.
Central Gas Co., Westfield.
Cicero Natural Gas Co., Cicero.
Citizens' Natural Gas Co., Atlanta.
Citizens' Natural Gas and Oil Co., Jolietville.
Clarksville Natural Gas Co., Clarksville.
Fall Creek Township Natural Gas Co., Fisher's Switch.
Hortonville Natural Gas Co., Hortonville.

Keck Natural Gas Co., Omega.
Noblesville Natural Gas and Improvement Co., Noblesville.
Nora Natural Gas Co., Nora.
Olio Natural Gas and Oil Co., Olio.
Stony Creek Natural Gas Co., Noblesville.
Strawtown Natural Gas Co., Strawtown.
Westfield Gas and Milling Co., Westfield.

HENRY COUNTY.

Cadiz Natural Gas Co., Cadiz.
Central Natural Gas Co., Cadiz.
Citizens' Natural Gas Co., Knightstown.
Citizens' Natural Gas Co., Middletown.
Enterprise Natural Gas Co., New Castle.
Farmers' Free Gas Co., Mt. Summit.
Farmers' Natural Gas Co., Middletown.
Farmers' Natural Gas Co., Spiceland.
Gronendyke Natural Gas Co., Middletown.
Honey Creek Natural Gas Co., Honey Creek.
Kennard Natural Gas Co., Kennard.
Knightstown Natural Gas Co., Knightstown.
Mechanicsburg Natural Gas Co., Mechanicsburg.
Montgomery Creek Natural Gas Co., Greensboro.
Moreland Natural Gas Co., Moreland.
Ogden Natural Gas Co., Ogden.
Spiceland Natural Gas Co., Spiceland.
Sulphur Springs Natural Gas Co., Sulphur Springs.
Welcome Natural Gas Co., Knightstown.

HOWARD COUNTY.

Flabby Natural Gas Co., Plevna.
Greentown Natural Gas Co., Greentown.
Howard Natural Gas, Oil, Mining and Pipe Line Co., Sycamore.
Jerome Natural Gas Co., Jerome.
Kokomo Natural Gas and Oil Co., Kokomo.
J. M. Leach Natural Gas Co., Kokomo.
Liberty Natural Gas Co., Plevna.
Manufacturers' Pipe Line Co., Kokomo.
Pittsburg Plate Glass Co., Kokomo.
Sycamore Natural Gas Co., Sycamore.

HUNTINGTON COUNTY.

Huntington Light and Fuel Co., Huntington.
Warren Natural Gas Co., Warren.

JAY COUNTY.

Citizens' Natural Gas and Oil Co., Portland.
Dunkirk Natural Gas and Oil Co., Dunkirk.
Pennville Natural Gas and Oil Co., Pennville.

Portland Natural Gas and Oil Co., Portland.
Red Key Natural Gas and Oil Co., Red Key.
Richmond Natural Gas and Oil Co., Red Key.

MADISON COUNTY.

Alexandria Mining and Exploring Co., Alexandria.
Alfont Natural Gas and Oil Co., Alfont.
Bear Creek Natural Gas Co., Perkinsville.
Citizens' Natural Gas Co., Anderson.
Citizens' Natural Gas and Mining Co., Elwood.
Citizens' Natural Gas Co., Summitville.
County Line Natural Gas and Oil Co., Ingalls.
Dyar's Creek Gas and Oil Co., Lapel.
Elwood Natural Gas and Oil Co., Elwood.
Fall Creek Natural Gas Co., Hamilton.
Farmers' Mutual Gas Co., Summitville.
Foster's Branch Natural Gas Co., Hamilton.
Green Township Natural Gas Co., Hamilton.
Gilman Natural Gas Co., Gilman.
Hardman Natural Gas and Oil Co., Markelville.
Lapel Natural Gas and Oil Co., Lapel.
Markelville Natural Gas and Oil Co., Markelville.
Mendon Natural Gas and Oil Co., Mendon.
Perkinsville Natural Gas and Oil Co., Perkinsville.
Pendleton Natural Gas Co., Pendleton.
Summitville Mining Co., Summitville.
Victory Natural Gas and Oil Co., Summitville.

MARION COUNTY.

Consumers' Gas Trust Co., Indianapolis.
Indianapolis Natural Gas Co., Indianapolis.
Manufacturers' Natural Gas Co., Indianapolis.
United States Encaustic Tile Co., Indianapolis.

MIAMI COUNTY.

North Grove Natural Gas Co., Peru.
Xenia Natural Gas and Pipe Line Co., Converse.

RANDOLPH COUNTY.

Citizens' Natural Gas Co., Parker.
Eastern Indiana Natural Gas and Oil Co., Union City.
Elkhorn Natural Gas Co., Farmland.
Farmland Natural Gas Co., Farmland.
Lynn Natural Gas Co., Lynn.
Parker Natural Gas Co., Parker.
Rock Oil Co., Winchester.
Windsor Natural Gas Co., Windsor.
Ridgeville Natural Gas Co., Ridgeville.

RUSH COUNTY.

Big Four Natural Gas Co., Carthage.
Carthage Natural Gas Co., Carthage.
Citizens' Natural Gas Co., Manilla.
Farmers' Natural Gas Co., Mays.
Five Points Natural Gas Co., Sexton.
Hackleman Natural Gas Co., Mays.
Homer Natural Gas Co., Homer.
Manilla Natural Gas Co., Manilla.
Milroy Natural Gas Co., Milroy.
Peoples' Natural Gas Co., Rushville.
Riverside Natural Gas Co., Rushville.
Rushville Natural Gas Co., Rushville.
Rushville Fuel Co., Rushville.
Walnut Ridge Natural Gas Co., Carthage.
Walker Natural Gas Co., Carthage.

SHELBY COUNTY.

Citizens' Natural Gas Co., Shelbyville.
Fountaintown Natural Gas Co., Fountaintown.
Morristown Natural Gas Co., Morristown.
Southern Indiana Natural Gas Co., Shelbyville.
Waldron Natural Gas Co., Waldron.

TIPPECANOE COUNTY.

Lafayette Natural Gas Co., Lafayette.

TIPTON COUNTY.

Citizens' Natural Gas Co., Tipton.
Citizens' Natural Gas Co., Windfall.
Lutz Natural Gas Co., Goldsmith.
Tipton Line and Improvement Co., Tipton.
Tipton Light, Heat and Power Co., Tipton.
Windfall Natural Gas, Oil and Mining Co., Windfall.

WABASH COUNTY.

Lafontaine Natural Gas and Oil Co., Lafontaine.
Somerset Natural Gas and Oil Co., Wabash.

WAYNE COUNTY.

Hagerstown Natural Gas Co., Hagerstown.
Richmond Natural Gas Co., Richmond.

MISCELLANEOUS.

Central Contract and Finance Co., Lima, Ohio.
Indiana Natural Gas and Oil Co., Chicago, Ill.
Logansport and Wabash Valley Gas Co., Lafayette, Ind.
Ohio—Indiana Gas Co., Lima, Ohio.

REPORT OF STATE INSPECTOR OF MINES FOR 1897.

LETTER OF TRANSMITTAL.

PROF. W. S. BLATCHLEY,

State Geologist of Indiana:

I transmit herewith my third annual report as Inspector of Mines. I have endeavored to cover all the points required by law to be included therein, but it is unsatisfactory in some respects, owing to the reluctance of mine operators to furnish necessary data which can be obtained in no other way. This has compelled me to make some estimates which I can not claim to be accurate, notably the amount of capital invested, and the cost and character of improvements made during the year.

ROBERT FISHER,

Inspector of Mines.

Indianapolis, Ind., Jan. 15, 1898.

Report of Inspector of Mines

TO THE STATE GEOLOGIST.

1897.

ROBERT FISHER, Inspector.
JAMES EPPERSON, Assistant.

REPORT.

The first attempt at legislative control of coal mining in Indiana was by an act passed by the Fifty-first General Assembly, approved March 8th, 1879, though the industry had assumed considerable importance prior to that time. The first report submitted, by Herbert H. Richards, showed a total of 177 mines in 17 counties; employes, 3,459; coal produced, 1,196,490 tons of 2,000 pounds, and a capital invested of $1,135,562. Of the mines reported, 115 employed less than ten men, leaving but 62 employing more than that number. Three hundred and eighty-eight of the 3,459 employes were employed in those small mines, and 3,071 employed in such mines as are now affected by the law in force, an average of nearly 50 men in each mine. Under the law then in force no mines were exempt from its operation. Now, the law does not apply to the mines employing less than ten men. During the year 1897 there were in operation in the State a total of 137 mines employing over ten men, with a total of 7,636 employes, and a production of 4,078,085 tons, from mines employing ten or more men.

The average production per employe in the 62 larger mines was 370.8 tons in 1879, while in 1897 the average per employe was 535 tons. The increase in average production in spite of the prolonged strike, referred to elsewhere, is to be accounted for by the increased use of powder in the mining of coal and the use of machinery for mining and handling the coal. These points will be referred to at greater length later in this report. The facts stated above will give some idea of the development of the industry in Indiana during the past 18 years. While this has been great, we have not kept pace with our sister States in this respect. Illinois, Ohio and West Virginia have been especially active in increasing their production of coal during the past ten years, and have entered markets which were previously considered as belonging peculiarly to the Indiana fields.

From 1879 to 1891 no assistant was provided by law, the Inspector being required to do both the field and office work. This prevented him from visiting the mines as frequently as was necessary for the proper enforcement of the law. When recommendations were made or orders given for changes or improvements, his duties would not permit a return visit to learn whether or not they had been complied with, and many mine foremen took advantage of this fact to refuse to improve their mines. The Legislature in 1891 provided for the appointment of an Assistant Inspector, with a stated salary, but provided for an appropriation for expenses for both officers of only Three Hundred Dollars per year. This was totally inadequate to pay office and traveling expenses, and the result was that the Inspectors did the work that could be done with the least expense, and mines which were not convenient to visit were to a certain extent neglected. These facts account, to some extent, for the slow progress that has been made in improving the conditions of our mines, and cause us to feel like congratulating ourselves that so much advance has been made. The last General Assembly made an appropriation of One Thousand Dollars per year for the expenses of the Inspector and his assistant, which took effect on Nov. 1st, 1897. We hope to be able to do more effective work during the remainder of our term than has been done heretofore.

During the year under review our work in inspecting mines has been interrupted from a variety of causes. Feeling the necessity for the amendment of the law relating to mines in several respects, some of which have been suggested by my predecessors in every report since 1880, I spent considerable time in Indianapolis during the session of the Legislature endeavoring to secure the passage of such laws as I considered necessary, to the partial neglect of some of my other duties. I refer to this at length in another part of this report. The enactment of some of those amendments added greatly to the office work of my position, especially those requiring maps of mines to be filed, and requiring the examination of Mine Bosses, Fire Bosses and Hoisting Engineers. These laws took effect July the 15th, and nearly my whole time during the month of May was taken up with examinations and correspondence in relation to them and to other of the amendments to the law. On July 4th a general strike of the miners of the State took place, and no systematic examination of the mines affected was possible until its conclusion, which occurred September 14th.

Since then so many mines have required examination that it has been impossible to make the number of visits necessary to assure compliance with the law where it was being violated, as prosecutions, in most cases, can be commenced only after giving notice of defects, and a reasonable time to remedy them. However, at the close of the year there are but few mines in the State which are not in fairly good condition, although those that could be passed without comment on some failure to fulfill the law are very few. Under appropriate heads, I notice Legislation, Examinations, Mine Maps, Improvements, Inspections, New Developments, Accidents, Operators and Employes, Production, and Wages, and other matters properly included in my annual report.

The following have been the Inspectors under the law:

Herbert H. Richards	1879—1881.
Thomas Wilson, Jr.	1881—1885.
Thomas McQuade	1885—1889.
Thos. R. Tislow	1889—1891.
Thomas McQuade	1891—1895.
Robert Fisher	1895—

And the following have been assistants:

Welman A. Lackey	1891—1892.
Michael Comiskey	1892—1894.
Barney Martin	Jan. 1 to Mar. 15, 1895.
Wm. McCloud	Mar. 15 to Dec. 1, 1895.
James Epperson	Dec. 1, 1895—

Since the creation of the office its incumbents have been handicapped by reason of the amount of territory to be covered with the force of Inspectors, and inadequate provision for the necessary traveling and other expenses incident to the proper performance of the work to be done.

The report for 1879 notes that a ventilating fan had been placed in position by the Brazil Block Coal Company, at one of their mines, presumably the first that had been used in the State. At present there are but few mines in Indiana that depend on any other means of ventilation, as will be seen by reference to the descriptions of the different mines. This is the most efficient means that has been devised of forcing a current of air through a mine, and its use shows the progressive spirit of our operators. In this respect we compare favorably with any other State whose reports I have examined. I am sorry to say that in many cases the underground management of mines has been entrusted to persons whose knowledge of the business is deficient, and that I am compelled to repeat a remark made by Mr. Richards. Referring to mine bosses, he says: "Many of them, having the means of good ventilation directly under their control, having a good supply of fresh air at the intake, yet leave the rooms of the workmen practically without air." While this is still true to some extent, there has been great progress in this direction, and the proportion of such mines and mine bosses is much smaller than he had to report. This refers, of course, to those that come under the observation of the Inspectors. In the small mines a great deal of the work is done on the haphazard plan of getting the most with the least present expense and letting the future care for itself. We usually find the effects of this when a mine that has been run with a small capacity increases its force of men sufficiently to bring it under our jurisdiction.

LEGISLATION.

As noted in closing my last annual report, several recommendations were made for amendments to the mining legislation of the State of Indiana. As there were but few, if any, members of the Legislature who had a practical knowledge of the working of coal mines, it became necessary for me to spend the larger part of my time, while the session continued at the Capitol, explaining the necessity of the proposed legislation, and urging favorable action upon the bills which were introduced for the better regulation of the mining industry. The committees in both Houses to whom they were referred were impressed with their importance and took prompt action upon them. All of the members of the Committee on Mines in the House and of that on Mines and Manufactures in the Senate were active in securing favorable consideration and final passage of each of them, and but for the pressure of other business at the close of the session I feel confident that each of my recommendations would have found a place upon the statutes of the State. Those recommendations were as follows:

1. Making better provision for communication between the working places of the mine and the escape ways.

2. That the Inspector of Mines shall be notified immediately when any serious accident occurs at a coal mine.

3. Providing that each mine owner shall make (or have made) a map of his mine, and furnish a copy to the Inspector of Mines.

4. Providing for the examination of Mine Bosses, Fire Bosses, and Hoisting Engineers.

5. Providing for the use of a pure oil for illuminating purposes in mines.

6. Providing for the inspection of mines employing less than ten men.

The bills prepared by this office, covering the first four of these subjects, were, after having been amended in some particulars, passed by both Houses and signed by the Governor. Copies of the acts are given below:

(Acts 1897, Page 226.)

AN ACT to amend an act entitled, "An act providing the means for securing the health and safety of persons employed in coal mines, providing penalty for the violation thereof, and repealing all laws and parts of laws in conflict therewith."

(Senate 154. Approved March 8, 1897.)

Section 1. Be it enacted by the General Assembly of the State of Indiana, That section 1 of the above entitled act, the same being section 5459 of Horner's Revised Statutes of 1896, be amended as follows:

Section 1. That it shall be unlawful for any owner, agent or operator to allow more than ten persons to work in any shaft, slope or drift at any one time after five thousand square yards have been excavated until a second outlet shall have been made. The said outlet or manway, and all approaches thereto, shall be separated from the hoisting shaft and its approaches by at least one hundred feet in width of natural strata, and shall be available at all times to all employes engaged in such mine, and that for every shaft used as a manway there shall be provided stairways at an angle of not more than sixty degrees, with landings at easy and convenient distances, and with guard rails attached to each set of stairs from the top to the bottom of the same: Provided, That, where such shaft shall be more than one hundred and fifty feet deep, the operator, owner or agent may elect to provide at such outlet or manway a hoisting apparatus, which shall be at all times available to miners and other employes of the mine, the same signals to be used as provided by law for use at hoisting shafts. The traveling roads or gangways to said outlet shall be not less than the height of the vein worked, and four feet wide, and shall be kept as free from water as the average hauling roads in such mines. All water coming from the surface or out of any strata in such shaft shall be conducted by rings, or otherwise, to be prevented from falling down the shaft so as to wet persons who are ascending or descending the shaft.

(Acts 1879, Page 168.)

AN ACT to amend sections 12, 14, 17 and 24 of an act regulating the weighing of coal, providing for the safety of employes, protecting persons and property injured, providing for the proper ventilation of mines, prohibiting boys and females from work in mines; conflicting acts repealed, and providing penalties for violation, in force June 3, 1891, the same being sections 5480M, 5480O, 5480R, 5480Y of the Revised Statutes of 1896.

(S. 195. Approved March 6, 1897.)

Section 1. Be it enacted by the General Assembly of the State of Indiana, That section fourteen (14) be and is hereby amended to read as follows:

Section 14. That whenever any accident whatsoever shall occur in any coal mine in this State which shall delay the ordinary and usual working of such mine for twenty-four consecutive hours, or shall result in such injuries to any person as to cause death or require the attendance of a physician or surgeon, it shall be the duty of the person in charge of such mine to notify the Inspector of Mines of such accident without delay, and it shall be the duty of said Inspector to investigate and ascertain the cause of such accident as soon as his official duties shall permit: Provided, That if loss of life shall occur by reason of any such accident said Inspector shall immediately, with the Coroner of the county in which such accident may have occurred, go to the scene of the accident. They shall investigate and ascertain the cause of such loss or life and have power to compel the attendance of witnesses and administer oaths or affirmation to them and the cost of such investigation shall be paid by the county in which the accident occurred, as costs of Coroner's inquests are now paid.

Sec. 2. That section 17 of said act, the same being section 5480R, of the Revised Statutes of 1896, be amended to read as follows:

Section 17. That the currents of air in mines shall be split so as to give separate currents to at least every fifty (50) persons at work, and the Mine Inspector shall have discretion to order a separate current for a smaller number of men if special conditions render it necessary. Whenever the Mine Inspector shall find men working without sufficient air, or under any unsafe condition, the Mine Inspector shall first give the owner, operator, agent or lessee a notice giving the facts and a reasonable time to rectify the same, and upon his or their failure to do so the Mine Inspector may order the men out of said mine or portion of said mine, and at once order said coal mine, or part thereof, stopped nntil such mine or part of mine be put in the proper condition. And the Mine Inspector shall immediately bring suit against such owner, operator, agent or lessee for failure to comply with the provisions of this section, who, upon conviction, shall be fined in any sum not exceeding one hundred dollars ($100) for each and every day or part of day that said mine was operated.

Sec. 3. That section 24 be amended to read as follows:

Section 24. That for the violation of the provisions of any section of this act, where no special penalty is provided herein, the person or persons violating the same or any part thereof shall be held and deemed guilty of a misdemeanor, and shall, upon conviction, be fined in any sum not less than five dollars ($5.00) nor to exceed two hundred dollars ($200) in the discretion of the Court trying the cause.

Sec. 4. That section 12 of said act, being section 5480M of the Revised Statutes of 1896, be and the same is hereby amended to read as follows:

Section 12. That the Mining Boss shall visit and examine every working place in the mine at least every alternate day while the miners of such place are, or should be at work, and shall examine and see that each and every working place is properly secured by props and timber and that safety of the mine is assured. He shall see that a sufficient supply of props and timber are always on hand at the miners' working places.

He shall also see that all loose coal, slate and rock overhead wherein miners have to travel to and from their work are carefully secured.

Whenever such Mine Boss shall have an unsafe place reported to him he shall order and direct that the same be placed in a safe condition; and until such is done no person shall enter such unsafe place except for the purpose of making it safe. Whenever any miner working in said mine shall learn of such unsafe place he shall at once notify the Mining Boss thereof and it shall be the duty of said Mining Boss to give him, properly filled out, an acknowledgment of such notice of the following form:

I hereby acknowledge receipts of notice from .... of the unsafe condition of the mine as follows ...., dated this ...... day of ...., 18.....

........................Mining Boss.

The possession by the miner of such written acknowledgment shall be the proof of the receipt of such by said Boss whenever such question shall arise; and upon receipt of such notice such Mine Boss shall at once inspect such place and proceed to put the same in good and safe condition. As soon as such unsafe place has been repaired to the approval of such Boss, he shall then give permission for men to return to work therein, but no miner shall return to work therein until such repair has been made and permission given.

(Laws 1897, Page 269.)

AN ACT to compel owners of coal mines to make maps of mines, to file copies of the same with the Inspector of Mines, to make monthly reports of certain matters to said Inspector, providing a penalty for failure to comply with its provisions, and providing an office for the said Inspector.

(House 366. Approved March 8, 1897.)

Section 1. Be it enacted by the General Assembly of the State of Indiana, That within three months from the time this act takes effect the owner, operator or agent of each coal mine shall make or cause to be made, an accurate map or plan of the working of such mine on a scale of not less than one inch to one hundred feet, showing the area mined or excavated, the arrangement of the haulage roads, air-courses, break-throughs, brattices, air-bridges and doors used in directing the air current in such mine, the location and connection with such excavation of the mine, of the lines of all adjoining lands, with the names of the owners of such land, so far as known, marked on each tract of land. Said maps shall show a complete working of the mine and, when completed, shall be certified to by the owner, agent or engineer making the survey and map, to be a true and correct working map of said mine. The owner or agent shall deposit with the Inspector of Mines a true copy of such map within thirty days after completion of the survey for the same, the date of which shall be shown on such copy, the original map and survey to be kept at the office of such mine, open for inspection of all interested persons at all reasonable times. Such map shall be corrected each year between the first day of May and the first day of September, and a new map and copy of the same shall be filed as required in the original survey, or the original map may be so amended as to show the exact workings of the mine at the date of the last survey.

Sec. 2. In case the owner, agent or operator of any coal mine shall fail or refuse to comply with the provisions of section one (1) of this act, it shall be the duty of the Inspector of Mines to appoint a competent Mining Engineer to make the survey and maps, and file and deposit them as required by said section one (1), and for his services he shall be entitled to a reasonable fee, to be paid by the party whose duty it was to make such survey and map, and shall be entitled to lien on the mine and machinery to the same extent as is now provided by law for other work and labor performed in and about the coal mines of this State.

Sec. 3. That the owner, operator or agent of every coal mine of the State shall be and is hereby required to report to the Inspector of Mines on or before the 15th day of each calendar month the name of the person in charge of such mine, the number of tons of coal produced at such mine during the preceding month, the amount of wages paid employes during such month, the amount of money expended for improvements during the said month, together with such other information as may be necessary to enable said Inspector to prepare his annual report as is now required by law.

Sec. 4. That any person who shall fail, refuse or neglect to do or perform any act or duty required by this act shall be held guilty of a misdemeanor and upon conviction shall be fined in any sum not less than five nor more than twenty-five dollars.

Sec. 5. That in order that maps, reports and other records pertaining to the office of Inspector of Mines may be properly preserved, a room in the State House shall be set aside and furnished in a suitable manner as an office for said officer.

Sec. 6. Provided, That the provisions of this act shall apply to all coal miners in this State except to those employing less than ten men.

(Acts 1897, Page 127.)

AN ACT to provide for the examination of mine bosses, fire bosses and hoisting engineers of coal mines, for issuing certificates of competency or service, prohibiting the employment of persons in either of such capacities without such certificate, and providing penalties for violation of the provisions of this act.

(S. 308. Approved March 4, 1897.)

Section 1. Be it enacted by the General Assembly of the State of Indiana, That after three months from the taking effect of this act, it shall be unlawful for any person to serve in the capacity of mine boss, fire boss or hoisting engineer at any coal mine in this State without having first received from the Inspector of Mines a certificate of service or of competency as hereinafter described and provided.

Sec. 2. That certificates of service shall be issued by the Inspector of Mines to any person who shall furnish satisfactory proof that he has been engaged as, and has successfully discharged the duties of mine boss, fire boss or hoisting engineer at coal mines in this State for three years preceding the granting of such certificate.

Sec. 3. That certificates of competency shall be issued by the Inspector of Mines to any person who shall prove satisfactorily upon examination, either written or oral, or both, as may be prescribed by such Inspector, that he is qualified by experience and technical knowledge to perform the duties of either mine boss, fire boss or hoisting engineer at the coal mines of the State. Examination for certificates of service or competency shall be public, and open to all citizens of the United States, and at least fifteen days' notice of such examination shall be given by publication in a newspaper published in the city where such examination is to be held. No certificate shall be issued to any person entitling him to serve in more than one of the capacities set out in this section, but two or more certificates may be issued to the same person on proper examination.

Sec. 4. It shall be the duty of the Inspector of Mines to hold examinations for certificates of service and competency within sixty days after this act takes effect in each of the cities of Brazil, Terre Haute, Washington and Evansville, and to publish notice of such examinations as provided in section 3 of this act, stating the time and place where examinations are to be held, and shall make and publish rules and regulations under which such examinations shall be conducted, previous to the first of such examinations.

Sec. 5. It shall be unlawful for any owner, operator or agent of any coal mine in this State to employ in such capacity any person in the capacity of mine boss, fire boss or hoisting engineer, unless such person has a certificate of service or competency as provided in sections 1, 2 and 3 of this act, or to allow any person not having such certificate to continue in his employ in such capacity after three months from the time this act takes effect, unless he has procured such certificate.

Sec. 6. That for the purpose of providing for the expense of holding the examinations and issuing the certificates herein provided for, each applicant, before entering upon examination, shall pay the Inspector of Mines one dollar, a receipt for which must be endorsed upon such certificate before it becomes effective.

Sec. 7. That any person violating any of the provisions of this act shall be guilty of a misdemeanor, and, upon conviction, shall be fined in any sum not less than five dollars nor more than fifty dollars.

The bill providing for the use of pure oil passed the House of Representatives too late to be acted upon in the Senate, and that for the inspection of the smaller mines failed of passage in the House. I wish to return thanks especially to Senators Horner, Humphreys and McCord and Representatives Berry, Henderson and Williams for their efforts in behalf of the above legislation.

The miners of the State wished to have a law enacted providing for a uniform screen at all mines in the State. A bill drawn by their officials was introduced into both Houses and passed by each, but neither House acted on the bill passed by the other before final adjournment, so the law failed to pass. This was intended to take the place of the law passed in 1891 providing for weighing coal before screening, which was declared inoperative by the Supreme Court in the case of Martin vs. The State, 143 Ind., 545. This matter causes a great deal of friction between miners and operators, as screens are of different sizes, and in many instances screens have been changed after the price for mining screened coal had been fixed. By this means more coal is permitted to pass through the screen, causing a virtual reduction in the price paid for mining. On the other hand, those operators whose screens are of a different kind or size than was contemplated by the law claim that it would entail a large expense to make the necessary changes and be a burden to the business. Improvements in coal-handling machinery are introducing rolling and shaking screens, for which it would be very difficult to make provision in a law on this subject that can be made effective, without providing that coal shall be weighed before screening. The States of Illinois and Pennsylvania each enacted a law for this purpose during the past year, but its enforcement is being resisted in both States. When our Legislature again convenes we may have some light on the subject from the courts of those States to enable our lawmakers to frame a law that will give relief from the annoyance that arises from dissatisfaction with the present method of basing the price paid for mining. One of the features of the law passed last winter provides that operators shall make monthly reports of their production to the Inspector of Mines. In the past there has been a great deal of trouble in getting anything near an accurate return of the coal production of the State, as many operators failed or refused to furnish the information. This year there is a marked improvement in this respect, and I hope that next year the returns will be reliable. As the law was effective only eight months of the current year they are not so in the present report. However, the basis for such estimates as were necessary is much broader than it has been in previous years.

EXAMINATIONS.

By an act approved March 5th, 1897, it was made unlawful for any person to perform the duties of a Mine Boss, Fire Boss or Hoisting Engineer without first having received a certificate of service or compentency from the Inspector of Mines. Certificates of service are issued on satisfactory proof of three years' successful service in the position for which the certificate is issued. This office prepared the following form of application for this kind of certificate:

..................Ind., ... 189....

To Robert Fisher, Inspector of Mines for Indiana:

I......................hereby apply for a "Certificate of Service" in the State of Indiana, as provided by section 2, page 127, Acts 1897. I am....years of age, have been employed about mines for....years and have served as................for....years, as follows:

At ....Mine, from............. to.............
At ....Mine, from............. to.............
At ....Mine, from............. to.............

I have successfully discharged the duties of such position, as shown by the annexed "Certificate of Employer" or "Affidavit"—(as the case may be). I here inclose One Dollar Certificate fee, and 4c postage, for which please mail certificate.

...................Applicant.
..........................Ind.

CERTIFICATE OF EMPLOYER.

..................Ind., ... 189....

This is to certify that ....
has been employed by ...... as .... at .... Mine for more than three years last past, has successfully discharged the duties of such position and is still so employed.

Affidavit of two acquaintances—(to be used only in case "Certificate of Employer" in above form can not be obtained).

State of Indiana.....................County, ss.

Personally appeared before me, ...a Notary Public, in and for the County and State aforesaid.............................and

....................known to me to be reputable citizens of said County and State, who being duly sworn, say that they have for more than...... years past been acquainted with....................who is applying for Certificate of Service as................in the State of Indiana, that they have known him to be engaged as a ....in said State for more than three years, as follows, to-wit:

At ....Mine, from............. to..............
At ....Mine, from............. to..............
At ....Mine, from............. to..............

That they were well acquainted with his work at each of said places and that to the best of their knowledge, information and belief, he has always successfully discharged the duties of said position, and is sober and competent.

Subscribed and sworn to before me, this ......day of...........189...

........................Notary Public.

Note.—The right is reserved to require further proof if necessary.

INSTRUCTIONS.

1. Fill out and sign the application.
2. You should have employer make and sign the "Certificate of Employer" if possible.
3. If for any reason you can not get this Certificate, have two of your acquaintances go with you to a Notary Public and make the affidavit attached to this Application.
4. When you have filled the blanks as instructed above, mail as soon as possible to Robert Fisher, Inspector of Mines, Brazil, Ind. Enclosing one dollar for certificate and 4c in postage stamps.
5. If the papers are satisfactory, your "Certificate of Service" will be mailed to you shortly after next regular examination. Otherwise, they will be returned to you for correction.
6. Applicants for Service Certificates need not attend examinations.

ROBERT FISHER, Inspector of Mines.

As the law requiring certificates became effective on July 15th the "Certificate of Employer" has not been accepted as sufficient since that time, because any person having served after that date without a certificate did so in violation of the law. Though the instructions given answered all questions that had been asked about the matter up to the time the blanks were prepared, I was compelled to reject thirty applications for "Service Certificates" besides those which were returned and corrected.

Many of those whose applications were rejected passed examinations and received "Certificates of Competency." In only one case has there been manifested serious dissatisfaction with my rulings, when they were explained. To date there have been issued "Certificates of Service" as follows:

To........Mine Bosses 119
To........Hoisting Engineers 165
To........Fire Bosses 4

A list of the names and addresses of those to whom certificates have been issued is given below:

MINE BOSSES.—SERVICE CERTIFICATES.

C. H. Baetz, Evansville.
Joseph Peters, Alum Cave.
George Mitch, Rosedale.
D. W. Davis, Cannelburgh.
Wm. Grey, Seeleyville.
John Jennings, Ayrshire.
H. W. Jenkins, Perth.
James Dunn, Linton.
Andrew Dodds, Littles.
John W. Odell, Evansville.
Andrew Gilmour, Cardonia.
Ellsworth Tibbitts, Turner.
Thomas Faulds, Clay City.
John Crosby, Shelburn.
Morgan Roberts, Mecca.
James Skene, Mecca.
Henry Schlatter, Brazil.
James Johnson, Coal Bluff.
Herbert Wheatley, Linton.
R. C. Walker, Troy.
H. T. Brewis, Petersburgh.
J. R. Willey, Petersburgh.
W. E. Evans, Eagle.
Wm. Wooley, Boonville.
R. M. Freeman, Bicknell.
S. C. Risher, Linton.
Wm. Chesterfield, Clinton.
Jacob D. Lewis, Carbon.
Welty A. Jacobs, Raglesville.
D. J. Evans, Carbon.
Thos. R. Small, Washington.
R. J. Wallace, Diamond.
Robert Lander, Boonville.
Joseph Ferry, Linton.
H. B. Ehrlich, Brazil.
John Cox, Brazil.
James A. King, Brazil.
Charles Nash, Coal Bluff.
Gus. Wellinger, Washington.
W. H. Sexton, Linton.
David M. Hopkins, Shelburn.
James Cuthbertson, Brazil.
W. J. Price, Cardonia.
Jacob Ehrlich, Sr., Turner.
T. J. Thompson, Hoosierville.
John Chesterfield, Sr., Brazil.
Thomas McQuade, Burnett.
H. A. Butler, Dugger.
Wm. T. Hopkins, Carbon.
John J. Scott, Brazil.
James F. Andrew, Clay City.
T. V. Robertson, Linton.
Jos. W. Small, Washington.
George A. Davis, Coxville.
Henry Payne, Coxville.
John E. Kelley, Boonville.
Robert F. Bieler, Macksville.
John Bolin, Brazil.
Jos. Carmichael, Seeleyville.
John W. Alvis, Seeleyville.
Pius Schultheis, Evansville.
Walter Knox, Ashersville.
Edward Donnely, Seeleyville.
Thomas Harris, Washington.
Isaac H. Williams, Rosedale.
Wm. Conroy, Brazil.
Wm. Spears, Brazil.
Wm. Penze, Brazil.
Wm. Wilson, Cardonia.
Alfred L. James, Brazil.
J. W. Hawkins, Terre Haute.
N. C. Walker, Rockville.
Frank Smith, Farnsworth.
Moses Marks, Cardonia.
Chas. Harting, Edwardsport.
Wm. Devoll, Seeleyville.
Isaac H. Valentine, Rosedale.
Frank Lockhart, Linton.
Louis Schultz, Petersburgh.
Ed. Somers, Staunton.

Thomas Dalton, Carbon.
G. W. Briggs, Cannelton.
Geo. R. Anthony, Fontanet.
Thos. J. Thomas, Princeton.
Louis M. Gaisser, Evansville.
Steward Shirkie, Silverwood.
James L. Devonald, Burnett.
John McAnally, Hymera.
Jeff. Ladson, Burnett.
Patrick Bartley, Evansville.
Wm. F. Horst, Evansville.
W. L. Wallace, Turner.
A. M. Moreland, Eagle.
J. P. Hargrove, Boonville.
August Norkus, Diamond.
George A. Donie, Perth.
Samuel Campbell, Del Carbo.
M. Atkinson, Edwardsport.
Geo. H. Sargent, Eagle.
J. S. Tiley, Silverwood.
Andrew Winterbottom, Sullivan.
Peter Andrew, Clay City.
Thomas Clemmitt, Linton.
George West, Seeleyville.
Wm. Hutchinson, Voorhees.
James C. Pascoe, Linton.
A. W. Stuckey, Raglesville.
I. H. Wooley, Shelburn.
D. B. Hall, Evansville.
Geo. Bonenberger, Evansville.
James McCombs, Shelburn.
August Dutell, Ashersville.
John F. Perry, Del Carbo.
Simeon Wooley, Shelburn.
Wm. Gatt, Odd.
Wm. Robertson, Newburg.
Jas. Dunlap, Brazil.
W. A. Barrowman, Huntingb'gh.

HOISTING ENGINEERS.—SERVICE CERTIFICATES.

Wiley McCarty, Diamond.
Geo. Bolin, Harmony.
Chas. Marshall, Harmony.
James B. Downey, Bicknell.
Chris. Menning, Clinton.
Irwin Stewart, Del Carbo.
Albert Marshall, Clay City.
Wm. Downey, Bicknell.
Chas. Froment, Shelburn.
John Stewart, Staunton.
Ellet Froment, Shelburn.
Hubert Haag, Cannelburgh.
John Meakin, Turner.
J. N. Rettinger, Evansville.
Jas. Burroughs, Center Point.
Wm. Frazer, Ashersville.
Wm. Meakin, Staunton.
A. D. Blacketer, Ayrshire.
Robert Wylie, Rosedale.
James D. Miley, Ayrshire.
T. M. Nelson, Littles.
Marlin Rhodes, Clinton.
I. N. Cassaday, Montgomery.
Jos. A. Kauble, Clay City.
Geo. C. Harth, Fontanet.
Jos. W. Harth, Fontanet.
R. Winningham, Seeleyville.
James A. Harris, Littles.
J. W. LaFollette, Shelburn.
Wm. A. Cecil, Evansville.
Herman Ehrlich, Turner.
Ignatz Trappler, Washington.
Fred Heiliger, Sr., Harmony.
John Dosch, Washington.
Noah Manuel, Alum Cave.
Barney Wilhelm, Evansville.
John Hunter, Macksville.
Frank Yocom, Perth.
Frank Purcell, Washington.
Chas. Jackman, Washington.
John Kunkler, Washington.
Wm. J. Thomas, Clinton.
Thos. Foxworthy, Coal City.
Nimiviah Bush, Shelburn.
Wm. Biggins, Diamond.
Robt. F. Bieler, Macksville.
John W. McCarty, Diamond.
Andrew Davidson, Coxville.
Grant M. Duncan, Brazil.
Fred Heiliger, Jr., Harmony.
S. N. Pritchard, Seeleyville.
Grant McCurdy, Boonville.
N. M. Humphreys, Linton.
J. W. Yant, Ashersville.

Louis Heiliger, Harmony.
John A. Sharps, Carbon.
David Reynolds, Center Point.
Roy A. Somers, Staunton.
James Kimlo, Blackburn.
John J. Laurent, Eagle.
Wm. Loyd, Shelburn.
R. G. James, Burnett.
E. W. Helton, Brazil.
Algie A. Church, Clay City.
Zeno Calvert, Clay City.
Luther Pullen, Knightsville.
Thos. Davidson, Shelburn.
Aaron Martin, Knightsville.
Harry H. Cotterill, Oakland City
Albert Hixon, Carbon.
Geo. Wood, Petersburgh.
Thos. Lauder, Boonville.
Daniel Kincaid, Diamond.
John Miller, Linton.
S. Winningham, Seeleyville.
Robt. Schofield, Washington.
John Stiner, Dugger.
James Parfitt, Brazil.
Henry Herrington, Fontanet.
Thomas B. Brooks, Carbon.
Henry Heacox, Harmony.
Thomas Alderson, Harmony.
T. W. Thomas, Clinton.
J. W. Hardin, Carbon.
Edwin S. Boling, Coal Bluff.
Henry Poff, Burnett.
Wm. Morris, Coal Bluff.
Jos. R. McCafferty, Augusta.
Andrew Kennedy, Jr., Perth.
Lee Morris, Clinton.
Joseph D. Brown, Coal Bluff.
Wm. Lauder, Boonville.
Griff Howells, Center Point.
Levi B. Cramer, Shelburn.
Wm. H. Field, Vincennes.
S. D. Holbert, Rosedale.
W. T. Cassity, Fontanet.
Louis F. Bergenroth, Troy.
John J. Bergenroth, Troy.
John Vonderschmidt, Linton.
Wm. Judson, Fontanet.
Geo. Biggins, Diamond.
Wm. Spears, Brazil.
Frank Bard, Brazil.
Harry C. Duncan, Brazil.
John L. Wilson, Washington.
Wm. M. Boling, Coal Bluff.
O. D. Bowles, Brazil.
Wilmer Strawn, Eagle.
James Gilmour, Cardonia.
John Gilmour, Brazil.
Noah Brillhart, Brazil.
Arthur DeCamp, Diamond.
Pearl Milburn, Brazil.
L. S. White, Linton.
Orion Rose, Petersburgh.
James M. Toppas, Rosedale.
W. S. Fulwider, Mecca.
John E. Azbell, Vincennes.
Harry T. Reed, Brazil.
Wm. Snedden, Knightsville.
John Moore, Brazil.
Thomas Judson, Fontanet.
Truman Hedge, Boonville.
Hulbert Schee, Macksville.
Wm. Burroughs, Center Pt.
D. McPherson, Seeleyville.
Thos. Potter, Macksville.
Louis Lauby, Washington.
J. W. Dunbar, Washington.
James McCarty, Diamond.
John Green, Montgomery.
Frank Stanley, Burnett.
Thos. W. Jones, Boonville.
Nich. Polaskovitch, Brazil.
Andrew Kennedy, Sr., Perth.
J. C. Hopkins, Linton.
Robert Jones, Alum Cave.
Van Partington, Evansville.
David Thomas, Brazil.
W. J. Hancock, Farnsworth.
Robert O. Pruett, Coxville.
Leslie C. Frazer, Knightsville.
Ira Champer, Seeleyville.
Joseph Church, Washington.
Otto Hartloff, Chandler.
Jesse B. Auman, Ashersville.
Rufus Bowles, De Forest.
Andrew J. Blair, Harmony.
J. N. Broadhurst, Macksville.
George Watson, Vincennes.
Fred Collins, Coal Bluff.
Ross Vansickle, Silverwood.
W. W. Fisher, Ashersville.

Sam W. Gentry, Macksville.
P. Krackenberger, Macksville.
Richard G. Gentry, Macksville.
Thos. Andrew, Clay City.
L. B. Southard, Huntingburgh.
Harvey Cochran, Sullivan.
Fred McClanahan, Hymera.
John R. Dickson, Brazil.
Wm. F. Somers, Staunton.
John Davidson, Coxville.
C. A. Taylor, Clinton.

FIRE BOSSES.

Thomas J. Thomas, Princeton.
Joseph Drovetta, Vincennes.
Wm. Norton, Shelburn.
Evan Davis, Shelburn.

Section 4 of the act above provides that "within sixty days after this act takes effect examination shall be held in each of the cities of Brazil, Terre Haute, Washington and Evansville, and that previous to the first of such examinations the Inspector of Mines shall make public rules and regulations under which such examinations shall be held." In compliance with this provision of the law the following circular was published, and notice was given by publication in "The Clay County Enterprise," "The Terre Haute Express," "The Washington Gazette," and "The Evansville Journal," of the time and place of the examination in the cities in which said newspapers are published.

The circular referred to is as follows:

To Whom It May Concern:

By an act of the Legislature of Indiana, approved March 4, 1897 (Cap. 84, Page 127, Session Laws 1897), in effect April 15, 1897, persons employed as Mine Bosses, Fire Bosses or Hoisting Engineers at coal mines in this State, after three months from the latter date, must have certificates of service or of competency signed by the Inspector of Mines. Certificates of the first class will be issued upon satisfactory evidence being presented to the Inspector that the applicant has successfully served in or about the mines of this State for three years or more, in the capacity for which he desires a certificate. Blanks on which to make this proof will be mailed about May 1st to all persons asking for them by mail.

Certificates of competency will be issued to all citizens of the United State who satisfactorily pass a public examination as to their fitness to discharge the duties of the position for which they desire certificates.

The following rules have been adopted to govern the first series of examinations held under the law:

1. Examinations will be held at Brazil, Indiana, Saturday. May 22d, 1897; Terre Haute, Indiana, Tuesday, May 25th, 1897; Washington, Indiana, Thursday, May 27th, 1897, and Evansville, Indiana, Saturday, May 29th, 1897. The hour and place of examination will be published twice in a weekly paper of the city where the examination is to be held, giving at least 15 days' notice.

2. The examination will be by a series of printed questions, given to each applicant on the morning of the examination. Answers to the same must be written on one side of ruled foolscap paper and numbered to correspond with the questions. Oral questions may be asked in addition if deemed necessary by the Inspector to test the knowledge of the applicants.

3. The examination for Mine Bosses will embrace questions on the "mining law of the State;" "examination of hoisting ropes, saftey catches, cages and scales;" "ventilation of mines;" "safety of shafts, entries, rooms and pillars;" "drainage and haulage roads," and "handling men."

4. The examination for Fire Bosses will embrace questions on the "mining laws of the State," "ventilation of mines," "gases of explosive nature," "safety lamps," "detecting fire damp," and "clearing working places."

5. Examination of Hoisting Engineers will embrace questions on "mining laws of the State," "steam boilers and water," "steam and steam engines," "ventilating fans," "examination of wire ropes and safety appliances," and "pumps."

The questions will be so arranged that the work can be done in four hours by a fair penman who knows his subject, but six hours will be given in which to do it.

The above is intended to be suggestive and contains all that I can consent to give to any possible applicant before the day of examination, and I must decline to answer letters on the subject, except to send the blanks referred to above.

ROBERT FISHER, Inspector of Mines.

Brazil, Indiana, April 17th, 1897.

While holding this series of examinations it was learned that quite a number of Hoisting Engineers who had not served in that capacity in this State long enough to entitle them to "Certificates of Service" did not have sufficient education to pass a written examination, while they were well recommended as careful and competent workmen by their employers and others. Several of them requested an oral examination at the time specified in the notices of examination. As Rule 2, published, stated that the examination would be in writing I refused to grant the request. As I had some doubt of my power to hold an examination where part of the applicants took a written and part an oral examination, I submitted this and some other questions to the Attorney General for his opinion. The correspondence follows:

Robert Fisher, Esq., Mine Inspector:

Dear Sir—Answering the inquiries contained in your undated letter, handed me this morning, I beg to say:

Yes, to the first and second which are as follows:

(1) Under Section 4, Page 127, Acts 1897, is an examination entirely oral permissible?

(2) Is an examination entirely written permissible?

No, to the third which is as follows:

(3) Can an examination at the same time and place be held allowing the candidate to elect either written or oral examination, different lists of questions being used?

It is for the Inspector to elect or decide upon the propriety of an oral or written examination, and not at all for the candidate.

To the fourth, that the examination should take place at the cities named when and as in the opinion of the Inspector there is just occasion for it, and it might well be that there would be no occasion for an examination in one at a particular time when it might be very necessary in the other.

For answer to the fifth: The General Assembly has selected the particular cities in which examinations are required to be held. I doubt the right of the Inspector to have examinations held elsewhere, and yet, I can see no one who can complain, if circumstances should make it apparent that it was more convenient and therefore desirable to hold the examination at some other place. The better practice, however, is to conform to the letter of the law where that is practicable.

I have the honor to be Yours very truly,

WILLIAM A. KETCHAM,

Indianapolis, June 17, 1897. Attorney General.

Acting upon this opinion, and to afford an opportunity to all desiring certificates to secure them, I issued the following circular and published notice of the examination as required by law:

To Whom It May Concern:

Notice is hereby given that on the 8th day of July, 1897, I shall hold an oral examination of applicants for Certificates of Competency as Hoisting Engineers, and on the 9th day of July a like examination of applicants for Certificates of Competency as Mine Bosses and Fire Bosses at the coal mines of Indiana, at the Court House, in the city of Terre Haute. Examinations will begin at 9 o'clock a. m., and continue till all applicants who present themselves have been examined under the following rules:

1. All persons desiring to take the examination must notify me by mail before July 7th, 1897, or present themselves for examination at the hour named above for examination of their class.

2. Applicants will be examined separately, but one applicant at a time being permitted to be in the room where the examination takes place. To all other persons the examinations shall be public.

3. Before entering upon examination each applicant must make a statement that he has not been informed by any person of the nature of any material question used on the examination, nor received any assist-

ance in preparing for the same since the examination opened, and promise that he will not divulge anything that transpires in the examination room until the last applicant has been examined.

4. Upon entering the examination room the applicant must deliver to the Inspector of Mines all books, papers and memoranda which might be used by him to assist in answering questions that might, or may be, asked him on his examination.

5. The examination will be by a list of written questions which will be read in their order to each applicant. If he does not understand the question he may ask for an explanation before attempting to answer, but not after.

6. The examination of Hoisting Engineers will include questions on the use, care and repair of boilers, engines, hoisting machinery, ventilating machinery, and pumping machinery, including fuel, water, lubricants, etc.

7. The examination for Mine Bosses will include questions on sinking, timbering and equipping shafts, development, ventilation and drainage in the different veins and mines found in Indiana, also accidents and the means of preventing them.

8. Examination of Fire Bosses will include questions on safety lamps, testing for gas, removing gas, ventilating of gaseous mines, and gaseous mines of Indiana.

9. Questions on the Mining Laws of Indiana. Copies of the edition of 1895 will be furnished free on request. The 1897 edition is about ready for delivery to those who have ordered it.

10. Answers will be graded as given and results announced at the close of each day of the examination.

11. This circular contains all information that will be given previous to the day of examination.

ROBERT FISHER, Inspector of Mines.

Brazil, Indiana.

Examinations have since been held in Evansville, September 22d, and Terre Haute, September 28th and October 23d. The following table shows the number of applicants at each examination, Certificates granted and Applications rejected:

EXAMINATION AT	Date.	APPLICANTS.			CERTIFICATES.			REJECTED.		
		M B.	F B.	Eng.	M B.	F B.	Eng.	M B.	F B.	Eng.
Brazil	May 22	22*	1	12	14	1	10	7	0	2
Terre Haute	" 25	28	1	11	22	1	11	7	0	0
Washington	" 27	9	0	4	8	0	3	1	0	1
Evansville	" 29	5	0	4	5	0	4	0	0	0
Terre Haute	July 8-9	18	1	7	13	1	6	5	0	1
Evansville	Sept. 22	5	2	8	3	2	8	2	0	0
Terre Haute	" 28	19	1	13	14	1	8	5	0	5
Terre Haute	Oct. 23	7	1	8	5	1	6	2	0	2
Totals		113	7	67	84	7	56	29	0	11

*One applicant not a citizen of the United States.

This table shows that of 187 applicants 147 passed the examination and 40 failed, a percentage of failure of 21½. This in spite of the fact that there is nearly a total absence of technical questions in the examinations. We have endeavored to so frame the questions as to test the practical knowledge of the applicants, and not to allow practical and successful men to be displaced by others who, while they may have made a theoretical study of the subjects pertaining to the business, have little or no practical experience in the duties of the position for which a certificate is desired. I herewith give a sample of the questions used for each kind of certificate. These will give a fair idea of the scope of the examinations held to this date. Future examinations will be made more difficult, with a view of increasing study among those affected by them:

QUESTIONS FOR THE EXAMINATIONS OF MINE BOSSES IN THE STATE OF INDIANA, AT WASHINGTON, MAY 27, 1897.

1. Give your name, age and postoffice address.

2. Where were you born? If abroad, when and where were you naturalized?

3. What in your judgment are the necessary qualifications in a successful Mine Boss?

4. Describe the duties of a Mine Boss as provided by the law of the State of Indiana.

5. In what capacities have you been employed in coal mines, and how long in each capacity?

6. How do gob fires originate in mines? What are the best means to put them out, and how would you guard against them?

7. What precautions are necessary to prevent falls of roof or coal? How would you induce workmen to take those precautions?

8. What are the causes of foul air in mines? How would you discover the presence of black damp? white damp? explosive gas?

9. The velocity of the air current as shown by the anemometer is 280 feet, the air course is 9 feet wide and 4½ feet high, what amount of air is passing?

10. How many ways are there of producing a current of air to assist in ventilating a coal mine?

11. How do you determine the amount of air circulating in a mine?

12. What means can be used to increase the amount of air circulating in a mine without increasing the power used to produce the current?

13. Name the heaviest and the lightest gases met with in coal mines. In what parts of the mine would you expect to find each?

14. If an entry is driven at an angle of one-third with the face of the coal, how far apart would rooms on the face have to be turned to give rooms 21 feet wide and pillars 12 feet thick?

15. What persons are prohibited from working in the coal mines of Indiana, and what precautions that these provisions of the law are complied with?

16. Name some of the bad results of poor drainage in mines.

17. Describe the best means of constructing a haulage road where the bottom is soft and makes a good deal of water.

18. If you were not getting out the amount of coal that you should with the forces employed, what means would you take to discover the cause?

19. If miners or other workmen in your mine were in the habit of leaving doors open in the mine, or in any other way violating the law, what steps would you take to put a stop to the practice?

20. In a certain mine the main entries are advanced 500 feet on one side of the shaft and 350 feet on the other side. Two pairs of cross entries are working on each side of the shaft. The first pair are advanced 350 feet, the second 250 feet, the third 250 feet and the fourth 100 feet. Rooms are turned off the cross entries every 35 feet. The air splits at the bottom and measures 25,000 feet at the downcast. The mine worked six days in April, 1897. Make out the monthly report to the Inspector. (Blanks furnished.)

QUESTIONS FOR THE EXAMINATION OF FIRE BOSSES.—INDIANA, MAY, 1897.

1. Give your name, age and place of birth.

2. If born abroad, have you been naturalized? When and where?

3. What is the duty of a Fire Boss as provided in the mine law of Indiana?

4. How would you learn whether a safety lamp is in condition for use? Name three defects that would render it unfit.

5. In what part of a mine is fire damp most likely to gather? What conditions of the ventilation of a mine make the accumulation of gas most likely?

6. How would you prevent the accumulation of gas in the worked out parts of a mine?

7. Under what conditions would it be safe to use open lights in a place that makes fire damp?

8. What record would you keep of your daily examinations for fire damp?

9. How fast should the air current travel in places where there is likely to be a dangerous amount of gas generated?

10. What is the first indication given by the safety lamp of the presence of gas? What other indications as the amount of gas increases?

11. What kinds of safety lamps are you familiar with?

12. What dangers are met by a rescuing party in a mine after a serious explosion of fire damp?

13. What means would you use to overcome such dangers?

14. What experience have you had in gaseous mines? In what capacity?

QUESTIONS FOR THE EXAMINATION OF HOISTING ENGINEERS, AT TERRE HAUTE, IND., OCTOBER 23, 1897.

1. What do you consider the most essential qualifications of a Hoisting Engineer?

2. Who may be placed in charge of a hoisting engine under the laws of Indiana?

3. In a general way describe the principles involved in the construction of steam boilers.

4. Describe two ways of setting boilers and how provision is made for their expansion and contraction.

5. Do the flues and tubes used in boilers increase or diminish their strength? Give reasons.

6. Where should water gauges be placed on a boiler? Why are steam gauges necessary?

7. Describe three different kinds of grates with which you are familiar.

8. Describe the principle of the safety valve.

9. The shell of a plain cylinder boiler is 30 inches in diameter and 20 feet long, and is made of single riveted wrought iron boiler plate three-eighths inches thick. What pressure can it carry safely?

10. How is a forced draft produced in a boiler furnace?

11. What different kinds of stress, or strain, is placed upon the different materials used in a hoisting outfit, including boilers?

12. What should be the smallest rope used to hoist two tons of coal, the cars, cage and rope weighing 3,500 pounds?

13. What different kinds of bolts are used in the construction of a steam engine? Tell where one of each kind is used.

14. An expansion joint is to be placed in a line of steam pipe 450 feet long. How much movement should it have?

15. What different methods are in use to fasten wheels and pulleys rigidly to shafts?

16. Suppose a spur wheel broke and you wished to order a new one, where would you measure the diameter of the old one?

17. Name the parts of a plain slide valve engine to which motion is imparted when running.

18. Describe the course of steam from the boiler to make a complete revolution of the cranks.

19. How does the reverse link produce the desired result?

20. Give the changes made in the direction of motion in hoisting a cage from a shaft, and by what mechanism each change is produced.

On August 2d the following circular was published and distributed to all persons holding certificates and to all operators of mines employing ten or more men, as far as such operators had come to the knowledge of this office:

To Whom It May Concern:

I herewith publish a list of persons who have been granted certificates under the provisions of "An Act to provide for the examination of Mine Bosses, Fire Bosses and Hoisting Engineers at coal mines, etc.," p. 127, Acts 1897.

While in terms this law applies to all mines in the State, construing it in connection with other mining laws, this office holds that it applies only to mines employing more than ten men. However, if more than this number are employed at any time, even for a day, the person acting in either of the above capacities, without a certificate, is liable to be fined, as is the person, firm or corporation employing him. The theory of the law is that all persons entrusted with the performance of the duties of either of the above positions should be able to demonstrate their competency by passing an examination, but as a special favor to those who have served in either of those capacities for three years, in this State, they are exempted from such examination. A service certificate, therefore, does not indicate any opinion of the Inspector of Mines as to the competency of the person holding it, though it has the same force and effect in protecting the employer from a criminal prosecution as a certificate of competency. Certificates of competency are granted only after an examination, and are, in effect, a recommendation from the Inspector to the extent indicated by the percentage earned.

It is the duty of the Inspector of Mines to file affidavits against all persons holding, or giving, employment to persons not provided with certificates, as soon as evidence sufficient to secure conviction can be secured, either from personal investigation, or through other witnesses. Persons affected will govern themselves accordingly.

Examinations will be held within three weeks at any time after twenty-five applications, accompanied by the fee of $1.00, have been received at this office. The convenience of the greatest number of applicants will determine the place where examinations will be held. No certificates will be issued until after the next general examination.

As inquiries are frequently addressed to this office for persons to fill positions, it will be of mutual advantage to all interested if all certificate holders who desire to change location would notify me by mail of such desire, where position is wanted, and salary expected, so that I can put parties into communication with each other. Hoping that by co-operation we may be able to raise the standard of efficiency in the positions covered by the law, I am, Respectfully,

ROBERT FISHER, Inspector of Mines.

Brazil, Indiana, August 2, 1897.

I found it necessary to institute legal proceedings in several cases where the law was being violated flagrantly, but in only one case was any defense made. In that, the case of the State vs. William Horst, before —— Poole, J. P., at Evansville, Indiana, the defendant was found guilty and fined five dollars and costs. No appeal was taken, so that no case has been tried in a higher court. All other parties against whom affidavits were filed pleaded guilty.

Several complaints have reached this office of persons who occasionally hoist coal and men at places where a properly certified man is in charge. I have uniformly refused to file charges in such cases, as I believe the spirit of the law permits such action as a part of the training and experience necessary to fit persons to pass examinations in the future. It appears to me that any other construction of the law would debar citizens of our State from securing the necessary preliminary practice to fit them to take charge of hoisting machinery and would limit our future choice of Hoisting Engineers to those who had obtained their practical knowledge of the business in another State or to those who had a purely theoretical knowledge. While the privilege may be abused by allowing incompetent men to have temporary charge, the remedy is with the certified men who have the responsible positions, and not at law.

The following is a list of those who have secured certificates of competency at the various examinations:

MINE BOSSES—CERTIFICATES OF COMPETENCY.

M. McMorrow, Brazil.
Alex. Orr, Harmony.
James G. Biggins, Perth.
Thomas Orr, Harmony.
Roland Elstone, Diamond.
R. F. Jenkins, Knightsville.
R. M. Irving, Knightsville.
Joseph W. Williams, Brazil.
Andrew Spears, Brazil.
George Myers, Brazil.
Samuel Lindsay, Brazil.
John Mushett, Terre Haute.
P. J. Mooney, Brazil.
Mike Hofmann, Ashersville.
G. C. Potter, Augusta.
Thos. R. Small, Washington.
Thomas Harris, Washington.
W. H. Walton, Linton.
Geo. B. Brown, Montgomery.
Jas. B. Brown, Washington.
Joseph Fennel, Linton.
Richard T. Jones, Princeton.
Hugh Monahan, Evansville.
Geo. F. Archbold, Newburgh.
H. L. Williams, Troy.
Wm. T. Conroy, Brazil.
Martin Navin, Diamond.
J. S. Newport, Linton.
Ed. Stewart, Hymera.
G. E. Broadhurst, Macksville.
Wm. P. McQuade, Brazil.
James Watters, Clay City.
George Epperson, Linton.
Thos. Gregory, Fontanet.
David W. James, Clinton.
Wm. Devonald, Clinton.
W. A. Edwards, Clinton.
John Archer, Clinton.
Duncan McCallum, Clinton.
C. C. Hall, Shelburn.
George L. Potts, Diamond.
Griff Howell, Center Point.
Thomas Parr, Fontanet.
Wm. Britton, Alum Cave.
James Steele, Macksville.
Alex. Faulds, Alum Cave.
John Paton, Lyford.
Wm. R. Scott, Vincennes.
Frank Gendthar, Evansville.
John A. Bolin, Harmony.
Fred Eberwine, Knightsville.
Thos. J. Russel, Cardonia.
R. J. Monkhouse, Coal Bluff.
John Watters, Clay City.

James McInnis, Carbon.
John Chesterfield, Jr., Brazil.
James Baxter, Cardonia.
John A. Templeton, Linton.
Samuel Thorpe, Linton.
A. L. Boore, Clay City.
Frank J. E. Urbain, Brazil.
J. F. Erwin, Macksville.
David John, Shelburn.
Bartly Stinson, Sophia.
W. A. Jackson, Oakland City.
A. H. Zimmerman, Mecca.
John L. Suttle, Cardonia.
Wm. Wilson, Cardonia.
James Burt, Cardonia.
James M. Coakley, Cardonia.
John A. Beck, Dugger.
Michael Doyle, Brazil.
Frank Dunlap, Clinton.
Thomas G. Marshall, Carbon.
John Quigley, Carbon.
A. D. Scott, Del Carbo.
Hugh Kirkland, Perth.
P. H. Penna, Linton.
J. W. Risher, Linton.
Wm. L. Erwin, St. Mary's.
J. R. Horsfield, Knightsville.
D. Bogle, Clinton.
Valentine Martin, Rosedale.
Wm. F. Brown, Alum Cave.

FIRE BOSSES—CERTIFICATES OF COMPETENCY.

Fred Brink, Coal Bluff.
Robert M. Irving, Knightsville.
Chas. Sheridan, Diamond.
David John, Shelburn.
Wm. Woods, Princeton.
Richard T. Jones, Princeton.
Jos. W. Horsfield, Knightsville.

HOISTING ENGINEERS—CERTIFICATES OF COMPETENCY.

William Milburn, Cardonia.
John Beaton, Brazil.
Walter Irwin, Brazil.
Wm. Vanlieu, Lyford.
D. H. Collier, Diamond.
Milton Smith, Diamond.
A. G. Collier, Diamond.
Ed. Butts, Diamond.
W. C. Biggins, Diamond.
Thomas McNair, Carbon.
W. J. Hinkle, Hymera.
H. C. Cummins, Hymera.
Thomas Shannahan, Mecca.
Benjamin F. Lyday, Lyford.
Jona E. Meredith, Linton.
G. F. Archbold, Newburgh.
H. M. Graves, Voorhees.
E. R. Dickie, Dugger.
W. C. Ringo, Edwardsport.
Austin Jackson, Clinton.
Wallace Boone, Merom.
C. F. Thorpe, Linton.
Frank Craft, Clinton.
Robert Biggins, Diamond.
John Cloyd, Rosedale.
Benj. Smith, Linton.
John Dorman, Burnett.
Lee Wehr, Lyford.
Thomas Gregory, Fontanet.
Joseph Haag, Washington.
Ambrose Cramer, Rosedale.
Frank Ritzel, Evansville.
Alexander Maule, Princeton.
Smith H. Abshire, Newburg.
W. J. Price, Montgomery.
Robert Hall, Evansville.
James W. Powell, Evansville.
Thomas Roberts, Evansville.
Albert Lynch, Princeton.
Frank Turber, Princeton.
Charles Sterne, Francisco.
Michael B. Miller, Evansville.
Charles E. Boots, Macksville.
R. O. Pruett, Coxville.
Mellie S. Hunter, Montezuma.
Clarence Strader, Seeleyville.

Curtis Redding, Mecca.	Claude Erwin, St. Mary's.
A. H. Zimmerman, Mecca.	Otis Bledsoe, Lewis.
Geo. W .Rice, Coxville.	J. W. Davis, Brazil.
Mahlon R. Gustin, Sullivan.	Charles Woolf, Lyford.
John S. Robertson, Newburg.	Wm. F. Brown, Alum Cave.

MAPS.

The law requiring maps to be made and filed with the Inspector of Mines has been very generally complied with. The strike which began July 4th and lasted until the middle of September interfered materially with the making of maps at some of the mines that were allowed to fill with water. At others, where the roof was bad, it was allowed to fall in places, so as to make a complete survey impossible, and so maps were not filed within the time limited. Where such causes existed I have not taken advantage of the provision of the statute authorizing the appointment of an engineer to make the survey and maps. This has been done only in cases where there seemed to be a willful disregard of the provisions of the law, and in several instances when appointments were made the owners of the mines made contracts with the engineer for the work. In only two instances have any complaints been made of the operation of the law in this respect. Several of the maps furnished do not comply with the law in all respects, but as they evidence a disposition on the part of mine owners to keep within the law, I have not insisted upon their being corrected at this time. The law provides that all maps shall be corrected each year between May 1st and September 1st, and I shall insist on the work next year being done by a competent person and on having the details properly shown on the maps. In regard to the necessity of correct maps I cannot do better than quote from the first report of the Mine Inspector of this State:

"I cannot exaggerate the importance of having correct plans. When our present mines are abandoned and filled with water these maps will have to guide us in future mining operations, and if they are misleading we should be much better without them, for they may cause much destruction of life," and from the report of 1883: "A great expense and annoyance is occasioned in approaching an abandoned mine where the extent of the worked-out territory is not known. The survey and map should be made by a practical surveyor, so that the accuracy of the survey could be relied upon. When a mine is worked out and abandoned all trace of it may disappear in a few years." In the case of mines working toward abandoned works we have had several examples lately of the expense attending approaching them without a map, in one case a bore hole having been kept ahead of the workings for over 300 feet. In another case where apprehensions were felt as to the danger of breaking into an old mine, of which a map had been filed, a survey showed that the workings of the two mines were nearly 500 feet apart, and work was continued for more than a year without the expense attending upon keeping a drill hole in advance. But this does not appeal to mine owners, as the benefit derived from it will be received by future operators. But a correct working map is a present benefit in many ways. It has a tendency to secure a more systematic working of the mine, to keep the workings in such a shape that the greatest possible amount of coal is finally recovered from the pillars and to prevent accidents from shots blowing through pillars. In many instances an accurate map of a mine would have prevented costly litigation over property injured by roof falling on account of insufficient pillars being left to support it, and on account of trespassing on coal out of the proper lines. The value of the maps to this office lies principally in the assistance they render in understanding the monthly reports of Mine Bosses and their use as a guide to the mines on visits of inspection. We have received great benefit in these ways, and their value to a new incumbent of the office would be inestimable. One survey was made during the year at the request of an adjoining landowner, where a coal company was supposed to be trespassing on his land, which the survey showed to be true. The matter was amicably adjusted by the parties on the basis of the survey, and no certified copy of the map was necessary. This survey was made at the mine of the Currysville Coal Co., near Shelburn, on March 10th, 1897. No prosecutions have been instituted for failure to furnish maps, and I think none will be necessary.

DESCRIPTIONS OF MINES.

During the year 1897 mines employing more than ten men have been operated in the counties of Clay, Daviess, Dubois, Fountain, Gibson, Greene, Knox, Martin, Owen, Parke, Perry, Pike, Sullivan, Vanderburgh, Vermillion, Vigo, Warrick. I give below brief descriptions of the several mines in each county:

CLAY COUNTY.

BRAZIL BLOCK COAL CO.'S NO. 1.

Located in the north part of the city of Brazil, on the C. & I. C. Railroad. Electric Mining Machinery is used. The shaft bottom is lighted with incandescent lamps. In securing the roof at the bottom of the shaft, instead of the timbers usually employed for this purpose, legs of 4½-inch diameter gas pipe and cross bars of railroad iron are used. These are lagged overhead with 2-inch oak timber. The result to date is highly satisfactory, as there has been no necessity for repairs since the mine was opened, though the roof is one that is very sensitive to the action of air, and in mines of this vein where timber is used it requires frequent renewal, and the roof gives a great deal of trouble. The double partings at the bottoms are floored, and with good tracks, the handling of coal is made comparatively easy. The underclay is soft, making it necessary to corduroy the hauling roads, as a great deal of water is coming into the mine from others that have been worked out and abandoned in territory surrounding it, the Campbell, Morris and Black Diamond having opened the most territory. Where corduroy is not used the roads are very muddy. For convenience in handling machines the bottom is taken up in all entries and nearly all rooms, so that it is very hard to keep water off the roads. Where the roof will admit of it, rooms are driven double 50 feet wide, with a road on each side and the refuse gobbed in the middle. This gives an opportunity for the circulation of air around the working face at all times. Ventilation is good in all the entries, but as machine mining requires shot firing at all hours of the day, the air is smoky at times, requiring a great deal more than the statutory amount of air to be kept in circulation. Keyes' Automatic Mine Doors are used on the main airways and have given very good satisfaction. The roof requires constant attention, and it reflects credit on the management that so few accidents from falling of roof have occurred in the mine during the year. The last inspection was made November 10th, 1897, and very few recommendations were found necessary, and nearly all of the defects were easily remedied. The air is split to afford five separate currents of air to different sections of the mine. The largest section has but 30 men in it.

GART NO. 3 MINE.

Located on the Harmony North Branch of the E. & T. H. Railroad one and one-fourth miles north of the main line. It is in territory that is nearly surrounded by abandoned works, and makes a great deal of water, six pumps being in use at the mine. On two occasions during the year the mine was laid idle on account of the water rising at the shaft. The works and the escape ways are so located that no danger to the workmen is to be apprehended from this source, however. The mine is fitted with self-dumping cages, the mine car remaining on the cage and being emptied without handling by the top men. This result is displacing one or two laborers on the pit top, the weighman doing all the work.

Two veins are worked in the mine, the coal from the upper being brought through a tunnel to the lower vein and hoisted from the bottom of the shaft. The works on the southeast side of the shaft are worked out and abandoned.

The roof in the bottom vein is good in most places, but the coal lies uneven, giving a very irregular haulage way, the grades being heavy, and making the haulage very costly. The roof in the top vein is fair, but requires a good deal of timber to keep it safe. The water from the upper vein is drained through drill holes to the lower vein and from there brought to the surface by pumps. Some of these are operated through bore holes from the surface reaching low places in the workings, thereby doing away with a great deal of piping and ditching undeground, the steam pipes being laid from the boiler along the surface of the ground.

This helps to improve the ventilation by allowing the air passing through the mine to be kept free from the heat from a long line of steam pipe and from the exhaust steam from the pumps. Rooms and entries are worked standard width, as given in another part of this report, and are well drained and timbered where necessary. When the last inspection was made, November 10th, 1897, the ventilation was fairly good, but the air that was coming from the fan should have furnished a better current at the working faces. This was due to some extent to a door on the main air course being open a great deal, and to some of the air courses being used for stowage by miners, who lacked pure air in consequence. This is a thing that requires constant vigilance on the part of mine foremen, as workmen are in the habit of putting dirt, timbers, tools, etc., into the breakthroughs and thereby choking the air-passage of the mines. Good ventilation can be secured at least expense by keeping airways clean. Owing to this mine being idle so much during the year it had been allowed to get into bad condition and had not been fully repaired at the time of my visit, but it appeared that Mr. Conroy was pushing the work with all possible speed.

GART NO. 5 MINE.

Situated in the town of Cardonia, on the Knightsville North Branch of the T. H. & I. R. R. This is the largest mine in the Block Coal District worked exclusively by pick miners. At the time of last report the output was greatly reduced on account of its original territory being nearly worked out. Since then some territory has been acquired on the east, and a cut has been made to the south, which opens up a large field of coal. The production at the time of my last regular inspection was 600 tons of screened coal per day. About one-fifth of the coal goes through the screen, making the total production 720 tons daily. The roof is good and there is comparatively little water to contend with, so that the haulage roads are in good condition, but very heavy grades are met with, which greatly reduce the hauling power of the animals employed. As an illustration of this fact I may remark that the cut above referred to, being made nearly level on the bottom for a distance of 500 feet, has a depth of over 20 feet near the middle. At the time of my last regular inspection, October 22d, 1897, a tunnel was being driven to the upper vein of block coal, which had reached the coal at the time of my later visit. When this is opened it should add materially to the output of the mine. For the first time since this mine was opened I found the ventilation badly deficient on October 22d. Along the entry going northeast was a line of steam pipe which warmed the air almost to the suffocating point, and though it had cooled considerably before reaching the working places, it did not have the life-giving force that it should have. In this part of the mine, near the face of the last entry, water sometimes accumulates and interferes with the air current. While I should have been pleased to see this in better condition, I did not insist on the necessary changes, as this part of the mine will soon be abandoned. On the south I found a great deal worse state of affairs. The entry, which is now being used as a haulage way, had gone over an extensive rise, and the coal for a great part of the distance was thin, in some places less than two feet. The air course following the entry was made only the height of the coal; at the time it was driven only four men were at work there. When the haulage road was cut through no steps had been taken to increase the size of the airway. On the date above given I found 141 men and several mules at work in that part of the mine, and at least half of them were without sufficient air. If my authority had extended so far I should have ordered at least 40 men out of the mine, but the law provides, "Whenever the Mine Inspector shall find men working without sufficient air * * * he shall first give notice to the owner, operator, agent or lessee, a notice giving facts, and a reasonable time to rectify the same." I did this, and on my return found the conditions somewhat improved and work being pushed with reasonable diligence to still further improve it. The air course referred to was being enlarged by taking coal off the side and by taking down the roof, and another opening will shortly be made from the top vein to the surface in this part of the mine. This will, in my opinion, give sufficient ventilation for all men who are likely to be employed there in the future. However, the management could not be too strongly condemned for delaying this necessary work so long.

BRAZIL BLOCK COAL CO.'S NO. 8 MINE.

Located on the Coal Bluff Branch of the C. & I. C. R. R., near the north line of Clay County. Only the lower vein is now being worked. The output at present is about 400 tons of block coal daily. Adding screenings, the total will reach 500 tons. The production is restricted at present, owing to the difficulty of securing men to load coal after machines. Miners seem to prefer pick work when it is possible to get it, and men have been in demand ever since the settlement of the strike in September. While this mine employed 233 men in March, the managers could secure only 160 in October. The mine is laid out to be a large producer. Nearly all entries radiate from near the bottom of the shaft, and with roomy partings or sidings, give plenty of room to stock coal near the shaft, so that the underground work may go on for quite a while if, for lack of railroad cars or any other reason, the hoisting is suspended. The roof in most of this mine is excellent, giving a splendid opportunity to work machines to advantage. All entries are driven double, with a haulage road in each. Bottom is lifted to give the necessary height, the coal being from three to three and a half feet in height. All rooms are double, 50 feet in width, started from the entries with two necks, and having a road on each side, with a gob in the middle. This insures the passage of the air current around the face. The ventilating current is made into seven divisions, with regulating doors so arranged that, if necessary, two or more of them can be turned into any part of the mine. By this means much of the evil from continuous shot firing is avoided, and if smoke is troublesome in any part of the mine, an increased current soon sweeps it out. Keyes' Automatic doors are used on the main haulage ways, and to force the air into rooms old-style hinge doors are placed in convenient places when necessary. When inspected October 27th it was in all respects a model mine. Ventilation is provided by a Crawford & McCrimson blowing fan 20 feet in diameter, which, at a speed of 60 revolutions per minute, discharges 72,000 cubic feet of air per minute into the mine. This is well distributed through the entries and air courses of the mine. The plan of the mine is by P. J. Mooney, Mining Engineer of the company, and the mine has been worked out under the superintendence of Robert J. Wallace, and both deserve credit for its success.

BRAZIL BLOCK COAL CO.'S NO. 10 MINE.

Only a few men have been working in this mine at any time during the year, not enough to bring it within the law; consequently it has not been inspected.

BRAZIL BLOCK COAL CO.'S NO. 11 MINE.

Located on the Coal Bluff Branch of the C. & I. C. Railroad, southwest of No. 8. This mine was opened in 1896, but no top nor bottom was taken to give the necessary height to use mules. The coal was brought to the bottom by pushers. About the 1st of March it was closed down, and no more coal was taken out until Sept. 1st. When inspected October 12th nothing had been done in the bottom vein. This shaft is equipped to handle a large output of coal. The cages are self-dumping. Two fans are used, one at the main and one at the escape shaft, each 14 feet in diameter. The airway is partitioned from the stairway in the escape shaft, and this is very freely used by the workmen in entering and leaving the mine. It is in splendid condition. The coal lies fairly level in this mine, giving fair grades for haulage. The roof is very dangerous, being a shale cut into large irregular blocks, which fall with very little warning. Several accidents have occurred in this manner during the year in this mine. There was but little work being done on the west side of the mine, as the roof was so bad that it could not be made safe to work under.

HARRISON MINE.

Located on a branch of the E. & I. Railroad, three miles southeast of Clay City. The mine has run very irregularly during the year. The coal lies irregularly, which makes drainage difficult and makes the haulage roads bad. The air courses have not been kept clean, and are choked with mud and water. In spite of these disadvantages a fair current of air was found in all the working places, but there was only half the number of men at work that could be employed in the mine. I am inclined to think that with a full force of men the ventilation would be found insufficient. The coal is of the character known as semi-block, the roof of gray slate and the bottom of fire clay. Charles Nash is in charge of this mine, and is also sinking a new shaft for the same company, and no pains are spared to keep traveling ways and working places well timbered.

BRIAR HILL MINE.

On the main line of the E. & I. Railroad, one mile northwest of Clay City. This mine has been an annoyance to Mine Inspectors for years. A great deal of water comes into the mine from an overlying bed of quicksand, which softens the underclay, and, unless pillars are left very strong, allows the roof to break or the bottom to "heave," in either case making work in the part of the mine where it occurs either impossible, expensive or extremely dangerous. This has caused an abandonment of all works opened prior to the fall of 1896, and developments made since then by A. L. Boore, who has charge of the mine, have kept these facts in view, and pillars are being left sufficiently thick to bear all weight which can be expected to be thrown upon them. Roads are in good condition. There are numerous "pots" in the roof, which are liable to give way without warning and with but little indication of their presence. Several accidents have occurred from this cause during the year, one of them fatal. The ventilation on my last visit was in good condition. Air courses were opened sufficiently that persons could walk through their whole length. In some places there was more dirt thrown into breakthroughs than I like to see, but in all respects they were all that the law requires, and the air was sufficient for a great many more men than were at work. The underclay from this mine is sold for the manufacture of Terra Cotta ware and encaustic tile, that commands a good market.

PRATT MINE.

Located about two miles west of Perth on the Big Four R. R. This mine is owned and operated by the Coal Bluff Mining Co., of Terre Haute, Ind. It was opened in July, 1888, and is worked exclusively as a hand mine. An attempt was made some years ago to work it as a machine mine, both Harrison and Legg machines driven by compressed air being used, but without success. A twelve-foot Crawford and McCrimmon fan is used to ventilate the mine and produces a good current of air, which is well conducted to the working places, though there is a great deal of old work between the air shaft and the present workings. The coal is the upper vein of block coal and is reached by a shaft 119 feet deep; the coal is 4½ feet thick and has a good black slate roof. Room are driven 20 feet wide, with pillars six to nine feet in thickness. The coal from the pillars is recovered after the rooms are worked out. This mine was idle a great deal during the year, and it was not found working on either of my visits.

GLADSTONE MINE.

Is located on the Coal Bluff branch of the C. & I. C. R. R. near the line between Clay and Vigo counties. The lower vein of block coal is worked, which, however, is not of as pure a quality as further east, being somewhat of the nature of the semi-block found in the vicinity of Clay City. The roof is usually good, but in some places it is a flaky, sandy shale, which is very difficult to secure by timber. As it falls in thin sheets, however, it cannot be considered dangerous, and no accidents have been reported from this cause at the mine. The air courses which are not used as hauling roads had become badly choked by dirt from this cause, and have required a good deal of work to open them up this year. This work was the more necessary as the mine generates a quantity of firedamp in some places. The quantity of water had increased so much in the spring of 1897 as to emphasize the necessity of a better means of escape than was furnished by the old escape shaft, and an escape has been sunk at an elevated part of the workings, so that a sure means of egress would be given if water should rise so that the shaft and old escape-way should be shut off. On my last inspection, made October 21st, the ventilation of the mine was found in fair condition except in some rooms where impure oil was being used. On a later visit made by my assistant he reported that this had been remedied.

CRAWFORD NO. 2 MINE.

Located near Center Point on a branch of the T. H. & I. R. R., owned by the Crawford Coal Company, W. W. Risher, Superintendent. This has been one of the best mines worked in the block-coal field for many years. It is operating the lower vein, and has had good top throughout. The coal is very regular in height, about three feet nine inches, and the shaft being sunk in the lowest part of the territory, drainage has given but little trouble. Roads have been dry, and the grades being all in favor of the loaded cars, gave it a great advantage in hauling over other mines in this district. On every occasion when this mine has been examined it has been found in excellent condition in all respects. Pillars are being drawn now preparatory to abandonment. It will probably be finished during the present year. The company are making preparations to sink another shaft in this vicinity during the coming spring.

CRAWFORD NO. 3 MINE.

Located two and one-half miles northeast of Asherville, on the Center Point Branch of the T. H. & I. R. R. This mine was opened in 1896. It has had a very soft roof in a greater part of the work, as the territory goes to the outcrop of the vein in all directions. Good care has been taken by the mine boss to secure the working places and traveling ways, and but few accidents have occurred from falling roof. The mine has always been found in good condition when inspected. This mine will be worked out and abandoned within five months from January 1st, if present calculations do not miscarry.

WORLD'S FAIR MINE.

Located one and one-fourth miles northeast of Brazil, on the T. H. & I. R. R. Owned by the D. H. Davis Coal Co. Has been in operation very irregularly for several years. The coal is the average height and quality of block coal, and for the most part has a good roof. In some parts, however, the roof is a gray shale, badly cut up with slips, and requiring great care to prevent accidents. Under the circumstances these have been very few, which speaks well for Mr. Robt. F. Jenkins, who has charge of the mine, and for the character of the men employed there. Several times during the year complaint was made of the scales used at this mine, but on only one occasion were they found working badly. On that occasion they were promptly attended to when the attention of the mine boss was called to their condition. The original territory of this mine is pretty well worked out, but two entries are being driven to test another piece of land recently acquired by the company. Should this prove good, the mine will probably last several years yet, but at present the prospects are very unfavorable. The mine has usually been found in good condition, but on the last inspection several rooms were found where the air was bad, without any chance to remedy it until the places are nearly finished. As this would be shortly and the men working the place requested it, I permitted them to be driven on. Each of them would probably reach their limit in six days. With this exception the mine and its equipments were in good condition.

DIAMOND NO. 3 MINE.

Located one mile south of Perth; is reached by a switch from the main line of the C. & I. C. R. R. It is owned and operated by the Diamond Block Coal Company, of Chicago. During the year the shaft at this mine has been sunk to the lower vein of coal, and some development has been made in it. The distance between the two veins is 25 feet. The roof is hard over the bottom vein, and the coal about three and a half feet thick, but very hard to mine. The coal is reported to be of excellent quality. When last inspected this mine was found to be in good condition, all provisions of the law being fully complied with. This mine is now in charge of James Cuthbertson, Sr., one of the oldest mine men in Clay County, which is an assurance that it will be kept in good condition if that is possible.

EXCELSIOR MINE.

Located about one mile northwest of Perth, on the Coal Bluff Branch of the C. & I. C. R. R. The upper vein at this mine has been worked out, and was abandoned during the year. The vein now being worked is very irregular in thickness, ranging from two feet ten inches to three feet eight inches. Both top and bottom are fairly hard, giving good haulage roads and safe traveling ways in all parts of the mine now at work. The shaft is located on the bank of a branch of Otter Creek, and the former operators mined the coal from under the bed, and did not secure the roof properly. This has caused a great deal of trouble from water, and on two occasions the mine has been flooded. By the carefulness of H. B. Ehrlich, manager, however, all the workmen have been warned in time to escape. This part of the mine has been secured by timber and packing till I think it is safe.

SUPERIOR MINE.

One-fourth mile west of Turner, on the main line of the T. H. & I. R. R. Is owned and managed by Peter Ehrlich, the oldest coal operator in the State. The coal is bituminous, of good quality, and from six and a half to seven feet in thickness. This mine has usually been found in good condition, both in respect to ventilation and safety, as far as could be seen. Some apprehensions have been felt owing to the nearness of the works of several abandoned mines, but a survey shows that there is a sufficient pillar to prevent danger. There are two escape shafts communicating with different parts of the mine, and ventilation is provided for by a fan and furnace. On my last inspection the air was being well circulated around the mine. The location of the shaft makes drainage and haulage difficult and roads hard to keep in repair.

EUREKA NO. 2 MINE.

One-fourth mile east of Carbon, on the Big Four Railroad, owned and operated by the Eureka Block Coal Company, of Terre Haute. Both of the principal veins of block coal are worked in this mine. The lower vein varies in height from two feet ten inches to four feet six inches. The roof is good in this vein, but the coal lying uneven makes drainage difficult, and a good deal of water lies on the road in places. This also interferes with haulage. In the workings of the upper vein the roof is bad and the bottom is soft. Hauling roads require to be closely floored or corduroyed, and a great deal of timber is required to make them safe overhead. Air courses become blocked by falling slate, and this renders ventilation very difficult, even with two fans running. On nearly every occasion when a regular inspection has been made at this mine the ventilation in the upper vein workings has been found deficient. On making his last inspection Mr. Epperson found it necessary to order some improvements in this direction, and also in one or two places in the bottom vein. A special inspection will be made soon to learn whether his instructions have been followed. As all the coal from No. 1 mine is now being brought out through this opening, the work extends over a large territory, and a great deal of work is necessary to keep the mine in good condition.

A new mine, to be known as No. 3, has been opened by this company during the year, further east, but as it has but recently begun producing coal, it has not been inspected during the year.

MONARCH MINE.

Located on territory adjoining the city of Brazil on the northwest. This mine is owned by Goucher, McAdoo & Co., and is operated by them solely to supply material for their sewer-pipe factory. During the year about 15 men have been on two turns in order to avoid prosecution for failure to provide a second outlet. With the exception of this failure I have at all times found the mine operated in full compliance with the law. Material is taken out of both top and bottom—shale and clay—for use in the factory, making the workings from nine to ten feet high and giving plenty of room for air to circulate. The mine is always well timbered, and I have never had occasion to call attention to dangerous roof. A change of superintendents during the year is given as the cause of failure to provide a second outlet, but the present manager, Mr. George Goucher, assures me that one shall be provided early in 1898.

BRAZIL MINE.

Located two miles northeast of Brazil. Owned by the Jackson Coal Co. Is reached by the Knightsville North Branch of the T. H. & I. R. R. All three veins of block coal are mined here. The bottom vein has had excellent roof and fairly hard bottom. It has been nearly worked out, and on my last visit but few men were working there, and they near the bottom of the shaft. The principal part of the work now being done is in the middle vein. There is a great deal of bad roof in this vein, and the bottom is very wet. Falls frequently occur, making openings from this to the upper vein, and making it very difficult to carry air through the air courses in the middle seam. However, on my last inspection, October 30, I found nearly all working places in this vein fairly well ventilated, and with few exceptions, safely timbered. I called the attention of the workmen to the dangerous ones, and I presume they took proper precautions to make themselves safe, as no accidents have been reported from such places. The works in the upper vein are in good condition, dry and well ventilated. The coal is of good height, but rather softer than the block coal from the regular veins. Very little water is found on the roads and the roof seems to be easily held by timber. No complaints have reached me since my last inspection, and I am informed that improvements have been made in the middle vein and that all are well ventilated.

NICKEL PLATE MINE.

Three-fourths of a mile northeast of the above, and owned by the same company; is nearly worked out. Two veins have been mined here. The lower vein has nothing but entry pillars left, and those only where it is necessary to support the work that is to be done in the upper vein. For a mine that is so nearly completed it is in good condition. In some places there is a very weak current of air, and in others a great deal of black damp is given off from old works, but sufficient fresh air is supplied to dilute it and render it comparatively harmless. It is thought that it will be abandoned in about six months. In work of this character there is always great danger from falling roof. Accidents can only be avoided by the highest degree of care on the part of all concerned. I think this is being exercised by most employes at this mine, and I hope the mine will be finished without mishap.

MARKLAND MINE.

Formerly known as the Burger mine, located at the north limit of Clay City, is now operated by Andrews & Burnham, who are rapidly developing it. When inspected on November 4th 31 men were employed, with a daily output of 100 tons. The coal is from three to four and a half feet thick and of excellent quality. The law is being complied with in all respects, except that no second outlet is provided. Permission was given to run until spring without one, though more than 5,000 square yards have probably been excavated. Yet so much of the older works have fallen in that it would be very difficult to prove the fact. A surveyor could not get through nor around this part of the mine. The proposed plan is to sink a larger shaft for hoisting, and use the present opening for an escape way. This will probably be done.

FAIRVIEW MINE.

Located on the C. & I. C. Railroad, four miles northwest of Brazil. Two veins of coal are mined. This mine has always been found in good condition when inspected. While the upper vein has all the drawbacks and dangerous features commonly found in this seam, no accidents have been reported as caused by falling roof or coal at the mine during the year. The mine is operated by the Otter Creek Coal Company, of Brazil, Ind. The Nellie mine, near Brazil, operated by the same company, was abandoned during the year.

SAN PEDRO MINE.

Located north of Staunton, on the T. H. & I. R. R. Owned by Joseph Somers. This mine has been operated very irregularly during the year, and was inspected but once—December 10—and was found in good condition. The coal is bituminous, seven feet thick, and of good quality.

LOUISE MINE.

One and one-half miles north of Center Point; operated by the Weaver Coal Company. This mine has not been operated with any regularity for the last two years; in fact, it has not run long enough at a time to enable the managers to put it in good condition before another shut-down. This is one of the few mines in this State that have been developed on the single-entry plan. As a result of these two drawbacks the mine was found in bad condition when last inspected—December 13. However, but very little work was required to make it fairly good, and orders were given to have that done before the close of the year, and the changes were begun immediately, with a promise that they would be pushed to completion as soon as possible.

BRIAR HILL MINE.

Located at Asherville, on the Center Point Branch of the T. H. & I. R. R. Owned by Zeller, McClelland & Co.; was idle from May 1st till the latter part of September. It is now being operated with a view to its final abandonment early in 1898. When examined, December 13, it was found in fair condition for a mine where only pillar work is being done.

COLUMBIA NO. 4 MINE.

Located one and one-fourth miles southwest of Asherville, owned by the same company, was opened in 1896. It is being operated in the upper vein of block coal. The roof is very bad, even for this vein; and requires a great deal of timber and attention, making it difficult to make it secure. The main north entry is now standing in a very large fault. The mine is in fair condition, with a few exceptions, and efforts are being made to better those parts of the mine. The shaft at this mine will probably be sunk to the lower vein later. Several serious accidents have occurred here from falling roof during the year.

VICTORIA MINE.

Located one-half mile west of Cardonia, on the C. & S. E. Railroad. This is an old opening with a new name. It was operated by the Clay Coal Company in 1873, and by several other parties since then. The lower vein of block coal is being mined. The coal is brought to daylight through a drift, and is hoisted by a gin operated with horse power to a height of about 20 feet and dumped into railroad cars. While the mine has been operated so long there seems to be a considerable body of solid coal in the territory reached, and the mine may last quite a while. There are about 30 men employed, or were when the last inspection was made. The mine is operated by Allais & Urbain, Brazil, Ind. It is ventilated by a furnace which produces a sufficient circulation of air in all parts of the mine, and the roof is good.

DAVIESS COUNTY.

CABLE NO. 4 MINE.

Located on a branch of the B. & O. S. W. R. R., near Washington, Ind., owned by Cable & Co. Was opened in 1885; has a capacity at present of 330 tons daily. It is opened by a shaft 42 feet deep, and the second outlet is by a slope, and no men or mules are supposed to be hoisted at the shaft. This rule, however, is not strictly observed. The coal lies very uneven, giving considerable grades over which it has to be hauled, and making drainage troublesome, though it is fairly carried out. The bottom is fire clay and, where water is permitted to stand on it, works very easily into mud. A very good gray shale roof overlies the coal, and it is well timbered where it is necessary. The coal that is now being worked is bituminous, about 2 feet 10 inches thick, of good quality. Double entries are driven 7 feet wide, with a pillar 20 feet in thickness between the pair of entries. The bottom is taken up to make the roadways 5 feet high. This gives an area of 7 feet by 5 feet for the principal air-ways. They are kept fairly clean, and afford a good passage for air currents. The ventilation is produced by a fan at the main shaft, which gives a good supply of air, but doors and stoppings allow a good deal of it to escape before reaching the working places. However, on the last inspection, all working places were found well ventilated. Pillars are nearly all saved.

CABLE NO. 9 MINE.

Located on the same branch railroad as the above, some distance west; it is owned by the same company. This mine was opened in 1892. During the summer of this year an electric plant has been installed, and at present two Morgan-Gardner mining machines are in use. The capacity is 125 tons per day. The conditions are about the same as at number four, except that a band of draw slate from 2 to 20 inches in thickness is found above the coal, and the height necessary for entries is taken from the top instead of the bottom. The escape way is by a slope 700 feet from the bottom, which is used almost exclusively by men and mules.

Ventilation is produced by a ten-foot fan at the main shaft, and a good current of air is produced, which is nearly all carried to the working places. The size of the air compartment of the shaft is 7x8½ feet, and the principal air-ways are 8x5 feet in section. The miners here came out on a strike on May 1st, owing to a dispute about handling the dirt made by the draw slate which is spoken of above, and the mine was idle until August 1st, when it was started with colored men imported from Kentucky. A number of the old miners have left the place, but some are still insisting that the strike is being continued.

MONTGOMERY NO. 1 MINE.

Located on the main line of the B. & O. S. W. R. R. at Montgomery; it is operated by the Daviess County Coal Company. No men are hoisted at the shaft, as there is a good outlet by means of a slope 200 feet from the shaft. The capacity of the mine is 300 tons per day. The hoisting shaft is 85 feet deep, 18x7½ feet in size, with an air compartment 4½ feet wide cut off one end of the shaft. The coal is a good quality of steam coal and is about 4 feet thick, with a thin dirt band near the middle. Rooms are driven 22 feet wide, with pillars 12 feet thick between them. About half of them are saved. Grades are irregular and bottom soft, making it difficult to keep hauling roads in good condition. A 10-foot fan furnishes ventilation for the mine, and does the work very well. The company is sinking another shaft about one mile west of No. 2, the No. 1 Mine being so nearly worked out there will be nothing but pillars to draw by next Spring.

MONTGOMERY NO. 2 MINE.

Located near the above and owned by the same company. It was opened in 1896, and is connected with No. 1 Mine for a second outlet, and has a present capacity of about 150 tons per day. The shaft is 65 feet deep, and conditions are about the same as in the case of No. 1. An 8-foot fan at the main shaft furnishes sufficient ventilation. Both mines are under the superintendency of Geo. B. Brown, and the methods of working are so nearly alike that no further comment is necessary here. Coal is furnished to the engines of the railroad, 14 pockets having been constructed for that purpose.

MUTUAL MINE.

Located three-fourths of a mile south of the B. & O. S. W. Railroad, near Clark's Station. It is owned by the Mutual Mining Company. The coal is hauled by mules from the shaft to the tip-house on a tram road, one mile in length. The tipple is at the railroad, and the coal is loaded there into railroad cars. The production is 200 tons per day at present. The escape is a shaft 600 feet from the hoisting shaft. The depth of the shaft is 100 feet to the vein that is now being worked. Another vein lies above this, but it has never been worked here. It is from 3½ to 4 feet in thickness, but has not a good roof. The vein now being worked averages about 4½ feet in thickness, two-thirds of which is cannel coal, and the other one-third an excellent quality of bituminous. The vein lies nearly level, and has a good roof generally, though some bad places are found. The mine is well drained and the haulage roads are good, and are laid with 12-pound iron. Entries and air-courses are 8 feet wide, with pillars from 12 to 14 feet thick, and require no timbering. Rooms are driven 24 feet wide, and pillars 12 feet thick are left in such a condition that nearly all the coal will finally be saved, the rooms being well timbered, and the road placed near the pillar side. Ventilation is provided for by a 12-foot fan at the escape shaft. A good current of air is found at the faces of all entries, and all the working places, for safety and ventilation, will compare favorably with those of any mine in the State of Indiana. This mine was opened in 1884.

HAWKINS MINE.

Is located on the E. & I. Railroad, near Washington, and is owned by the Washington Coal Company. Its production is 100 tons daily. The second outlet is by a shaft 100 feet from the main opening. This is a shaft 64 feet in depth. The bottom is soft, but well drained, and a good haulage road is kept up. The track is all wood, and turntables are used instead of partings. The coal is 6 feet in thickness and is a good quality of soft coal, with no dirt bands in the seam. The roof is a soapstone, and entries and air-courses are driven only 6 feet wide; and timbered. Air-courses are kept clean and well drained. Rooms are 16 feet wide, with pillars 10 feet thick, which are nearly all saved before the workings are abandoned. A good road is maintained to the escape way. A fan 10 feet in diameter, located at the escape shaft, furnishes the air necessary to ventilate the mine. A good current of air is maintained at the faces of all entries, and the mine generally is in excellent condition.

WILLSON'S NO. 4 MINE.

Owned by the Washington Coal Company; it is located near the town of Washington, and is operated to supply local trade. It was opened in 1894. A gin hoist is used with a chain instead of a rope. The mine has, at present, a capacity of 50 tons per day. The mine is driven through the hill, thus affording two outlets, on opposite sides of the same. It is opened by a slope 100 feet long, and depends on natural ventilation for air. The vein is 3½ feet in thickness, of excellent soft coal, with a good shale roof and fire-clay bottom, and, while it lies irregularly, is well drained, and good roads are kept up. It is worked in such a way that all coal is saved. Timbering both in rooms and entries is well looked after. When inspected, December 22, a fair current of air was circulating in the mine.

RAGLESVILLE COAL CO.'S MINE.

Located one mile east of the town of Raglesville. It is operated by the Raglesville Coal Company, U. G. Stoy manager. The mine is opened by a shaft 36 feet deep, and the coal is hoisted with a gin operated by horse power. Coal is taken from the mine by wagon, the principal market being found in the immediate vicinity, though some is hauled to the E. & R. Railroad, a distance of three miles, and shipped from there. The vein is about 3 feet thick, with good roof and fairly hard bottom. No animals are employed, the coal being brought to the bottom of the shaft by pushers. This mine was opened during the year 1897, and was in good condition when inspected, November 27th. There were 24 men employed on that date.

UNION MINE.

Located one and one-fourth mile southeast of Raglesville. It is operated by the Union Coal Company; is a drift opening made in 1896. One mule is used in this mine, and, with this exception, the remarks made in regard to the Stoy Mine will apply to this. Sixteen men were employed November 27th, and the mine was in good condition.

CO-OPERATIVE MINE.

Located one and one-half miles southeast of Raglesville. It is operated by the Co-operative Coal Company; is a drift mine, opened in August, 1897. No screens are used, but the coal is cleaned in the mine by the use of riddles. The roof is good, and no timber is used in entries or air-courses, and to this time no falls have occurred to interfere with the course of the air, and the mine is in good condition at present. Ventilation in each of the above is by furnace.

FOUNTAIN COUNTY.

INDIANA BITUMINOUS MINE.

Located west of Silverwood, Indiana, on the Clover-Leaf Railroad. It is operated by the Indiana Bituminous Coal Company, of Terre Haute; R. S. Tennant, President. It was opened in the fall of 1894. By reason of its location a good market has been found for its product, and it has been operated more steadily than any other mine in the State since it began shipping coal. It is equipped with self-dumping cages, and has a capacity of 600 tons per day. The coal is of a good quality of bituminous and seems to give satisfaction wherever it is used. The coal is very irregular in thickness, running from 4½ to 7 feet, and has very great changes of level, requiring a great deal of grading to secure good haulage roads. The under-clay makes a good quality of brick, and has a fair demand for this purpose. The mine has usually been found in fair condition when examined, though an improvement could be made in the quality of oil that is used for light, which makes a great deal of smoke.

STURM MINE.

Located near Silverwood, on the Clover-Leaf Railroad. While this mine has been opened some time, it has been operated on a small scale until this year, when it passed under the control of the Silverwood Coal Company, who are now working about 25 men, and producing 50 tons of coal per day. The underground works of the mine are in good condition, and the ventilation is excellent. A few minor provisions of the law in respect to the equipment of the mine were not complied with when the mine was inspected, but they will be soon. The shaft is 51 feet deep.

DUBOIS COUNTY.

HUNTINGBURGH MINE.

Owned by L. B. Southard, Huntingburgh. It is located on the branch of the Air-Line Railroad, near the town. It was opened in 1886 and has been operated ever since, mostly, however, in a small way. The shaft is 35 feet deep. Very little attention was being paid to the mining law, and many recommendations were needed. There has not been a second visit made to see whether they have been complied with or not.

GIBSON COUNTY.

OSWALT MINE.

Located one mile north of Princeton, at the crossing of the E. & T. H. and the Air-Line railroads. It is operated by the Maule Coal Company, of Princeton, Ind.; it is opened by a shaft 440 feet deep. A second outlet has been completed at this mine during the year, and a good hoisting arrangement has been placed at the air-shaft. This has a separate engine, which is supplied by steam from the main boilers. The surface plant of this mine is one of the best in the State, having a double hoisting engine, with 18x32-inch cylinders coupled direct to a drum 8 feet in diameter. The coal is screened over perforated steel plates for the larger size, the screenings being elevated and passed through a revolving screen with meshes of three different sizes. The whole screening plant is operated by an engine, with a cylinder 10 inches in diameter with a 20-inch stroke. Seven different sizes of coal are made. Ventilation is produced by a fan 12 feet in diameter, which produces a good current in the mine. The shaft is very wet, but in other respects is in a good condition. The coal is a very hard bituminous, from 6½ feet to 7½ feet in thickness. Entries and air-courses are driven 8 to 9 feet wide, giving a large area for air travel. While considerable fire-damp is generated in some parts of the mine, no accidents have occurred from this cause during the year. Part of the coal is mined by hand and part by machinery. The Yoch mining machine, driven by compressed air, is used.

GREENE COUNTY.

ISLAND NO. 1 MINE.

Located one and one-half miles south of Linton, on the I. & V. Branch Railroad. It is the pioneer mine of Greene County, having been the first of any consequence opened in the county. It was opened in 1883 and worked as a pick mine until 1892, when the company equipped it with the Harrison compressed-air machines and a rope haulage about 1,200 feet in length. The mine is also equipped with the shaker screens, which are found to be very effective in removing all the fine dirt or slack, and making a very desirable grade of lump coal. They have also put in the improved Prox & Brinkman self-dumping cages. The capacity of the mine at present is 600 tons daily, giving employment to 100 men. When last inspected it was found necessary to order several changes in the mine to secure better ventilation, which was not good in some parts. This the company readily agreed to do. The depth of the shaft is 66 feet, and thickness of coal, as was given in the 1896 report, is 5 feet.

ISLAND NO. 2 MINE.

Located at Linton, one-half mile west of the town proper; it is worked by a shaft 95 feet deep. This is one of the most favorably situated mines in Indiana, as to railroad facilities, having a double tipple, one on the main line of the I. & I. S., and the other on the I. & V. Branch R. R. The advantages of location are two-fold; first, their ability to secure empty cars from either line, and that of sales and shipments on both roads. The mine is equipped with the Harrison machines, 25 in number, and has a rope haulage on the south side 2,200 feet in length, while the coal on the north side is hauled by mules, some of it a distance of 4,000 feet. The daily output at present is 1,200 tons. The coal, as has been previously reported, is 5 feet in thickness, and of excellent quality for steam and domestic purposes. I have made two visits to this mine during the past year, and at both inspections found the mine in excellent condition.

ISLAND VALLEY MINE.

Located two miles southeast of Linton, on the I. & V. Branch Railroad. It was opened in 1892 by a joint stock company, composed principally of miners, and has been one of the most successfully operated mines in Greene County. It is worked by a shaft 52 feet deep, and has an excellent vein of bituminous coal 5 feet in thickness. The daily capacity at present is 350 tons, giving employment to 58 miners. When last inspected, an overcast was ordered put in on the west side, to assist the ventilation in that part of the mine, which was very poor at that time. This the company did, and the mine is now fairly well ventilated.

FLUHART MINE.

Located one and one-half miles southwest of Linton; it is worked by shaft 72 feet deep. This mine was opened in 1891 and ranks among the largest pick mines in Indiana. The output at present is 800 tons daily, giving employment to 120 miners. This, however, is not its full capacity, owing to an insufficient number of miners to do the work. The mine is well equipped with improved screening machinery, also a number of coal bins for storing small coal. The coal is 5 feet thick and of excellent quality. When last inspected it was found necessary to request the air-courses to be cleaned out, and the brattice replaced in the main shaft to assist the ventilation, which at that time was poor in some parts of the mine. The company promptly complied with the request, and the mine is now in fair condition.

SOUTH LINTON MINE.

Located one mile south of the town proper of Linton. This is a pick mine, worked by a shaft 81 feet deep, and was opened in 1893. It has a vein of bituminous coal 5 feet thick, and of excellent quality for steam and domestic purposes. This is one of the best regulated mines in Indiana. I have made two inspections of it during the past year and at each inspection found it in excellent condition, the law being complied with in every particular. The daily capacity at present is 400 tons, giving employment to 66 men.

SUMMIT MINE.

Located one mile west of Linton. It is very favorably situated as to railroad facilities, having two switches, one from the I. & I. S. and the other from the I. & V. R. R.; thus giving it excellent shipping facilities and the additional advantage of securing empty cars from the two roads. This is one of the largest pick mines in Indiana, having a daily capacity of 750 tons, and employing 125 miners. It is worked by a shaft 95 feet deep and has an excellent vein of bituminous coal 5 feet 4 inches thick. This company suffered a very considerable loss in the early part of last March, owing to the heavy rainfall which flooded the mine and caused the man-way to cave in, which, when cleaned out and stairway replaced, cost several hundred dollars. At the last inspection the mine was in a fair condition.

TEMPLETON MINE.

Opened in 1892. This mine is situated within the corporate limits of the town of Linton, and about three-fourths of a mile from the town proper. It is located on a branch of the I. & I. S. R. R. It is a pick mine, worked by a shaft 52 feet deep, with a vein of bituminous coal 5 feet thick. During the past year the mine has been materially developed. One year ago about 40 men were employed, with a capacity of 250 tons per day, and there are now employed 112 miners, with a capacity of 750 tons per day. I have made two inspections of the mine during the past year. On the last inspection it was found necessary to order some changes made to promote ventilation, which order was promptly complied with, and the mine is now in good condition. Among other improvements made, with a view to the safety of the mine within the last year, there has been an escape shaft sunk and equipped with a stairway, as provided by the law.

KNOX COUNTY.

BICKNELL MINE

Located at Bicknell, on the I. & V. Railroad. At present it is operated by the Bicknell Co-Operative Coal Company, and is opened by a shaft 97 feet deep, sunk in 1890. The present production is about 140 tons per day, of a fair quality of bituminous coal. The roof is good and no timbering is required in the narrow work. The mine has always been found in excellent condition when inspected.

EDWARDSPORT MINE.

Located one mile northeast of Edwardsport, on the I. & V. Railroad, and is operated by the Edwardsport Coal Company of Indianapolis, Ind. The opening was originally made in 1894 by a slope, and the coal was brought to the dump by mules. During 1896 a shaft 45 feet deep was sunk and the coal is now brought out by that opening, the slope being used for an escape way. The mine is in excellent condition, except that at the point where the shaft was sunk the coal had been previously mined. This makes the pillar very weak at the bottom of the shaft, and may cause trouble in the future. However, every possible precaution has been taken to prevent this by putting in heavy timber, and it is likely to stand for years. The present output is 175 tons per day, of excellent bituminous coal. The vein contains two thin veins of clay near the middle of the coal, but the dirt is easily separated. No timber is used in the narrow work, and the air-courses are not kept clean, but a good current of air is kept in circulation. This is produced by a fan at the main shaft. The tipple is located 530 feet from the shaft, and a gravity plane is used to take the coal from shaft to the tipple.

PROSPECT HILL MINE.

Located near the city of Vincennes. It is operated entirely for local trade, having no shipping facilities. This mine has given us a great deal of trouble during the year, owing to the fact that it had no second outlet. An escape shaft had been begun some years since, but work on it had been abandoned and the mine worked with such a small force of men that its completion had never been undertaken. The experience of 1896 convinced the manager, Mr. F. Clarke, that to make the mine profitable more men must be employed, and he let a contract early in the Summer to have the escape-way completed. The contractor failed to do the work, and finally men were employed by the day, and the work was completed about December 1st. On several occasions we were informed that more than ten men were being employed in the mine at one time, and, on August 4th, we found nearly twice that number. On the promise of the manager that the offense would not be repeated, we did not prosecute the company for this violation. As far as we have been able to learn, the promise was kept, and two shifts of men, working night and day, kept the trade supplied. The probabilities are that this mine will be developed considerably during the year 1898, as means of ventilation and hoisting facilities will be greatly improved by the opening of the second shaft.

MARTIN COUNTY.

THE BEDFORD COAL COMPANY'S MINE.

Located at Tunnel Switch, on the E. & R. Railroad, is the only mine in this county employing over ten men. It is a drift opening, and has natural drainage; no steam power is used about the mine. The coal is of excellent quality, and has good roof and hard bottom, requiring very little timber. The vein is from 30 to 36 inches thick. Ventilation is produced by a furnace, and, while the current is not strong, working places were all found to be clear when inspected, November 26th. There are two other veins showing in the hill where this mine is located, both of good quality, but are thin—22 and 28 inches, respectively.

OWEN COUNTY.

LANCASTER NO. 4 MINE.

Located near the west line of Owen County, about three miles east of Clay City. It is operated by the Lancaster Coal Company, of which John Andrews, one of the first operators in the block coal field of Indiana, is President. The mine is connected with the E. & I. Railroad by a switch three miles in length. Its present capacity is about 100 tons per day. The coal lies near the surface, the shaft being but 20 feet deep. It is a hard coal, of good quality, and is known as the semi-block, as is all coal in the vicinity of Clay City. In thickness it is from 3½ feet to 5 feet. Being so near the surface, the roof is soft and requires a great deal of timber. In spite of this fact, the mine is in good condition, the air-ways being kept clean and a good current of air being circulated. This is the only mine in Owen County within the provisions of the law; and it will not last very much longer.

PARKE COUNTY.

COX NO. 3 MINE.

Located near Coxville, on the C. & I. C. Railroad. It is owned and operated by the Brazil Block Coal Company, of Brazil, Ind. The equipment of this mine for handling coal and preparing for market is the best in the State, being fitted with a screening and washing plant, which is described at length in another part of this report. The coal is mined by machinery. Twenty-one Harrison and one Ingersol-Sergeant machines are used, driven by compressed air. Two Norwalk compressors, each of 125 horse power, are a part of the plant. The coal is of the average quality of the "L" seam, as found in different parts of this State. It averages 6 feet in thickness, separated into two strata by a clay band from 2 to 4 inches in thickness. This gives a good height for haulage-ways and air-courses. The roof consists of a gray shale, which falls in slabs when acted upon by air current. This makes it very expensive and difficult to keep traveling roads and air-ways safe, but no accidents to persons have been reported as having occurred from unsafe roof in such places, which speaks well for the management. Ventilation is provided for by two fans, one at the main shaft and one at the No. 1 shaft of the company, which is located 1,200 feet from No. 3, and is used as an escape-way for the present works. A good current of air is maintained in all entries, and all working places are clear. No recommendations were necessary when the mine was last inspected.

OTTER CREEK MINE.

One mile northwest of Carbon, on a switch constructed from the Big Four Railroad. It is operated by the Brazil Block Coal Company. The works at present are in the upper vein of block coal, which is reached by a slope, and lies above water level. The bottom vein was reached by a shaft here, but this is now filled with water and has not been used for over two years. The roof in the vein now being worked is very bad, as a general thing, and as the bottom is a soft clay, and a good deal of water is found in the mine, plenty of timbers are needed to keep the entries and air-courses open. This is being accomplished in such a way as to prevent accidents and keep the mine well ventilated. But little work has been done here during the year 1897.

LYFORD NO. 2 MINE.

Located near Lyford Station, on the C. & E. I. Railroad. It is operated by the Calumet Coal Company, of Chicago, Ill.; has been open for several years, but has been idle a great deal of the time. Since the beginning of this year this mine has run as steadily as others in the bituminous district of this State. It is equipped to produce a large output, having a railroad track on each side of the shaft, with a full outfit for the handling of coal on either. Since starting this year, however, self-dumping cages have been put in, which are available only on one side. The present output is about 500 tons per day, which is mined by seven Harrison machines, operated by compressed air. The escape shaft has been provided with a stairway during the year. The coal is of the same general character as that at Coxville, with like material about 6½ to 7 feet in thickness, and has about 4 feet of gray slate overlying it. This cuts and falls when acted on by the air, until a stone is reached which requires no timber, but as the handling of so much dirt is expensive, different means have been tried to hold it. The only one that has proven successful so far is to leave enough coal to keep the air from the roof. Where this has been tried no breaks have occurred yet, though some of the work has stood a great deal longer than was necessary to show the failure of other plans. If that slate can be kept up, it will greatly reduce the cost of working this vein of coal here and elsewhere. This mine was found to be in good condition in all respects when last inspected. The No. 1 Mine of this company has not been in operation since February, when the shaft tower was burned. It has been rebuilt, but no work has been done underground.

PARKE NO. 8 MINE.

Located one mile northwest of Rosedale, operated by the Parke County Coal Co., of Rosedale, Ind. It is the same coal field as Cox No. 3, and remarks made as to underground condition apply here. This mine has a switch from the T. H. & L. Railroad from Rosedale, and from the C. & I. C. Railroad at Coxsville; is equipped with self-dumping cages and has a capacity at present of 500 tons per day; but this could be greatly increased. The coal is mined by Harrison machines, driven by compressed air, furnished by three 125 horse power Norwalk compressors. Twelve machines are in use at present, but 20 more are available when needed. The shaft is 125 feet deep, and coal is brought to the bottom by a rope haulage of 900 feet in length. The haulage roads and air-courses are timbered where it seems necessary, but where air-courses are not used as haulage-ways, very little attention is given to them, and they are generally found in bad condition, and the ventilation of the mine defective. The escape-way is through No. 6 shaft, which has recently been abandoned as a hoisting shaft. They are 2,100 feet apart. When inspected, December 15th, though the fan was running at a high rate of speed, the ventilation was found to be very defective. I hope to be able to report improvement soon.

MECCA NO. 1 MINE.

Located at Mecca, on the C. & I. C. Railroad. It is operated by the Otter Creek Coal Company, of Brazil, Ind. During the year an electric plant has been installed, consisting of a 30-horse-power dynamo, an electric motor for haulage and a power drill. The motor is not heavy enough for the work that it was expected to do, and is being operated over only a part of the distance it was intended to work upon. On my last visit some work was being done with a view of remedying this. Two veins of coal are being worked at this mine, but the upper vein seems to lie in pockets, and is reached by tunnels at two different points in the mine. The distance between the veins is from 4 to 10 feet, of a rather soft material. This mine has worked quite a distance from the shaft, and the motor is intended to haul coal about 2,600 feet. The roof in the greater part of the mine is so that it is not difficult to keep the roads open, and, with more power, the electric haulage would be a success. There are heavy grades and many curves, however, which require a great deal heavier motor than would be needed on a straight road. The coal in this mine is a hard bituminous, of good quality. It is mined by blasting without undercutting. All the work is done by hand except that accomplished by one electric drill. The output of the mine is about 150 tons per day. The mine is well ventilated in all of the working places. Only one fan is in use, but another is in place and can be put in operation at any time it should be desirable.

CRAWFORD NO. 1 MINE.

Located two miles northeast of Carbon. It is operated by the Crawford Coal Company, of Brazil, Ind.; is a block coal mine, working in both of the principal veins of this character. The bottom vein is reached by a shaft 35½ feet in depth, while the upper vein lies under the hill to the south of the shaft and is worked through a drift. The total output of the mine at present is 476 tons per day. Each vein is worked independently of the other with respect to ventilation and outlets, each having a fan and separate escape-way. The roof overlying the upper vein seems to be a brittle, hard pan, which, when it is allowed to fall, permits water to run into the mine from the surface, and the cracks do not close themselves, as is usual with the strata which overlies the coal in other places. This makes a great deal of trouble in the mine. In other respects this mine differs but little from other mines in the block-coal district. However, in spite of the fact that it usually runs very irregularly, I have always found this mine well ventilated, and the roadways well timbered and in good condition for hauling coal upon. The last inspection was made by Mr. Epperson, on November 10th, and was no exception to this rule.

McIntosh Mine.

Located on the Coal Bluff Branch of the C. & I. C. Railroad, three-fourths of a mile northeast of the Brazil Block Coal Company's No. 8 Mine. It is owned and operated by I. McIntosh & Co., Brazil, Ind. The shaft is 127 feet deep to the bottom vein of block coal, the upper vein having been exhausted. The most of the thick coal has been mined, and there is very little being worked in the mine over 3 feet in thickness. The roof is good and the bottom fairly hard, giving good roads generally in the mine. Very few pillars are being removed from the bottom vein yet. The ventilation has generally been found good in this mine, but, on my last visit, several places were found where doors and stoppings are needed to carry the air to the working places. The mine boss promised to remedy this soon.

Standard Mine.

One-fourth mile west of the above. It is operated by the Standard Coal Company, of Terre Haute, Ind. Both of the regular veins of block coal are being worked. The coal from the upper vein is lowered by a drop shaft to the workings below, and all the output is hoisted from the same landing. The car service from the C. & S. E. Railroad proved so unsatisfactory that during the year a switch has been secured for this mine from the C. & I. C. Branch, thus giving an outlet by two different routes. The latter switch was not finished on my last visit to the mine, November 9. But little work had been done in the upper vein at that time. The places that were open there were very wet. The bottom was in good condition, well ventilated and safely timbered.

COLUMBIA NO. 1 MINE.

Formerly known as Superior No. 1, is located one-fourth of a mile north of the above. This mine is being operated in the upper vein of block coal, has a bad roof, dips and rises are irregular in pitch and direction, and makes a great deal of water. This renders it difficult and expensive to maintain haulage roads and air-courses, and I have usually found the ventilation defective. During the past year, however, a great improvement has been made in this respect, and on my last visit, November 9, I found the ventilation much better than at any previous time. A large part of the mine is being finished, and when this is cut off it will be easier to keep the rest of the mine in good condition. This mine and Columbia No. 2 are owned by Zeller, McClellan & Co., Brazil, Ind.

COLUMBIA NO. 2 MINE.

Located one-half mile southwest of the above. It is owned by the same company. It is arranged to ship coal on both the C. & S. E and C. & I. C. railroads, having a separate screening outfit, scales and switch tracks from each road. The capacity is about 400 tons per day. There are no special features worthy of notice in the condition under which it is operated, except that possibly the roof in the upper vein is worse than usual, and a great deal of timber is necessary. The entries are well taken care of, but a great deal of dirt is allowed to accumulate in the air-courses. As the works have not been extended very far yet, a good current of air is being circulated around the regular air-ways, but it does not seem to have force enough to clear out smoke where work is being done any distance in advance of the current. All entries in the top vein were smoky, and a great many rooms where a good current of air was passing the mouths of the room. I think a great deal of this was due to bad oil. I found the bottom vein workings well ventilated and safe.

PERRY COUNTY.

CANNELTON MINE.

Located three miles northeast of Cannelton. It is operated by the American Cannel Coal Company. The mines have been operated here by this company for many years; in fact, they were among the first opened in this State. The coal lies in the hills above water level. Two of these have been worked out and abandoned; except that a haulage-way is maintained through them, through which all coal that is mined is drawn by mules. The present works are quite extensive, but there is very little being done now except to remove pillars. Ventilation is produced by a furnace, and this is the only extensive mine in which I have seen this method successfully employed. I found good air in all parts of the mine on my inspection, December 21, 1897. The daily capacity is about 160 tons, eight mules being used. The coal is hauled by mules through the tunnels mentioned above, to the dump, a distance of one and one-fourth miles. It is there dumped into hopper cars, which are taken to the river by a small locomotive, and lowered by a self-acting plane to a tipple and loaded on boats. The greater part of the product is sold for the use of the steamboats. Some, however, is used for local trade in the town, but there are several country mines in competition for this market.

TROY MINE.

Located one-half mile above the town of Troy, on the Cannelton Branch of the Air-Line Railroad. It is operated by Bergenroth Bros., and was opened in 1887. The daily output is about 50 tons, which is nearly all sold to boats on the Ohio River. The shaft is 50 feet deep, being sunk most of the distance through a massive sandstone. The roof and bottom are both hard, so that there is but little danger in working the mine. The coal is about 3 feet thick and of a very good quality. Ventilation is provided for by a furnace, which, however, was not in operation when the mine was inspected, on December 21st. There was a good current of air passing through the mine, being produced by natural ventilation between the two openings. The mine was not running on my last visit.

PIKE COUNTY.

PETERSBURGH MINE.

Owned by the J. Wooley, Jr., Coal Company, of Evansville; is located near the south limits of the town of Petersburg, on the E. & I. Railroad. It was opened in April, 1896, but employed but few men during that year. The production is 170 tons per day, mine-run. The shaft is 52 feet deep, and there is about 5 feet of clean coal, of a fair quality. It is driven on a very irregular plan, entries being from 8 to 12 feet, and rooms from 18 to 22 feet wide; this causes pillars to be of irregular thickness, and they are expected to be lost. Ventilation is furnished by a steam jet, which seems to furnish sufficient air for the workings at present. A second outlet will be necessary during the coming year.

AYRSHIRE MINE.

Located on the main line of the Air Line Railroad; is owned by David Ingle, of Oakland City. It is equipped with self-dumping cages and a roller screen to make nut coal from the coal that goes through the stationary screen. The capacity is about 600 tons per day. The coal is hoisted through the shaft, 22 feet deep, and is 5 feet thick of an excellent quality of bituminous coal, with a good roof and soft bottom. Very little timber is needed in the entries, but large pillars are left, containing about one-third of the total amount of coal in the vein. This keeps the roof good and the air-courses open, though haulage roads are muddy. The ventilation is produced by a fan and is good in all parts of the mine. A large proportion of the coal is nut and slack, and miners consider 33 cents per ton for mine-run coal the equivalent of 60 cents for screened coal.

HARTWELL MINE.

Located near Augusta, on a branch of the Air Line Railroad, five miles long. It was built in 1894, when the mine was opened, and is operated by the Cabel & Kaufman Coal Company, of Washington, Ind. It is opened by a drift and has a capacity of 70 tons per day. An electric plant has been installed here during the year, and one Morgan-Gardner chain machine is now in operation. Six mules are used in hauling the coal from the mine. The coal is 4½ feet in thickness, but contains a good deal of impurity in the way of sulphur and dirt. Ventilation is provided for by a small fan, which produces a good current of air. The engine house and tipple were burned during the year, but have been built more extensively than before the fire.

BLACKBURN MINE.

Owned by the S. W. Little Coal Company; is located at Blackburn, on the E. & I. Railroad. There is one of the most complete screening outfits here that is to be found in the State. Perforated plates 12 feet long by 4 feet 4 inches wide are used. For making lump coal the perforations are 4 inches in diameter and the nut coal screen has perforations 2½ inches in diameter. They are so arranged with double eccentrics that all jar from their motion is neutralized. The method by which this is accomplished was designed by Mr. S. W. Little, of Evansville. Space will not permit a full description of the arrangement here. The production of the mine is 300 tons per day. The main opening is a slope 475 feet in length, the coal being brought up by steam power. The escape-way is also a slope 400 feet in distance from the main opening. The grades in the mine are easy, with fairly hard fire-clay bottom, making the maintenance of good haulage roads comparatively easy. The coal is a hard bituminous, 7½ feet thick, with a good black slate roof. Entries are driven from 8 feet to 20 feet in width and stand without timbering. There being no falls of roof, air-courses are kept clean, giving a good passage-way for air. Rooms are driven 25 feet wide, with pillars 7 feet in thickness, and no attempt is made to remove the coal from room pillars. The ventilation is secured by a fan located at the old slope, 475 feet from the new one. This fan is 10 feet in diameter, driven by an engine whose cylinder is 7 inches by 12 inches, which produces a good current of air, which is carried fairly well to the working places.

LITTLE'S MINE.

Owned by the same company, located at Little's Station, on the E. & I. Railroad; was opened 1887. Its present capacity is 600 tons per day. It is opened by a shaft 80 feet deep. The mine is comparatively dry and has a hard bottom, the only drawback to the haulage being the uneven bottom, and the grades are light compared with other mines in the State. The coal is a fair quality of bituminous, 6½ feet thick, with an excellent roof and slate bottom. Entries are driven from 8 to 12 feet wide, and the height of the coal. No timbering is required. Air-courses are in good condition and kept clean. Rooms are from 24 to 30 feet wide, well timbered, and pillars 12 feet thick are left to support the roof. A splendid man-way communicates with the escape shaft, which is available at all times to the employes. A fan 10 feet in diameter, located at the escape-way, furnishes an excellent current of air, which is well conducted around the faces of the entries and rooms. About 100 men are employed, under the management of Andrew Dodds, mine foreman.

CARBON MINE.

Located one mile west of Ayrshire. It is operated by William A. Jackson, of Oakland City, Ind., and was opened in 1894. It is developed through a slope 160 feet in length. The coal is 4 feet and 4 inches in thickness, and of an excellent quality of bituminous. The roof is a black slate and requires no timber to keep it safe in entries. This is well attended to. Air-courses are kept clean and the ventilation, produced by a furnace, is fairly good.

SULLIVAN COUNTY.

STAR MINE.

It is located at Gramercy Park, on a branch of the E. & T. H. Railroad; owned and operated by Harder & Hafer Coal Company, and is worked by a shaft 120 feet deep, with a vein of bituminous coal 5 feet in thickness. This is one of the best-equipped mines in the State, having the Prox. & Brinkman self-dumping cages; also the latest improved roller screens for screening the small coal. It is an electric machine mine, the Morgan-Gardner machine (six in number) being used. On my last inspection they were running the machines night and day. Eighty-five miners were employed, with a capacity of 700 tons daily. The mine is also well regulated in way of ventilating apparatus, an overcast being provided for every pair of cross-entries, thereby doing away with doors on the entries and making a saving of no small consequence in way of expenses; and also providing a fresh current of air for each pair of entries. I have made two inspections during the year, and at both visits I found the mine in good condition.

JUMBO MINE.

It is located at Jackson Hill, on the E. & T. H. Branch Railroad, which leaves the main line at Farmersburgh. This mine ceased operating on September 16th, 1897, by reason of a fire, which destroyed all the buildings and damaged the machinery to a great extent, entailing a great loss to the company. The company rebuilt and resumed operation on October 15th, the same year. The mine is worked by a shaft 24 feet deep, with a vein of bituminous coal 5 feet 8 inches thick and of good quality. It is a machine mine, in which the Harrison machine is used, 15 in number; employs 69 miners, and has a capacity of 500 tons daily. It is equipped with Prox. & Brinkman self-dumping cages, and is ventilated by two fans, one on each side of the shaft. At the last inspection it was found in a very satisfactory condition.

CURRYSVILLE MINE.

Located one mile north of Shelburn, on the E. & T. H. Railroad. It is owned and operated by the New Currysville Coal Company; worked by a shaft 260 feet deep, with two veins of bituminous coal, the upper being 3½ feet and the lower 5½ feet in thickness. This is the oldest mine on the E. & T. H. Railroad, having been opened in 1867, when the top vein was worked quite extensively. Some years later the shaft was opened to the bottom vein, and the top abandoned; and it has been worked but very little since that time. Mr. Herbert Wooley, the superintendent, however, opened it in 1896, in order to get a few sample cars of the clay that underlies the coal, which he shipped to Evansville to have tested. I have not been able to learn the result of the test. The mine is worked partly by Harrison machines (three in number) and partly by hand. At my last inspection, made November 23d, it was in fair condition; 21 miners were employed, with a capacity of 120 tons daily.

PHENIX MINES NO.'S 1 AND 2.

Located at Alum Cave, on the E. & T. H. Branch Railroad. This mine ranks among the largest machine mines in the State, the Harrison compressed-air machine being the kind used; but the company have lately begun the work of putting in an electric plant, and intend mining and hauling their coal at No. 1 shaft by electricity. This mine is also well equipped in hoisting and screening machinery, having the Prox. & Brinkman self-dumping cages and the latest improved roller small-coal screens, together with a large washer, making it the most complete small-coal arrangement in the State. The No. 2 mine is a slope mine, and is worked by hand. The coal is hauled from the bottom of the slope by rope to the surface, and then hauled by mules through the west side of the No. 1 to the bottom of the shaft, the coal from both mines being hoisted through the same opening and dumped together. The coal at both mines has an average thickness of 6 feet. I have made two inspections of each mine during the year, and at each visit found them in excellent condition; employing 76 miners at No. 1 and 22 at No. 2 mine, with a capacity of 800 tons daily.

HYMERA MINE.

Located at Hymera, on the Farmersburgh Branch of the E. & T. H. Railroad. It is owned and operated by Harder & Hafer, of Chicago, Illinois. It is a shaft opening 55 feet deep, with a vein of bituminous coal 5 feet 6 inches in thickness. This is one of the most costly-equipped mines in the State, having the Prox. & Brinkman self-dumping cages and the latest improved screening machinery, with electric mining and hauling machinery. The Morgan-Gardner machines (7 in number) are in use mining the coal, and two large motors for hauling the same.

There are employed 51 miners, with a daily capacity of 225 tons. At the last inspection the ventilation of the mine was in a very bad condition, so much so that several changes were ordered to improve the same. It should be said, however, in extenuation of this seeming mismanagement, that the mine had been idle for some time previous, and had recently changed ownership.

SHELBURN MINE.

Located at Shelburn, on the E. & T. H. Railroad, and is worked by a shaft 240 feet deep, with a vein of bituminous coal 5½ feet thick. It is a machine mine, in which both the Lehner and Harrison machines are used. There are 28 miners employed, with a capacity of 200 tons daily. During the year the ventilating fan was moved from the No. 2 to the No. 1 Mine, and hoisting of coal from the latter has been suspended since that time. The two shafts are connected underground. This should give good ventilation, if air-ways were placed in proper order. At the last inspection the ventilation was poor, and necessary changes were ordered to remedy the same. This is one of the few mines in Indiana that generates fire-damp in quantities which make close attention to the ventilation apparatus necessary. By enactment of the last Legislature it became imperative on the part of coal companies to file maps of their mines with the Inspector of Mines. The Shelburn Mining Company failed to do this in the required time, and the Inspector employed a surveyor to do the work. A copy of the map is now filed in the Inspector's office.

BUSH CREEK MINE.

Located three miles east of Sullivan, on the I. & I. S. Railroad, and is owned by Thomas Watson, of Chicago, Illinois. At the time of my last inspection this mine was idle, and remained so until October, 1897, when operations were resumed again and continued until November 25th. It again lapsed into idleness, and remains so at this time. I have made one inspection, on November 19th, when I found the mine in a very unsatisfactory condition, chiefly owing to a long period of idleness. Orders were given to make the necessary changes, which the company readily agreed to do.

FREEMAN MINE, OR BRIAR HILL

This mine is located one-half mile southeast of the town of Dugger, on the I. & I. S. Railroad. At the time of my last report the mine was being operated on a very small scale, there being only 8 men employed, those being the lessees of the mine at that time. Since that time the mine has changed hands, and is now leased and operated by the Lyonton Coal Mining Company. There are now employed 35 miners, with a capacity of 125 tons daily. I have made one inspection during the year, and found the mine in good condition, and a full compliance with the law. This mine is equipped with the Prox. & Brinkman self-dumping cages, a roller screen for small coal, and a storage capacity of three 60-ton small-coal bins.

BUNKER HILL MINE.

Located four miles east of Sullivan, on the I. & I. S. Railroad. During the past year I have made two inspections of this mine, and found it in an excellent condition. It is worked by a shaft 72 feet deep, and has a vein of bituminous coal 4½ feet in thickness, of good quality. While the mine is not equipped with modern machinery, yet it is one of the best laid-out mines in the State. Its capacity at last inspection was 100 tons daily, with 35 miners employed. This, however, is by no means the full capacity of the mine, which at that time was limited by scarcity of miners.

VANDERBURGH COUNTY.

DIAMOND MINE.

Near the north city limits of the city of Evansville, on the Stringtown road. It is operated by the Diamond Coal Company, and does an exclusively local trade. This, as are all mines in this county, is opened by a shaft to a vein of bituminous coal, that runs about 4 feet in thickness. It is a fair quality of steam and domestic coal. Owing to the competition from outside coals, none of these mines are very largely developed. About 90 tons per day are being produced at this mine. The company have been trying all summer to arrange their escape-way so that men can be taken out of it, but claim that they have been delayed by the failure of machine shops to furnish the necessary machinery on time. All of it was on the ground but a drum when I made my last inspection, and the manager promised that it would be in operation before the end of the year; but it has not been so reported.

UNION MINE.

One-half mile southeast of the above. It is operated by the Evansville Union Coal and Mining Company; was opened in 1891, and has been working some ever since. It is at present producing from 40 to 60 tons per day. An escape shaft was completed to this in 1896, and the machinery with which it was sunk is still in the place, giving an available means of egress. The roof is a black slate, which cuts very badly after the coal is removed. The bottom is soft, and, water being allowed to lie on it, it becomes very muddy, and the hauling roads are in bad condition.

FIRST AVENUE MINE.

The improvements of this mine, noted in my report of last year, have been continued, and the mine is now in a fair condition. There is an indictment against the manager of this mine for violation of the law requiring an available means of escape besides the main hoisting shaft. No other complaint came to me of the condition of the mine.

SUNNYSIDE MINE.

This is the only mine in Vanderburgh County where mining machines are in use. Those of both the Harrison and Sergeant type are used. The production has been steadily increasing during the past 18 months, till now it has a capacity of 425 cars, which will average about one ton each. The shaft is 265 feet deep and is in good condition, but the tower and dump-buildings need repairing to conveniently handle the increase in output. The coal is all handled by mules, though the distance from the inside to the shaft bottom is 2,700 feet. For that distance the air has to be carried through old works. The ventilation is excellent, though the total volume is not so large as I have seen in other mines employing the same number of men.

UNITY MINE.

Was worked but a very little during the year. During the summer it was sold to a stock company, who intended to develop the north side of the mine, but dissension among the stockholders has delayed the work so that but seven men were employed when I visited the mine, December 18; and I made no inspection.

INGLESIDE MINE.

Located near the Ohio River, just below the city limits of Evansville. It is owned and operated by the John Ingle Coal Company. This is the oldest mine in the State, being opened in 1858, and has excavated a large area. Besides the local trade, the mine is convenient to the river and to the L. & N. Railroad, on both of which shipments are made. Coal is brought to the bottom of the shaft by a tail-rope haulage system, 3,000 feet in length. The other conditions are much the same as other mines in the county, except that very little trouble is experienced from water. I have always found this mine in good condition and complying with the mining law, except in respect to an escape-way. A second outlet is provided by a shaft a quarter of a mile from the main shaft, but no means are provided by which men may enter or leave the mine at the second shaft. As long as the law required a stairway in the escape-way, I took no steps to enforce it, as, by obstructing the air, it would have done more harm than the circumstances warranted for the possible good. The law now giving, as an alternative, a hoisting apparatus, and the company having begun to arrange for this before, but failed to complete it, I have caused an indictment to be found against them in the Circuit Court, which is now pending.

VERMILLION COUNTY.

FERN HILL MINE.

Owned by the Hazel Creek Coal Company, of Clinton, Ind. It is located on a branch of the C. & E.I. Railroad, about one mile west of the town of Clinton. This mine has been in operation a number of years, and the underground works are quite extensive. Its capacity is about 600 tons per day, equally divided between lump and screenings. The coal is hoisted through a shaft 48 feet deep, and the second outlet is by a slope separated from the main entrance about 100 feet. Men and mules use this way exclusively for entering and leaving the mine. The main entry is driven double width, and has double track for 1,400 feet. There are very few heavy grades, and coal is brought from the workings to the bottom of the shaft without change in the make-up of the "trips," or of the mules pulling them. The roadbed is hard and dry, which makes the work a great deal easier on animals than when water and mud is on the road. The coal mined here is a good quality of bituminous, 5 feet in thickness, with a hard slate for a roof. Large bowlders, known as "nigger-heads" among the miners, are frequently found. These often fall, leaving "pot-holes" in the roof, and are very difficult to handle, as the material of which they are composed is so hard that it is almost impossible to break them. Some instances have occurred where they lay so far down into the coal as to cause entries to be turned to pass around them. Bottom is taken up to give entries a height of 5 feet 3 inches. They are driven in pairs 7 feet wide, with pillars 18 feet thick between them. Rooms 21 feet wide, pillars 9 feet thick. Room pillars are not saved. The east side of the mine is worked out and abandoned, and a great deal of black damp is given off from these abandoned places into the air circulating through the mine, which makes it very difficult to secure good ventilation. In addition to this, I have nearly always found a very poor quality of oil burned in the mine, especially by drivers. At the time of my last visit 18 mules were being used. All of these came to the bottom of the shaft with their loads. On the main entry the air was so strong that ordinary oil would not hold a light; so drivers burned a mixture of coal oil. When they went to the working places they left a trail of smoke behind them which would hang until their next visit. Many miners say that as they have to suffer from the smoke, it is of no use to burn pure oil themselves, and buy the cheapest they can get and add to the difficulty. The result is that in spite of a good current of air, few places in the mine are in a condition fit to work in. The same facts are found at other mines in the State, but at none to so great an extent as here. The mine is ventilated by a 12-foot fan, and sends a sufficient quantity of air into the mine to supply a great many more men than I ever found employed there, but from the causes noted the ventilation is usually very poor.

BROUILLET'S CREEK MINE.

Owned by the Brouillet's Creek Coal Company. It is located one-half mile south of the above. This mine has heretofore been reported as the Indiana Bituminous Coal Company's No. 1 Mine. The present company was organized during this year. During the year 1896 the mine was remodeled, and it is one of the best-equipped mines in the State. Self-dumping cages are used, and about the only set of track scales at a coal mine in the State that are of sufficient strength and length to handle the largest coal cars without especial effort. A revolving screen is used to make nut coal, the screenings being elevated for that purpose. A 10x12 engine furnishes the power for this work. The total production at the time of my last visit was 700 tons per day, with a fair prospect of an increase in the near future. The shaft is 60 feet deep to the same vein of coal as is worked at the Fern Hill Mine, and what is said in regard to coal, roof and bottom there, applies equally to this mine. Coal is taken from but one side of the shaft, and, to facilitate handling it, a track has been made around the shaft at the bottom, the empty cars being taken from the cage on the east side, and pushed around to the west side to be taken into the works. The main entry has a double track, and the mine is developed on the double-entry system. Ventilation is by a fan at the hoisting shaft, which supplies a good current of air to all parts of the mine. The only defect found on the last inspection was at a point where the works had broken into those of the Fern Hill Mine, where a great deal of black damp was found.

TORREY NO. 4 MINE.

Owned by the Torrey Coal and Mining Company. It is located near the town of Voorhees, 3½ miles northwest of Clinton. The equipment of this mine is in good order, as all the buildings about the shaft were burned on June 12th, and the machinery was badly damaged and had to be completely overhauled. The boiler and engine room has been replaced by a brick building, and the shaft tower is enclosed with galvanized iron siding. The screens are stationary, but constructed entirely of iron, and seem to be very conveniently arranged. The production is 400 tons per day. The shaft is 75 feet deep to the vein that is now being worked, but has been sunk 175 feet farther to the "L" seam, and it is intended to develop this during 1898. The present workings are very wet, and the haulage roads are soft and difficult to keep in repair. The roof is generally very good, but there are some bad places, and falls frequently block air-courses and interfere with the ventilation. A tail-rope haulage system was used previous to the fire, but has not been placed in order since, all the coal now being brought to the bottom of the shaft by mules. Entries and air-courses are 8 feet wide and 5 feet high, this being the thickness of the coal. A fan at the hoisting shaft furnishes ventilation. A good volume of air is sent down the shaft, but stoppings and doors are so poorly constructed that most of the working places are smoky and foggy-looking. This is especially true where mining machines are at work and compressed air is being discharged. There are 11 Harrison and two Ingersoll-Sergeant mining machines in use.

BUCKEYE MINE.

Owned by McClellan, Eastman & Co. It is located one mile north of Fern Hill. It is in the territory where the upper vein was worked out by the Thompson Hill Coal Company. The present company sunk a shaft to the lower or "L" seam in 1895, and have been working since that time. The production is about 300 tons per day. The coal is from 5 feet 10 inches to 6 feet 6 inches in thickness, with a hard clay bottom. The roof appears hard when the coal is removed, but after standing some time it cuts and falls in slabs. This has not occurred to any great extent in this mine yet, but it has begun, and, taking warning from what has happened elsewhere, the experiment is being tried of leaving a layer of coal under the slate. This is easily done, as there is a parting at which the lower coal separates about a foot from the top. There is also a clay band from 2 to 6 inches thick, 2½ feet from the bottom. The plan of work differs very little from that described in the Parke County mines at Rosedale and Lyford. I have generally found the ventilation good in all working places here. The fan is driven by an engine 10 inches by 14 inches in size, geared by a link-belt to make two revolutions of the fan to one stroke of the engine. The air is divided into separate currents near the bottom of the shaft, thus giving a current of fresh air to each section of the mine.

VIGO COUNTY.

DIAMOND NO. 2 MINE.

Owned by the Coal Bluff Mining Company. It is located two and one-half miles southwest of Fontanet, on the Big Four Railroad. It was opened in 1895, but has not been worked very steadily. This mine is equipped with self-dumping cages, and an air compressor is in place, but no use has been made of it yet. Five hundred tons per day are being produced, all mined by hand. The shaft is 65 feet deep to the "L" vein, which shows all the characteristics noted elsewhere in describing this seam. Twenty-four-foot entry pillars and 15-foot room pillars are the rule, and nearly all of them are finally gotten out. The mine is well timbered and the safety of employes is well looked after. Ventilation is produced by a fan placed at the escape-way, 145 feet from the hoisting shaft, which produces an excellent current of air. All the working places are well ventilated. Bins have been erected with a view to putting in screening machinery.

PEERLESS MINE.

Owned by the Coal Bluff Mining Company. It is located one-half mile north of the crossing of the Big Four and C. & I. C. railroads. Shipments are made by the latter road. Shaking screens are used, the power being furnished by an 8x10 engine. The production is 200 tons per day, all mined by hand, but a great deal more could be handled. The shaft is 101 feet deep. The bottom is soft, but is well drained, and haulage roads are good. Iron weighing 16 pounds per yard is used on main entries, and 12 pounds on cross-entries. The coal is good quality, 7 feet thick. It is soft, however, and does not bear handling. Entries and air-courses are 8 feet wide, with 40-foot pillars. Rooms are 24 feet wide, with 14-foot pillars, most of which are removed in finishing the mine. Ventilation and timbering are well attended to. The fan is situated at the escape-way, 100 feet from the hoisting shaft. The shaking screens were recently introduced. A bar screen is used to clean the lump coal and perforated plates to screen nut. A double eccentric is used which relieves the jar on the tipple. Its success was not assured at my last visit, as it had not been sufficiently tested at that time, but I have no doubt that it has come to stay.

UNION MINE.

Owned by the same company. It is located one and one-half miles northeast of Fontanet. Seven Harrison mining machines, driven by a Norwalk air-compressor, are in use at this mine. The mine is equipped with self-dumping cages and is producing about 700 tons of coal per day. The grates used under the boilers admit of burning the finest screenings that are made at the mine, and give good service. The shaft is 111 feet deep to the same vein that is worked at the Peerless. Haulage roads are good and the output is handled by 11 mules. Entries are 7 feet wide, with 24-foot pillars, rooms 22 feet, pillars 5 feet. The coal is nearly all saved. Near the bottom of the shaft some bad roof was found, but this is not the case in the present working part of the mine. Ventilation is produced by a 12-foot fan situated at the escape-way, 200 feet from the shaft. A good current of air was found in all entries on last inspection. Cross-bars of railroad iron are being used quite extensively on the north side of the mine, and have proven a success, especially in narrow entries. Rooms are well timbered.

BROADHURST MINE.

Owned by J. N. & G. Broadhurst. It is located one mile southwest of Macksville. It has been operated on a small scale for several years, the product being hauled in wagons to Terre Haute. There is no likelihood that more than a local business will be done, though from 20 to 30 men have been employed this year for this trade. The shaft is 89 feet deep, 6 feet by 12 feet in size. The coal is 5 feet in thickness, with a fair roof but very soft bottom. This gives trouble both in making haulage roads and in keeping up the roof. Pillars are left 12 feet thick and are not removed. The mine was originally worked on a very poor system, but this has been improved during the last year, and it is now being developed systematically.

SEELEYVILLE MINE.

Owned by Julius Ehrlich. It is located immediately south of the town of Seeleyville, on the T. H. & I. Railroad. It has been opened for a number of years, but for some time past has worked very little. It is fairly well equipped for handling coal, having self-dumping cages, and plenty of hoisting power in a double engine with cylinders 22x42 inches. Everything about the pit top is in good condition, but very little coal is being produced. Only one side of the shaft is used for hoisting coal, a water box being used in the other. Part of the mine is being finished by drawing pillars. On my last inspection I found several rooms very smoky for lack of break-throughs between them. In other places the ventilation was good.

NICKEL PLATE MINE.

Owned by the Ehrman Coal Company, of Terre Haute. It is located on the Brazil Branch of the C. & E. I. Railroad, three miles southeast of Grant Station. The coal lies nearly on a level with the valley up which the railroad switch runs. The mine is developed under the hills on each side of the valley, and is ventilated by two fans, one on each side. Men and mules enter and leave the mine by a slope running from the bottom of the shaft to the surface, and a second outlet is provided by the air-shaft on the west side of the mine. The coal is soft, but of a good quality for steam purposes, and is 7 feet thick. The roof is a gray shale and very soft in some places, but the mine is well timbered. There is very little deviation from the usual plan of working. Ventilation was found to be good in all parts of the mine.

HECTOR MINE.

Owned by the Loughner Coal Company. It is located one-fourth of a mile west of Seeleyville, on the T. H. & I. Railroad. It was opened in 1896, and an escape shaft has been made this year. The production is about 300 tons per day, but only one side of the mine is being worked at present. The roof is good and the bottom hard. The roadways are well drained. The coal is from 6 to 7 feet in thickness, and of fair quality. No timbering is necessary in entries, which are driven 12 feet wide. Rooms are 24 feet wide, and all pillars 12 feet thick. The work is well laid out, and as the company has a large territory, this is likely to be an important mine in the near future. Ventilation in those parts of the mine where work is being done is excellent.

GRANT MINE.

Owned by the Grant Coal Company. It is located on the Brazil Branch of the C. & E. I. Railroad, one-half mile south of the crossing of the Big Four at Grant Station. It was opened in 1889, and has quite a large territory worked out. In addition to the usual hoisting equipment an Ingersoll air-compressor is in use at this mine. The shaft is 80 feet deep; 600 feet of tail-rope haulage is in use, and all coal is being mined beyond that distance from the shaft. The track is laid with 16-pound iron on a good roadbed. The coal is 6½ feet in thickness, of the same character and quality as that at Fontanet. Large pillars are left both in entries and room work, and they are only partially saved. There is not enough attention given to the timbering of entries and air-courses, so that the ventilation is very imperfect in many places in the mine. This is caused in a great degree by the air having to be carried so far along abandoned works before reaching the working places. The road to the escape shaft is not very well timbered, and it has been necessary, on every visit I have made to this mine, for me to call the attention of the Superintendent to this fact. This road is seldom used and is therefore neglected. It is available in case of an accident, but should be kept in better order.

BRICK WORKS MINE.

Owned by the Terre Haute Brick and Pipe Company. It is located at their brick works, one mile northwest of Macksville. The product is nearly all used by the company. The mine is splendidly equipped, and is worked on a regular plan. An escape shaft has been completed during the year. It is 600 feet from the main shaft, and, as the coal is but 35 feet from the surface, it makes a convenient means of getting in and out. The ventilation is all that could be desired, a 10-foot fan having been placed at the mine during the year.

VIGO MINE.

Operated by Ed. Davis. It lies one and one-fourth miles northeast of the Nickel Plate Mine, and was originally opened in 1893. This is a slope, and two engines are used. One hauls the coal from the opening to the incline, which is built to the tipple, and another draws it to the tipple. The capacity is only 75 tons per day. The mine was in fair condition when last visited.

RAY MINE.

Owned by the Vigo County Coal Company. It is located one-half mile east of Seeleyville, on the T. H. & I. Railroad, and was opened in 1893. This mine has a very complete equipment, everything being in first-class shape. A double hoisting engine, with self-dumping cages, is used to bring the coal up the shaft. Elevating machinery carries the screenings to a roller screen, by which the nut coal is separated from the slack. The production of the mine is 350 tons per day. The shaft is 110 feet deep, and the coal 7 feet thick. The plan of working includes double entries 7 feet wide, separated by 21-foot pillars, rooms 28 feet wide, room pillars 12 feet. No pillars are taken out. A good escape shaft is provided. The fan is placed at this opening.

ST. MARY'S MINE

Operated by J. F. Erwin. It is located near the Convent of St. Mary's of the Woods, and is owned by the Sisters of Providence. This mine was opened in 1894, and, though it has never come under the provisions of the mining law, I found, on inspection, that it complied in all respects with its requirements, except that no safety catches were on the cages. The owners informed me that they were ordered, and I presume they have been put on before this time. The shaft is 97½ feet deep, and is excellently timbered and equipped. The working under ground is following the usual plan used in working similar veins of coal, and though not extensive, may be made so. Timbering and ventilation are excellent.

LARIMER MINE.

Operated by William Lankford. It is located on the National road, two miles southwest of Macksville. It is a shaft 125 feet deep, sunk in 1888, and has been working more or less ever since. Though a good deal of territory has been worked over, the mine is in excellent shape, except parts that have been abandoned. A second opening has been made 900 feet north from the hoisting shaft, and an entry 7 feet wide and 4½ feet high is driven between them. The production is about 50 tons per day. Ventilation and timbering were all that could be desired when inspected, and I have good reports from there ever since.

KRACKENBERGER MINE.

Owned by P. Krackenberger. It is located on the Paris road, one mile west of Macksville. It was opened in 1896, and but little has been mined from it. Everything about the pit top bears evidence of pinching in expenses, which gives a bad impression. The boiler and machinery are old, and the shaft buildings are cheaply constructed. The shaft itself is 4½ feet by 5 feet in size, and a part of this is cut off for an air-chamber, in which a steam jet was used to produce a current of air. The underground works are laid off in a good manner, and if the shaft were enlarged to admit of two cages being used a good output could be secured. Entries are 6 feet wide, driven in pairs, with 45-foot pillars and rooms in proportion, the idea being to save pillars before abandonment. Since my inspection, connection has been made with an abandoned shaft, and a furnace built; this should secure good ventilation. The last three mines described, as well as Broadhurst's and several small mines west of the Wabash River, depend entirely upon wagon trade, having no railroad connections. Risher's, Eagle and Gruenholtz mines, which were mentioned in my last report, have not employed ten men at any time during the year, and I have not inspected No. 10 Mine since the water was gotten out of it at the close of the year.

WARRICK COUNTY.

STAR MINE.

Owned by John Archbold, Evansville, Ind. It is located on the Evansville Suburban & Newburgh Railway, one mile from Newburgh, and has shipping facilities by this railroad and by the Ohio River. The mine is well fitted up to handle coal and produces 220 tons per day. The shaft is 100 feet deep, and the coal 5 feet thick, of a fair quality of steam coal. The mine is dry and fairly level, so that good haulage roads are easily maintained. Entries are 14 feet in width and air-courses 8 feet. They are driven parallel, with a pillar of 15 feet between them, and stand without timbering. Rooms are 24 feet wide, with pillars 12 feet thick. Pillars are left in the mine permanently. Ventilation is furnished by a fan at the escape-way 100 feet northwest of the main shaft. A good current of air is maintained throughout the mine, and during my term as Inspector there has been no necessity for any recommendations to improve the condition of the mine, on any of the visits of myself or assistant, as it has always been found in compliance with the law and is one of the best cared-for mines in the State.

CHANDLER MINE.

Owned by Patrick Bartly, Evansville, Ind. It is located near the depot at Chandler, on the Air Line Railroad. Its production is 50 tons per day. The shaft is in good condition, 115 feet in depth. It was opened in 1892, and there has been a great deal of trouble from decaying timbers in the bottom this year. The coal is 5 feet thick, of a fair quality of soft coal. The mine is dry and the haulage roads and air-ways are in good condition. About half the coal is left in pillars, and is not taken out on abandoning the working places. A second outlet has been made 400 feet south of the shaft, but for the two years previous to July, 1897, no attention had been paid to it and the road had become closed. A new shaft is now being sunk and will soon be finished. There were only 11 men working in the mine when inspected, July 30th, and, though the air current was weak, there was sufficient for the men employed.

GOUGH MINE.

Owned by Robert Gough, and operated by Kelly & Nester. It is located one-half mile east of Boonville, on the Air Line Railroad. This mine was opened in 1879, but has been operated only in a small way. The second outlet is by a slope 150 feet from the shaft, reached by a good road under ground. The hoisting shaft is 42 feet deep and the coal varies from 4 to 7½ feet in thickness, and is of good quality; excellent roof, except near the outcrop. The plan of working is very irregular, pillars being thin, and no attempt is made to save them. Places are well timbered and ventilation is good. Production, 150 tons mine-run coal per day, when inspected.

BIG VEIN MINE.

Owned by the J. Wooley, Jr., Coal Company. It is located one mile east of Boonville, on the Air Line Railroad. It was opened in 1891. This mine is opened by a slope. In addition to the necessary hoisting machinery an air-compressor is used, which furnishes power to two

Jeffery air-drills and three mining machines. The daily capacity is about 300 tons. The coal is an excellent quality of bituminous, and is from 6 to 8 feet thick. Ventilation is provided for by a fan located 50 feet from the slope, the outlet being furnished by openings to the surface where falls occur. The coal lying near the surface, the roof is very soft, but no trouble is experienced from this source in narrow work, as it is easily held by timber. The ventilation is good in the working places.

CALEDONIA MINE.

Owned by the Caledonia Coal Company, of Boonville, Ind. It is located east of the Big Vein Mine. It was opened in 1894, but for the greater part of the time not men enough have been employed to make the mining laws applicable. However, when visited, July 29th, the mining law was being fairly well complied with. The production at that time was 85 tons per day; this, as well as other mines in this part of the State, having a better market than usual on account of the general strike.

BRITZIN'S MINE.

Owned by William Robertson; near Newburgh, Ind. This mine was not employing 10 men when visited, October 21st, but the owner expected to have more during the fall and winter. This mine has connection with the E. S. & N. Railroad, and will ship coal to Evansville, in addition to local trade. It is in the same vein of coal as the Star Mine, and underground conditions will be the same as there, most likely. No inspection was made, but a second outlet was ordered to be made as speedily as possible.

TABLE No. 1.

Showing Men Employed Inside and Outside of Mines, Animals Used About Mines, Mines Opened and Abandoned During the Year, and Mines in Operation at the Close of the Year.

COUNTIES.	MEN EMPLOYED.		ANIMALS.	MINES.		
	Inside	Outside.		New.	Abandoned.	Working
Clay	2,320	195	186	7	5	31
Daviess	330	46	40	7	2	9
Dubois	15	2	1	1	....	1
Fountain	112	10	13	1	....	2
Gibson	85	12	13	....	1	1
Greene	751	77	69	....	....	7
Knox	113	18	9	....	....	3
Martin	33	2	2	....	....	1
Owen	31	4	3	....	....	1
Parke	715	88	58	....	1	18
Perry	58	5	6	....	....	2
Pike	343	49	60	1	....	6
Sullivan	554	63	76	....	....	12
Vanderburgh	183	26	33	....	....	6
Vermillion	432	35	44	1	....	5
Vigo	632	86	71	1	....	5
Warrick	128	21	18	1	....	8
Total	6,835	739	702	16	13	124

The above table refers, of course, to mines employing more than ten men, and a number of those listed as new mines are such as have come into the list during the year, having previously been operated on a smaller scale. On the other hand, mines which employed more than 10 men at the date of my last report, and are now employing less than that number, are classed as abandoned mines; so that the number of new openings and the number of mines finally abandoned are less than shown in the table, and some classed as abandoned may again increase their employes so as to bring them within the list of mines in operation.

TABLE No. 2.

Showing Production of Coal, Men Employed Inside and Outside of Mines, and Animals Used in the Mines During the Years 1896 and 1897, by Months.

MONTHS.	COAL PRODUCTION.		MEN EMPLOYED.				ANIMALS USED.	
			Inside.		Outside.			
	1896.	1897.	1896.	1897.	1896.	1897.	1896.	1897.
January	445,077	409,626	7,257	6,564	796	708	580	539
February	372,628	408,137	6,66[illegible]	6,690	719	707	569	532
March	433,751	388,640	6,445	5,7[illegible]6	688	542	557	506
April	417,155	380,321	5,886	5,[illegible]76	669	537	498	532
May	132,329	241,114	3,835	4,065	4[illegible]4	501	339	361
June	196,[illegible]95	261,907	4,130	4,349	330	5[illegible]0	333	419
July	181,879	1[illegible]2,553	3,937	1,746	403	276	318	287
August	253,965	61,131	4,453	681	461	112	287	92
September	301,050	229,188	4,757	4,349	505	448	388	357
October	382,272	484,680	5,111	5,903	571	662	459	584
November	390,602	544,946	6,143	6,448	614	741	531	590
December	424,763	562,5[illegible]2	6,413	6,835	69[illegible]	739	542	702
Small mines, estimated	136,398	150,000	....	....	....	....	....	....
Total	4,068,124	4,228,085	....	....	....	....	....	....

The increased estimate for small mines is based on the fact that many of them had a largely increased output during the strike of the larger mines from July to September.

TABLE No. 3.

Table Showing the Annual Production of Coal for the State of Indiana, from 1879 to 1896 Inclusive, as Shown by Reports of Mine Inspectors.

YEAR.	TONS.	CAPITAL.	INSPECTORS.
Oct., 1879, to Oct., 1880.	1,996,490	$1,135,562	Richards.
1881	1,771,536	1,442,210	Wilson.
1882	1,990,000	....	
1883	2,5[illegible]0,000	1,60[illegible],000	Wilson.
1884	Est. 2,26[illegible],000	1,7[illegible]0,000	Wilson.
1885	2,375,000	1,850,000	McQuade.
1886	3,[illegible]00,[illegible]00	1,975,000	McQuade.
1887	3,140,979	....	McQuade.
1888	....	....	
1889	3,676,00[illegible]	2,081,000	McQuade.
1890	3,714,479	....	Tislow.
1891	3,819,600	(new) 185,000	McQuade.
1892	4,494,811	....	McQuade.
1893	4,358,897	....	McQuade.
1894	3,440,353	....	McQuade.
1895	4,312,081	1,852,500	Fisher.
1896	4,068,124	1,750,000	Fisher.
1897	4,228,085	1,600,000	Fisher.

LABOR TROUBLES.

The year has been prolific of labor difficulties in the mines of this State; but, to the credit of the miners, generally, and especially of their leaders, but little violence occurred. As a result, the sympathy of the public has been with the miners, and an unbiased investigation and discussion of the condition of the coal business in all its phases has been possible for the first time in many years. The result has been to show that the wages paid in the mines of the State and its competing fields, taken in connection with the small amount of work that could be given, had brought the employes to a state of nearly absolute destitution. On the other hand, the selling price of coal had reached a point where operators could not afford to pay living wages, and make a profit on their product. The result has been that the price of coal to consumers has been advanced to some extent, and the present tendency seems to be upward, so that there are lively hopes that an era of comparative prosperity will soon be enjoyed in this industry.

The year began with a slight reduction in the output of this State, which fell from 424,763 tons in December, 1896, to 403,074 tons in January, 1896, but during the first four months of the year the monthly increase averaged 3,293 tons. Owing to the question of wages being amicably settled on May 1st, 1897, the next two months showed a large increase of production over the corresponding period of 1896, though it still did not reach one-half the production, monthly, of December, 1896, nor one-third the productive capacity of the mines of the State. The general strike which occurred on July 4th, referred to below, caused an almost complete paralysis of the coal business in this State. The coal produced during July and August, and the greater part of that produced in September, came from the southern end of the State, where a number of mines continued in operation; most of them, however, of small capacity. Some coal was also mined in Knox and Vigo counties. The agreement made in April, 1897, provided for a price of 51 cents per ton for pick mining in Standard Bituminous coal, and 61 cents per ton in Standard Block coal, with extras for deficient coal, yardage and room timbering, based on this price. Machine mining was also governed by the price paid for pick mining, as had been customary in this State. On July 3d, a majority of the miners of the State ceased work, in common with those of Illinois, Ohio, western Pennsylvania and parts of other States, in response to an order from the national organization of United Mine Workers, and within a few days thereafter the strike extended to all mines from Washington northward, with a few unimportant exceptions, and they were employed principally in supplying local trade. The strike, which at one time affected 125,000 miners in the Central Western States, continued until September 12th, when an agreement was reached by which nearly all began work within 10 days thereafter. In some parts of the territory, however, notably northern Illinois, the struggle was continued into December, on account of a failure to adjust the general settlement to local conditions. This affected the business in Indiana by curtailing the supply of coal in the market and making a greater demand here. This, together with the fact that stocks had been depleted by the long idleness, had the effect of stimulating production here, which would have been greater than is shown but for the scarcity of men and of railroad cars. On the basis of the September agreement, pick mining in Indiana was advanced 5 cents per ton, with a proportionate increase in other classes of work. The only difficulty that was left unadjusted in this State was that at Washington, referred to above. The company imported miners from the Kentucky coal fields, and put them to work in their mines, which are now running with a much smaller force than usual. Many of the old men have secured work in other places, but probably one-third of those who came out on strike are still continuing the struggle. While the advantage in a financial way from the strike was slight, comparatively, it gave the miners opportunity to let the public know their actual condition, and secure sympathy and, to a certain extent, co-operation, in their efforts to better it, also brought about a bitter feeling among all interested in the industry than has prevailed for years. The miners' organization has been greatly strengthened, and greater confidence is reposed in their leaders by the workmen, than has been the case for some time past. The effect of all this is bound to be that employers will enter agreements with the miners' officials with confidence that they will be carried out in good faith, and great benefits will be derived in the future, as much of the uncertainty attending the operation of mines will be removed, and sales of coal can be made with the assurance that strikes will not interrupt its delivery. It is to be hoped that the present good feeling will continue. The present mining rate is to continue until January 15th, 1898, and a conference of miners and operators is to be held at Chicago on January 17th, to fix the price for the year 1898.

TABLE No. 4.

Giving a List of Mines Employing More than Ten Men, the Names and Addresses of Mine Bosses and the Number of Men and Mules Employed at Each, January 1, 1898.

CLAY COUNTY.

MINE BOSS.	ADDRESS.	MINE.	EMPLOYES. Inside.	EMPLOYES. Outside.	Mules.
John Bolin	Brazil	Brazil Block No. 1	112	19	10
Wm. Conroy	Brazil	Gart No. 3	125	10	15
Andrew Gilmour	Cardonia	Gart No. 5	204	10	12
James Baxter	Brazil	Brazil Block No. 7	19	2	1
August Norkus	Diamond	Brazil Block No. 8	188	22	19
....	....	Brazil Block No. 10	7	1	1
Martin Navin	Diamond	Brazil Block No. 11	110	8	5
Robert J. Wallace	Diamond	Brazil Block No. 12	37	9	1
W. P. McQuade	Brazil	Gladstone	138	9	12
A. L. Boore	Clay City	Briar Hill	34	6	3
Charles Nash	Clay City	Harrison No. 2	77	6	6
....	....	Harrison No. 3*	....	....	....
H. W. Jenkins	Perth	Pratt	60	8	6
Walter Knox	Asherville	Crawford No. 2	78	6	6
Wm. Penze	Brazil	Crawford No. 3	107	7	6
Samuel Lindsay	Brazil	Crawford No 4*	....	....	....
R. F. Jenkins	Knightsville	World's Fair	59	3	3
James Cuthbertson	Cardonia	Diamond No. 3	159	7	8
....	....	Klondyke*	....	....	....
H. B. Ehrlich	Brazil	Excelsior	27	4	4
T. J. Russell	Turner	Superior	55	5	3
W. T. Hopkins	Carbon	Eureka No. 2	179	8	16
John Quigley	Carbon	Eureka No. 3	23	2	6
James A. King	Brazil	Monarch	15	1	2
Moses Marks	Cardonia	Brazil	139	8	9
John Cox, Sr.	Brazil	Nickel Plate	36	3	4
Peter Andrew	Clay City	Markland	34	3	5
W. J. Price	Cardonia	Fairview	56	5	5
Ed. Somers	Staunton	San Pedro	42	7	4
Griff Howell	Center Point	Louise	75	6	6
M. Hofmann	Asherville	Columbia No. 3	14	2	1
Thos. Thompson	Hoosierville	Columbia No. 4	83	5	4
F. J. Urbain	Brazil	Victoria	28	3	3
Total	....	....	2,320	195	186

DAVIESS COUNTY.

Anton Kocher	Washington	Cabel No. 4	31	3	3
Joseph W. Small	Washington	Cabel No. 9	54	8	8
James B. Brown	Washington	Montgomery No. 1	66	10	14
Geo. B. Brown	Washington	Montgomery No. 2	40	4	5
Geo. B. Brown	Montgomery	Montgomery No. 3*	....	....	....
Daniel W. Davis	Cannelburgh	Mutual	47	9	4
A. W. Stuckey	Raglesville	Stoy	16	2	....
W. A. Jacobs	Raglesville	Union	16	2	1
....	....	Co-operative*	....	....	....
Thomas Harris	Washington	Hawkins	37	6	3
J. Teverbaugh	Washington	Wilson's No. 4	23	2	2
Total	....	....	330	46	40

*New mines; no reports yet.

TABLE No. 4—Continued.

DUBOIS COUNTY.

MINE BOSS.	ADDRESS.	MINE.	EMPLOYES. Inside.	Outside.	Mules.
W. A. Barrowman	Huntingburgh	Huntingburgh	15	2	1
Total			15	2	1

FOUNTAIN COUNTY.

Steward Shirkie	Silverwood	Ind. Bituminous Co.	92	7	12
J. S. Tiley	Silverwood	Silverwood	20	3	1
Total			112	10	13

GIBSON COUNTY.

Thomas J. Thomas	Princeton	Oswald	85	12	13
Total			85	12	13

GREENE COUNTY.

S. C. Risher	Linton	Island City	98	12	7
J. S. Newport	Linton	Island No. 2	165	21	17
Wm. Walton	Linton	Island Valley	67	5	5
James Dunn	Linton	Fluhart	122	11	12
Joseph Ferry	Linton	South Linton	69	6	5
W. H. Sexton	Dugger	Summit	119	12	17
John Templeton	Linton	Templeton	11	10	6
Total			751	77	69

KNOX COUNTY.

R. M. Freeman	Bicknell	Bicknell	41	4	2
M. Atkison	Edwardsport	Hofmann	50	8	4
W. R. Scott	Vincennes	Prospect Hill	22	6	3
Total			113	18	9

MARTIN COUNTY.

M. Dickie	Short's	Bedford	33	2	2
Total			33	2	2

TABLE No. 4.-Continued.

OWEN COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Employes. Inside.	Employes. Outside.	Mules.
James T. Andrews	Clay City	Lancaster No. 4	31	4	3
Total			31	4	3

PARKE COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Inside.	Outside.	Mules.
George E. Davis	Coxville	Cox No. 3	134	22	8
John Bolin	Carbon	Otter Creek	48	4	4
		Lyford No. 1†			
John Musket	Lyford	Lyford No. 2	40	6	5
H. Schlatter	Carbon	Crawford No. 1	95	6	7
W. L. Wallace	Perth	McIntosh No. 1	90	6	6
James Skene	Mecca	Mecca No. 1	40	6	5
Morgan Roberts	Mecca	Mecca No. 2†			
George Mitch	Rosedale	Parke No. 8	65	11	6
John J. Scott	Brazil	Standard	80	6	3
George Myers	Brazil	Columbia No. 1	75	9	8
John Chesterfield	Brazil	Columbia No. 2	48	12	6
Total			715	88	58

PERRY COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Inside.	Outside.	Mules.
Geo. W. Briggs	Cannelton	Cannelton	42	4	4
R. C. Walker	Troy	Troy	16	1	2
Total			58	5	6

PIKE COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Inside.	Outside.	Mules.
G. Wellinger	Augusta	Hartwell	45	7	14
John Jennings	Ayrshire	Ayrshire	160	15	21
John R. Willey	Petersburgh	Blackburn	49	9	6
Andrew Dodds	Littles	Little	123	8	11
Bart Stinson	Sophia	Carbon	20	5	2
H. T. Brewis	Petersburgh	Wooley	46	5	6
Total			343	49	60

SULLIVAN COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Inside.	Outside.	Mules.
J. A. Beck	Dugger	Briar Hill	35	4	2
Frank Smith	Farnsworth	Bunker Hill	49	6	5
S. Campbell	Del Carbo	Star	77	14	16
H. A. Butler	Dugger	Dugger	69	8	7
W. E. Evans	Eagle	Jumbo	98	18	17
R. M. Irving	Shelburn	Currysville	32	10	3
Wm. F. Brown	Alum Cave	Phenix No. 1	1 3	20	15
Wm. Britton	Alum Cave	Phenix No. 2	21	1	3
	Hymera	Hymera*			
D. M. Hopkins	Shelburn	Shelburn Nos. 1 and 2	50	12	8
A. Winterbottom	Farnsworth	Bush Creek†			
Total			554	63	78

*No report. †Shut down.

TABLE No. 4—Continued.

VANDERBURGH COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Employes. Inside.	Employes. Outside.	Mules.
Geo. Bonenberger	Evansville	Diamond	26	4	6
Pius Schultheis	Evansville	Union	25	5	4
John Odell	Evansville	Ingleside	22	10	3
Frank Gendthar	Evansville	First Avenue	36	8	8
C. H. Baetz	Evansville	Sunnyside	74	9	12
Total			183	26	33

VERMILLION COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Employes. Inside.	Employes. Outside.	Mules.
Frank Dunlap	Clinton	Fern Hill	92	8	18
D. W. James	Clinton	Brouillet's	133	8	6
Wm. Hutchinson	Voorhees	Torrey No. 4	131	11	14
Wm. Chesterfield	Clinton	Buckeye	76	8	6
		New Hazel*			
Total			432	35	44

VIGO COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Employes. Inside.	Employes. Outside.	Mules.
Thomas Gregory	Fontanet	Diamond No. 2	118	7	7
G. R. Anthony	Fontanet	Peerless	76	7	5
James Johnson	Fontanet	Union	150	13	11
J. W. Erwin	Macksville	Broadhurst	15	3	2
J. Carmichael	Seeleyville	Ehrlich	40	6	3
Wm. Grey	Seeleyville	Hector	62	6	4
Thomas McQuade	Burnett	Nickel Plate	60	8	13
James Devonald	Burnett	Grant	90	10	14
Wm. Gatt	Rosedale	Parke No. 10	71	9	4
Robert Bieler	Macksville	Brick Works	9	1	1
John W. Alvis	Elsie	Vigo	28	2	3
Geo. West	Seeleyville	Ray	68	9	3
W. L. Erwin	St. Marys	St. Mary's	22	3	1
James Steele	Macksville	Larimer	23	2	
Total			632	86	71

WARRICK COUNTY.

MINE BOSS.	ADDRESS.	MINE.	Employes. Inside.	Employes. Outside.	Mules.
Geo. Archbold	Newburgh	Star	34	5	4
Patrick Bartley	Chandler	Chandler	13	2	2
Wm. Nester	Boonville	Gough	19	3	3
T. B. Hall	Chandler	Air Line	7	3	1
Wm. Wooley	Boonville	Big Vein	36	6	6
F. P. Hargrove	Boonville	Caledonia	19	2	2
Total			128	21	18

* No report.

TABLE No. 5.

Showing the Production of Coal in Tons of 2,000 Pounds in Indiana During the Year 1897.

CLAY COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
										Strike					
Allais & Urbain	Brazil	Victoria	590	630	916	847	895					716	1,777	1,478	7,849
Brazil Block Coal Co	Brazil	No. 1	7,133	4,974	6,595	5,594	3,887	2,767	353		2,520	6,683	7,46[illegible]	8,982	56,918
Brazil Block Coal Co	Brazil	Gart No. 3		2,061	3,127	3,844	3,2[illegible]7	1,979			2,546	1,183	5,5[illegible]7	4,363	27,897
Brazil Block Coal Co	Brazil	Gart No. 5	7,853	6,121	4,638	6,988	1,245	2,166	343		5,427	12,485	1[illegible],656	10,120	69,012
Brazil Block Coal Co	Brazil	No. 7	†									26	772	1,047	1,845
Brazil Block Coal Co	Brazil	No. 8	13,546	11,772	13,334	12,447		3,526	783		3,946	9,801	11,193	11,138	91,496
Brazil Block Coal Co	Brazil	No. 10	775	697	637	627						471	627	522	4,[illegible]56
Brazil Block Coal Co	Brazil	No. 11	6,[illegible]94	3,664	154						3,2[illegible]4	8,[illegible]96	8,067	6,840	36,529
Brazil Block Coal Co	Brazil	No. 12	†										414	9[illegible]4	1,348
Brazil Mining Co	Brazil	Gladstone	6,152	6,331	5,631	6,364	2,646	1,721	339		2,818	6,[illegible]00	6,500	6,500	51,002
Briar Block Coal Co	Clay City	Briar Hill	900	1,200	770	700	480	1,300				1,[illegible]70	1,900	84[illegible]	9,160
Chicago and Indiana Coal Co.	Terre Haute	Harrison No. 2	3,446	4,155	573	7[illegible]1	944	703	80		927	3,389	3,898	4,[illegible]00	22,866
Coal Bluff Mining Co	Terre Haute	Pratt	5,082	5,124	5,790	3,741	*				3,112	4,621	546	3,671	35,687
Crawford Coal Co	Brazil	Crawford No. 2	5,739	5,252	5,226	6,102	1,033	4,822	418		3,760	7,535	7,594	3,555	51,036
Crawford Coal Co	Brazil	Crawford No. 3	5,742	3,302	3,[illegible]71	3,526	838	2,612	49		4,058	8,061	6,342	5,449	43,050
Crawford Coal Co	Brazil	Crawford No. 4	†												
D. H. Davis Coal Co	Knightsville	World's Fair	1,543	1,479	1,3[illegible]9	1,191	824	759			1,37[illegible]	3,197	2,846	2,943	17,469
C. Ehrlich	Turner	Fortner	2,[illegible]18	2,125	784	3,678	‡								9,005
C. Ehrlich Coal Co	Turner	Klondyke	†											7,454	7,454
C. Ehrlich & Co	Turner	Excelsior	*				2,964	1,891			1,188	2,623	3,215	1,992	13,873
P. Ehrlich	Turner	Superior	5,626	2,813	3,576	4,320		2,090	200		2,000	8,[illegible]20	5,520	7,268	41,733
Eureka Coal Co	Terre Haute	Eureka No. 2	11,192	10,81[illegible]	3,956	9,677	2,846	3,144	536		7,909	5,443	10,721	7,978	74,517
Eureka Coal Co	Terre Haute	Eureka No. 3	†												
Diamond Block Coal Co	Chicago, Ill.	Diamond No. 3	9,031	9,472	8,823	8,280	4,520	2,404	96	47	3,406	8,441	8,342	7,511	70,273
Goucher, McAdoo & Co	Brazil	Monarch	750		600	653		622	578	5[illegible]9	572	6[illegible]6	636	645	6,221
Jackson Coal and Mining Co.	Brazil	Brazil	5,021	4,153	4,038	4,755	1,980	282	292		5,024	10,216	9,653	4,975	50,389
Jackson Coal and Mining Co.	Brazil	Nickel Plate	2,962	2,979	1,840	2,957	939	20	§					1,604	13,301
I. McIntosh & Co.	Brazil	McIntosh No. 2	641	118	‡										759
Andrew & Burnham	Clay City	Markland	100	100	100	100	100	113	144	193	522	1,310	1,495	1,378	5,655
Otter Creek Coal Co	Brazil	Fairview	3,974	4,312	2,611	2,[illegible]10	2,547	4,280			924	2,421	2,523	2,561	28,163
Otter Creek Coal Co	Brazil	Nellie	9[illegible]9	1,072	[illegible]73	785	‡								3,559
Jos. So[illegible]ers	Staunton	San Pedro	2,431	2,623	2,215	*						3,386	2,720	2,787	16,162
Weaver Coal Co.	Center Point	Louise	360	1,0[illegible]0							2,640	1,100	3,450	3,000	11,600
Zeller, McClellan & Co	Brazil	Columbia No. 3	2,105	3,891	3,0[illegible]8	2,811					566	1,731		1,217	15,379
Zeller, McClellan & Co	Brazil	Columbia No. 4	3,668	2,140	1,753	2,597	1,053	1,662	196		2,529	5,686	4,886	3,786	29,956
Total			116,003	104,425	85,898	95,355	32,998	39,163	4,407	799	60,986	124,817	134,[illegible]90	126,538	925,679

*Idle. †New mine. ‡Abandoned. §Included in line above.

TABLE No. 5—Continued.

DAVIESS COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	Total.
Cabel & Co	Washington	Cabel No. 4	3,467	2,932	1,973	1,038	......	......	......	......	......	......	......	7 6	10,146
Cabel & Co	Washington	Cabel No. 9	2,723	3,307	3 011	3,748	......	......	......	......	......	......	1,750	1,800	16,369
Daviess County Coal Co	Montgomery	M'tgomery No. 1	7,599	7,429	5,522	6,999	6 388	4,906	......	......	......	6,164	6,236	6,642	57,975
Daviess County Coal Co	Montgomery	M'tgomery No. 2	1,410	1,735	1,546	1,983	2,294	2,527	......	......	......	2,948	3,497	3,846	21,766
Daviess County C al Co	Montgomery	M'tgomery No. 3	......†	......	......	......	......	......	......	......	......	......	......	......	......
Mutual Mining Co	Cannelburg	Mutual	1,150	810	885	605	485	890	2,500	......	......	2,650	......	1,720	11,695
Odon Coal Co	Odon	Winklepeck	100	100	191	......‡	......	......	......	......	......	......	......	......	391
A. F. S oy & Son	Raglesville	Stoy	......¶	......	......	......	......	......	......	......	......	......	......	......	......
Raglesville Coal Co	Raglesville	Stoy	......†	......	......	......	......	......	......	......	......	830	785	645	2,260
Raglesville Co-operative C. Co	Raglesville	Co-operative	......†	......	......	......	......	......	......	......	500	750	1,000	1,000	3,250
Union Coal Co	Raglesville	Union	149	115	58	......	......	374	219	377	387	663	377	300	3,049
Wa hington Coal Co	Washington	Hawkins	1,403	1 080	1,121	692	403	807	1:6	......	1,077	1,185	2,0 9	2,000	11,953
Washington Coal Co	Washington	Wilson No. 4	......†	......	......	......	......	......	32	......	55	636	1,077	1,000	2,900
Total	......	......	18,001	17,508	14 337	15,045	9,570	9,591	2,917	377	2,119	15 826	10,771	19,689	141,754

DUBOIS COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	Total.
L. A. South rd	Huntingburg	Huntingburg	300	3 0	300	300	200	150	250	300	200	400	500	500	3,600
Total	......	......	300	300	300	300	200	150	250	300	200	400	500	500	3,6 0

FOUNTAIN COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	Total.
Indiana Bituminous Coal Co.	Terre Haute	Ind. Bit. No. 2	10. 12	10,487	9,8 0	12,9 0	6,101	10,715	4,117	......	991	10,592	12,247	12,478	100,470
Silverwood Coal Co	Silverwood	Silverwood	3 0	300	300	300	500	50	1,0 0	1,3 0	1,500	1,700	1,79	1,717	11,357
Total	......	......	10,312	10,787	10,100	13,230	6,601	11,365	5 117	1,300	2,4 1	12,292	14,037	14,195	111,927

† New mine. ‡ Abandoned. ¶ No report.

GIBSON COUNTY.

Maule Coal Co	Princeton	Oswald	7,500	4,900	3,750	1,250	1,500	2,007	4,000	2,171	3,000	5,800	7,300	6,780	49,878
Total			7,500	4,900	3,750	1,250	1,500	2,007	4,000	2,171	3,000	5,800	7,300	6,780	49,878

GREENE COUNTY.

Island Coal Co	Indianapolis	Island City	5,753	8,680	6,048	5,760	......*	3,881	......	......	......	9,372	10,321	10,000	59,815
Island Coal Co	Indianapolis	Island No. 2	12,222	12,517	15,389	10,484	15,380	11,841	......	......	......	16,714	17,407	17,000	128,584
Island Valley C. & M. Co	Linton	Island Valley	4,858	5,630	4,230	3,100	3,105	2,909	676	......	1,413	5,263	6,[illegible]04	6,175	44,273
Linton C. & M. Co	Linton	Flubart	8,468	9,815	10,582	3,635	1,870	2,052	388	......	1,207	8,878	9,166	8,891	64,902
South Linton Coal Co	Linton	South Linton	4,215	......	4,725	3,150	2,870	4,725	700	......	1,075	6,285	7,220	9,000	44,745
Summit Coal Co	Bloomfield	Summit	5,835	6,655	6,455	4,472	6,851	5,400	902	......	3,783	11,915	13,215	14,165	79,651
Western Indiana Coal Co	Terre Haute	Templeton	3,589	4,290	1,500	3,993	7,6[illegible]	5,526	417	......	1,892	7,651	10,425	8,758	55,231
Total			44,740	47,617	48,959	35,794	37,179	36,334	3,083	......	9,370	66,078	74,058	73,989	477,201

KNOX COUNTY.

Bicknell Co-operative C. Co	Bicknell	Bicknell	1,500	840	667	150	324	343	556	208	975	2,371	2,932	2,906	13,972
Edwardsport Coal Co	Indianapolis	Hofmann	2,463	2,742	2,335	870	935	1,101	359	......	738	2,624	2,500	2,500	19,167
Prospect Hill Coal Co	Vincennes	Prospect Hill	1,090	839	749	381	290	383	853	1,510	1,142	982	1,240	1,118	10,577
Total			5,053	4,421	3,951	1,401	1,549	1,827	1,768	1,718	2,855	5,977	6,672	6,524	43,716

MARTIN COUNTY.

Bedford Coal and Mining Co	Bedford	Bedford	612	990	722	498	685	700	700	700	700	750	900	1,100	9,057
Total			612	990	722	498	685	700	700	700	700	750	900	1,100	9,057

*Idle.

TABLE No. 5—Continued.

OWEN COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Lancaster Block Coal Co.....	Terre Haute .	Lancaster No. 4..	2,331	1,534	1.815	2,230	851	455	....	....	700	2,000	2,100	1,403	15,419
Total....................	....	....	2,331	1,534	1,815	2,230	851	455	....	....	700	2,000	2,100	1,403	15,419

PARKE COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Brazil Block Coal Co	Brazil	Cox No. 3.........	8,228	10,948	11,359	6,846	9,557	10,344	....	....	....	6.860	13.876	15,853	93,8[illegible]1
Brazil Block Coal Co	Brazil	Otter Creek	211	1.060	.....**	....	....	....	....	....	446	2,109	2,811	2,203	8,840
Cal[illegible]met Coal Co.............	Chicago, Ill.	Lyford No. 1	1,019	.....††	....	....	....	....	....	....	....	....	....	....	1,019
Calumet Coal Co...............	Chicago, Ill..	Lyford No. 2	....	1,194	7,16	9,563	10,813	2,381	341	....	....	6,399	10,129	8.051	56.070
Crawford Coal Co.............	Brazil	Crawford No. 1 ..	5,969	3,908	4.718	3,286	1[illegible]6	....	144	....	3,572	4.966	7,125	4,280	30,164
I. McIntosh & Co.............	Brazil	McIntosh No. 1..	7.227	5,800	6.869	7.452	3.641	4,629	646	....	47	3,340	3.814	4,844	48,[illegible]09
Otter Creek Coal Co	Brazil	Mecca No. 1.......	1.004	2,393	2,387	2,824	1,6[illegible]9	1,563	... .	....	....	2,[illegible]00	3,586	4,140	22,136
Otter Creek Coal Co	Brazil	Mecca No. 2......	665	779	939	582	.....**	....	....	....	....	....	....	....	2.965
Parke County Coal Co.........	Rosedale	Parke No. 6......	5,862	6.114	5.620	8.078	5,284	9.154	....	....	239	682	.......‡	....	41,033
Parke County Coal Co.........	Rosedale	Parke No. 8......	4,[illegible]54	6.113	3,576	6,773	8,097	8,[illegible]39	....	....	3,067	8,236	11,067	12,015	71,688
Standard Coal Co..............	Terre Haute .	Standard.........	2.838	2.932	4.648	3.308	722	1,527	123	....	2,[illegible]99	4,620	3.224	5,699	3[illegible].740
Zeller, McClellan & Co.......	Brazil	Columbia No. 1..	4,185	4.090	1,912	3,173	....	....	....	....	2,103	6,940	8.090	7,578	38,0[illegible]1
Zeller, McClellan & Co.......	Brazil	Columbia No. 2..	3,584	3,606	4,[illegible]34	4,986	1,905	2,694	392	....	2,513	7,038	8,240	7,636	46,628
Total....................	....	....	45,146	48,937	53,231	56,871	41,944	40,682	1,646	....	14,086	53,790	71,962	72,299	500,534

PERRY COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
American Cannel Coal Co....	Cannelton ...	Cannelton........	1.116	1,184	1,494	1,543	1.3[illegible]8	1,229	1,631	781	1,405	394	9[illegible]4	1,428	14,507
Bergenroth Bros..............	Troy	Troy	1,000	760	1,140	807	746	886	764	758	844	760	611	1,104	10,180
Total....................	....	....	2,116	1,944	2,634	2,350	2,094	2,115	2,395	1,539	2,249	1,154	1,565	2,532	24,687

†† Shaft buildings burned.

PIKE COUNTY.

Cabel-Kaufman Coal Co......	Washington..	Hartwell.........	2,940	2,880	2,205	.....‡‡	....	350	....	1,077	2,059	1,716	1,982	2,767	17,976
D. Ingle......................	Oakland City.	Ayrshire.........	6, 4	6,561	4,675	4,766	3, 97	3,719	12,458	13,020	14,611	13,567	12,396	10,531	106,573
W. A. Jackson................	Oakland City.	Carbon...........	1,777	1,223	1,055	946	1,862	1,285	1,7 4	730	1,614	1,360	1,729	1,696	17,031
The S W. Little Coal Co......	Evansville...	Blackburn........	2,194	1,387	.......*	....	....	....	....	....	....	....	....	....	3 581
The S. W. Little Coal Co......	Evansville...	Little's...........	3,783	3,797	5,777	5,573	4,405	2,9 4	....	....	12,186	11,089	10,986	11 000	71,550
The J. Wooley, Jr., Coal Co..	Evansville...	Petersburg.......	....	....	....	....	1,408	1,347	3,455	1,954	4,153	4,981	....	3,615	20,943
Total...................	....	....	17,636	15,848	13,712	11,285	10,972	9,655	17,667	16,781	34,653	32,713	27,09	29,639	237,654

SULLIVAN COUNTY.

Lyonton Coal Mining Co.....	Dugger.......	Briar Hill........	150	150	125	1 0	100	100	100	100	500	700	1,000	800	3,975
Hancock & Conkel...........	Farnsworth.	Bunker Hill......	2,289	1,966	1 363	617	491	651	162	8	803	2,141	2,544	3, 83	16, 48
Harder Hafer Coal Co........	Del Carbo....	Star..............	13,469	14,653	8,9 0	15,464	7,843	13,258	7,729	47	14,336	15,931	11,018	16,663	139,311
Indiana & Chicago Coal Co...	Dugger.......	Dugger...........	6,241	5,716	2,718	1,351	.......*	....	....	....	....	556	3,855	4,858	25, 95
Jackson Hill Coal Co.	Eagle.........	Jumbo...........	11,047	11,898	9,261	11,431	6,924	5,390	4,540	....	....	....	3,977	11,985	76,453
New Curryville Coal Co.....	Shelburn.....	Curryville	1,500	1,472	978	687	749	....	39	99	....	1,936	2,423	1,77	12,355
New Pittsburgh C. & C. Co...	Alum Cave...	Phenix Nos. 1 & 2.	14,300	11,628	14,350	11,447	....	11,32	6,748	....	3,991	15, 31	11,018	16 809	117,548
Hymera Coal Mining Co.....	Hymera......	Hymera..........	3,000	3,000	1,800	1,320	1,440	1,000	....	....	480	2,174	2,174	5,736	22,124
Shelburn Mining Co......... Shelburn Mining Co..........	Shelburn..... Shelburn.....	Shelburn No. 1. Shelburn No. 2. }	2,120	2,000	1,440	1,500	1,500	1,800	299	....	2,025	2,610	2,700	2,800	20,824
Watson Little Coal Co.......	Farnsworth.	Bush Creek......	.....**	....	....	....	....	....	....	....	....	....	1,365	....	1,365
Total...................	....	....	54,115	52,483	40,935	43,997	19,047	33,525	20,117	445	22,135	42,009	42,074	64,506	435,398

VANDERBURGH COUNTY.

Diamond Coal Mining Co....	Evansville...	Diamond.........	2,992	2,816	2,784	1,440	1,320	1,158	1,463	1,072	1,678	1,840	1,885	2,343	22,791
Evansville Union C. & M. Co.	Evansville...	Union............	1,462	1,041	763	512	457	443	637	60	909	1,122	1,510	1,541	10,997
Jo n Ingle Coal Co..........	Evansville...	Ingleside.........	6 966	5,973	7,641	4,5 9	4,086	4,358	5,811	7,000	6 300	6,250	6,500	6,250	71,674
H. A. Lozier.................	Evansville...	First Avenue....	1,898	1,797	1,510	1,145	1,316	1,559	2,752	2,573	2,578	3,168	3,770	3 500	27,566
Sunnyside Coal & Coke Co...	Evansville...	Sunnyside........	5,945	5,164	5,408	3,304	3,603	2,973	6,927	6,552	7,726	7,798	8,27	8,616	72,228
Total...................	....	....	19,2	16,7 1	18 106	10,940	10,782	10,491	17,590	17,797	19,191	20,178	21,937	22,250	05,256

*Idle. ‡Abandoned. **Shut down. ‡‡Burned.

TABLE No. 5—Continued.

VERMILLION COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Hazel Creek Coal Co	Clinton	Fern Hill	6,560	10,425	12,434	12,450	3,389	2,055	....	....	8,166	10,759	12,845	11,000	90,083
Hazel Creek Coal Co	Clinton	Hazel No. 3	......†	....	....	....	....	....	....	....	....	....	....	....	....
Bruilette's Creek Coal Co	Clinton	Bruilette Creek	......*	....	....	....	....	....	....	....	5,627	13,202	16,529	11,500	46,858
McClellan, Eastman & Co	Clinton	Buckeye	850	7,686	9,723	6,793	6,682	7,893	....	....	2,000	6,200	8,000	7,500	63,327
Torrey Coal Co	Voorhees	Torrey No. 4	9,840	10,325	12,649	13,352	13,043	5,995	......*	....	233	4,149	7,074	7,000	83,660
Total	....	....	17,250	28,436	34,806	32,595	23,114	15,943	....	....	16,026	34,310	44,448	37,000	283,928

VIGO COUNTY.

OWNER.	ADDRESS.	MINE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
J. N. & Geo Broadhurst	Macksville	Broadhurst	1,347	1,000	1,000	1,000	....	....	3,459	965	965	700	900	921	12,287
Burke Bros	Glenn	Burke	100	100	100	100	75	75	120	200	150	200	200	200	1,620
Coal Bluff Mining Co	Terre Haute	Diamond No. 2	......*	....	....	....	....	....	....	....	1,644	5,195	7,[illegible]97	8,333	22,469
Coal Bluff Mining Co	Terre Haute	Peerless	2,915	803	3,986	4,494	3,971	4,033	499	....	....	1,877	3,748	6,296	32,619
Coal Bluff Mining Co	Terre Haute	Star	230	......‡	....	....	....	....	....	....	....	....	....	....	230
Coal Bluff Mining Co	Terre Haute	Victor	1,448	780	1,688	1,040	......‡	....	....	....	....	....	....	....	4,956
Coal Bluff Mining Co	Terre Haute	Union	7,766	10,176	13,118	15,940	11,5[illegible]8	15,583	1,232	....	4,932	14,010	14,100	12,902	121,297
Edward Davis	Elsie	Eagle	......‡‡	....	....	....	....	....	....	....	....	....	....	....	....
James H. Erwin	St. Mary's	St. Mary's	500	500	500	500	500	500	560	600	600	700	900	1,200	7,560
Ehrman Coal Co	Burnett	Nickel Plate	3,920	5,886	3,716	5,065	4,670	4,863	....	....	1,611	6,204	6,801	5,728	48,464
Julius Ehrlich	Seeleyville	Seeleyville	516	1,823	1,692	1,032	216	726	1,055	....	....	192	1,816	2,200	11,328
Grant Coal Mining Co	Burnett	Grant	11,1[illegible]6	10,1[illegible]3	10,704	11,800	9,638	9,683	....	....	3,173	8,648	9,717	9,169	93,771
T. H. Brick and Pipe Co	Terre Haute	Brick Works	700	685	720	745	760	765	755	750	750	750	7[illegible]0	750	8,880
Soales Bros	Terre Haute	Soales	500	500	500	500	500	500	575	700	700	800	800	800	7,375
Edward Davis	Elsie	Vigo	1,[illegible]00	2,100	....	....	....	1,200	....	....	....	825	600	1,000	6,9[illegible]5
William Lankford	Macksville	Larimer	575	691	628	3[illegible]1	241	213	74[illegible]	1,452	1,350	1,4[illegible]0	1,570	1,6[illegible]0	10,792
Loughner Coal Co	Seeleyville	Hector	2,001	2,[illegible]98	2,202	3,859	1,190	4,558	458	1,539	4,027	5,965	4,0[illegible]7	5,965	38,[illegible]89
Vigo County Coal Co	Seeleyville	Ray	4,084	4,307	4,203	6,587	284	1,705	....	....	1,455	5,342	6,166	7,804	41,937
Murry & Lloyd	Macksville	Murry	....	86	162	36	....	61	150	200	200	400	1,000	1,200	3,495
Parke County Coal Co	Rosedale	Park No. 10	....	....	....	....	....	....	....	....	....	....	5,941	6,679	12,620
Total	....	....	38,938	42,067	45,019	53,029	33,583	44,465	8,595	6,406	21,557	53,208	66,393	72,744	486,994

WARRICK COUNTY.

John Archbold	Evansville	Star	2,655	3,034	2,436	1,781	1,600	1,5[illegible]0	3,000	2,[illegible]00	2,300	2,052	3,125	3,700	29,233
Caledonia Coal Co	Boonville	Caledonia	1,088	1,100	1,000	9[illegible]6	7[illegible]0	800	1,100	1,100	864	1,672	1,539	1,[illegible]00	1[illegible],499
Kelley & Nester	Boonville	Gough	2,1[illegible]4	2,200	2,400	2,561	3,[illegible]00	1,[illegible]21	1,900	2,[illegible]83	2,809	1,800	1,5[illegible]	700	24,578
Hall & Lowrance	Chandler	Air Line	400	400	4[illegible]0	400	3[illegible]0	350	4[illegible]0	[illegible]00	5[illegible]0	600	600	600	5,800
Patrick Bartley	Chandler	Chandler	1,280	1,[illegible]00	1,0[illegible]0	432	5[illegible]0	500	600	850	800	8[illegible]0	9[illegible]0	900	9,912
Wm. Roberts n	Newburg	Brisbins	3[illegible]0	200	[illegible]00	2[illegible]0	15	150	[illegible]0	[illegible]5[illegible]	200	3[illegible]0	300	300	2,8[illegible]0
J. Wooley Jr., Coal Co	Evansville	Big Vein	2,333	1,765	2,779	691	1,895	1,315	4,7[illegible]1	3,515	5,297	5,[illegible]79	3,882	2,434	35,906
DeForest Coal Co	Evansville	DeForest	150	150	150	1[illegible]0	250	[illegible]50	400	500	300	4[illegible]5	5[illegible]0	500	3,675
Total			1[illegible],310	10,149	10,365	7,151	8,445	6,436	12,3[illegible]1	1[illegible],798	13,170	12,978	10,846	10,[illegible]34	*1[illegible]5,403

Coal produced in small mines .... 150,0[illegible]0 tons.
Grand total .... 4,228,085 tons.

*Idle. †New mine. ‡Abandoned.

METHODS OF MINING.

There are seven different veins of coal mined in the State of Indiana, varying in thickness from three to nine feet. Room and pillar is the only system of mining used in this State, subject to many modifications as to the direction and width of entries, the thickness of entry pillars, the width of rooms, and the arrangements for the recovery of the coal in the room pillars before the final abandonment of the mine. These modifications are made necessary by the character of the coal and of the overlying and underlying strata. This system, when conditions are favorable, as they are in but few mines in this State, consists of a main entry and air-course, each 8 feet wide, separated by a pillar 12 feet in thickness, and making what is known as a double entry. At intervals of 100 yards cross-entries are driven at right angles to the main entries. These are of the same dimensions as the main entry, but the pillar between them is usually not so thick, and a haulage road is kept up in each cross-entry. Break-throughs are made between each pair of entries every 45 feet to provide for the circulation of the ventilating current through the mine. These entries are driven to the boundaries of the territory in each direction. As the cross-entries are being driven, rooms are "turned" at right angles. These are started at a width of 8 feet and are gradually widened to 24 feet. They are carried at this width until they reach a point midway between the two cross-entries. The roadway is kept near one side of the room, so that it is in place to be used in taking the coal from the pillars. These are left standing until the mine, or at least that part of it, is about to be abandoned, when all the coal is removed that it is possible to remove, and the roof is allowed to settle to the floor. Where conditions are favorable, nearly the whole of the coal in the vein can be removed. The pillars in this case are left about 10 feet thick, and break-throughs are made in them at intervals to provide for the ventilation of the rooms while they are being worked.

The first modification of this method occurs when, for any reason, it is not desirable to keep so much open work standing, on account of bad roof, or where the work is not being developed fast enough to keep up the desired output from the new work. In either of these cases, as soon as the rooms are driven to their destination, the pillars are taken out, or at least so much of them as circumstances will permit, care being taken to leave enough coal near the entries to keep them safe while the work is being carried on beyond the point where the room pillars have been taken out. While this allows the operator to realize the profits of his development work sooner than the first method, the coal can not be taken out so clean, and the final result is a loss to all concerned in the working of the vein.

In some of our mines, mostly those operating in low or thin veins, instead of keeping up a roadway in each of the entries, only one of each pair is made to serve the purpose of a permanent haulage road. This entry is made of sufficient height by taking roof or bottom along with the coal, and a good haulage road is made along it. Its companion entry is sometimes made only in the coal, and a branch road is laid from the principal entry to each room which is turned from the "air-course," as the second entry is called in such cases. A door is necessary at each of these roads to direct the ventilating current, and, as these are seldom made air-tight, and must be frequently opened to permit the passage of coal and men, this plan usually results in very poor ventilation, the more so as the area of the air-course is so much smaller than that of the entry. In fact, this method has nearly all the disadvantages of the single entry system. This is sometimes modified by making a "cross-cut" between the entries at every third or fourth room. This reduces the number of doors and improves the ventilation to that extent, but I find that the parts of the air-course between those which are used for a roadway are usually allowed to become filled with dirt, thereby choking the air-way and preventing the free circulation of air and requiring a great deal more ventilating power to keep the mine in a fit condition for the men to work in. Also, as the roads in the air-course are abandoned as soon as the rooms are worked out, the proper attention is not given to it to prevent it from being filled up with falling roof, and in a short time it is practically useless as an air-way. This is especially true where the roof is of such a character that it is affected by the action of the air. Where the roof is very much affected by the action of air, and also where it is naturally weak, a modification of the first plan, known as the "block system," is adopted.

In this system, instead of driving entries to the boundary and turning rooms at regular intervals for the whole distance, when the cross-entries have been driven a distance of 100 yards, a pair of entries are started parallel to the rooms and driven to the next cross-entry. When this is done the air may be sent through these entries, and they are also used for haulage-ways, and all but one of the original cross-entries may be abandoned to the point of connection with the cut-off entries, as soon as the coal has been removed from the block formed by the four pairs of entries. The advantage of this plan is that it avoids the necessity of keeping open so much haulage road and airway, and gives a shorter road for the air to travel. Also where the roof and surface conditions are favorable the coal may be taken out before the conditions have become unfavorable for pillar work.

In some machine mines, while one or the other of the plans outlined above is followed, the rooms are driven double with a road on each side. This is made possible on account of the fact that as the coal is mined by the machines comparatively little powder is used and the roof is not shattered, and so can be more easily kept up by timber than in places where large charges of powder are used to loosen the coal without mining, as is generally done where pick mining is practiced. This method allows all wastage to be thrown into that part of the room between the two roads, and provides for the ventilation of the working places without the necessity of such frequent breakthroughs between the rooms. It also does away with a great deal of the trouble and work in moving the mining machine from one working place to another and adds largely to the amount of work that it may do in a given time.

Other modifications of these plans are made necessary by the varying thickness of the coal in some veins, by the irregular dip and rise of the strata and by the character of the material forming the roof and floor of the mine. In thin veins, in order to save the expense of making the necessary height to permit of mules going to the faces of the rooms, entries are kept as nearly as possible in the "dip" or lowest part of the mine and all rooms are driven to the "raise," so that the mine cars may be brought to the entry by man power. This results in very crooked roadways and a great deal of experimental work, and working places running at all kinds of angles, making it almost impossible for a stranger to see any plan to the workings. In other cases pillars must be a great deal stronger than is given above; in some mines entry pillars are 50 feet thick, and room pillars 20 feet thick. In others entries can not be made more than 6 feet wide, and rooms 15 feet wide. The exigencies of drainage requirements and haulage conditions also have their effect in determining the final shape of the mine, so that although it is easy to plan mining operations as they should be, the person who directs them from day to day finds himself constantly confronted with problems whose successful solution means much to the comfort of the persons employed in the mine and to the financial outcome of the investment of his employer.

MINING MACHINERY.

Mining machinery was introduced into this State in 1884, as a result of a strike at the Currysville Mine, and the mines at Rosedale, Parke County. Having been introduced by force of circumstances, it was demonstrated that the bituminous coal of Indiana could be successfully mined by machinery, and its use has increased until at present a large part of the production of the State is mined by machinery. Originally, only compressed air was used as a motive power, but recent developments in electricity have led to the invention of mining machinery operated by its use. Block coal had not been successfully mined by machinery until 1894, when electric machines were installed at the No. 1 and No. 8 mines of the Brazil Block Coal Company. Since that time they have been successfully operated at those places, but no additional installments have been made in that district. I give a table showing the extent of the use of machinery in this State:

MINES.	COUNTIES.	Electric.				Compressed Air.		
		Jeffrey.	Independent.	Morgan-Gardner.	New Morgan.	Jeffrey.	Harrison.	Ingersoll-Sergeant.
Brazil Block Coal Co.'s No. 1	Clay	......	......	12	......	......	......	......
Brazil Block Coal Co.'s No. 8	Clay	......	5	10	1	......	......	......
Briar Hill	Clay	......	......	......	......	......	4	......
Cable No. 9	Daviess	......	......	2	......	......	......	......
Island City No. 1	Greene	......	......	......	......	......	12	......
Island No. 2	Greene	......	......	......	......	......	24	......
Oswalt	Gibson	......	......	......	......	......	......	10
Parke No. 8	Parke	......	......	......	......	......	*32	......
Cox No. 3	Parke	......	......	......	......	......	21	1
Lyford No. 2	Parke	......	......	......	......	......	7	......
Hartwell	Pike	......	......	1	......	......	......	......
Phenix No. 1	Sullivan	......	......	......	......	......	14	......
Jumbo	Sullivan	......	......	......	......	......	15	......
Curryssville	Sullivan	......	......	......	......	......	6	1
Shelburn	Sullivan	......	......	......	......	†4	......	......
Hymera	Sullivan	......	......	7	......	......	......	......
Star	Sullivan	......	......	6	......	......	......	......
Sunnyside	Vanderburgh	......	......	......	......	......	1	5
Torrey	Vermillion	......	......	......	......	......	12	2
Union	Vigo	......	......	......	......	......	7	......
Grant	Vigo	......	......	......	......	......	8	......
Big Vein	Warrick	......	......	......	......	......	......	3
Total	......	......	5	[illegible]8	1	4	53	22

In addition to the above a machine drill is used at Mecca, in Parke County, and two at the Big Vein Mine, in Warrick County. The Indiana & Chicago Coal Company are at work installing an electric plant, which they hope to have in operation before February 1st, as is the New Pittsburgh Coal & Coke Company, at its Phenix mines.

*12 idle. †3 of them Lechner.

Mechanical haulage is in use at several mines in this State. A list follows, showing the kind of power used and length of haulage.

MINE.	COUNTY.	KIND OF HAULAGE.	POWER USED.	LENGTH.
Island No. 2	Greene	Tail rope	Steam	2,600
Island No. 1	Greene	Tail rope	Steam	1,200
Parke No. 8	Parke	Engine plane	Steam	900
Hymera	Sullivan	Motor	Electricity	1,000
Torrey	Vermillion	Tail rope	Steam	1,200
Ingleside	Vanderburgh	Tail rope	Steam	3,000
Grant	Vigo	Tail rope	Steam	600
Mecca	Parke	Motor	Electricity	2,600

ACCIDENTS.

The following list shows the accidents, fatal, serious and minor, that have been reported to this office, or have by any other means come to the knowledge of my assistant or myself during the year. They consist of 16 fatal, 24 serious and 74 minor accidents. This is a large decrease since 1896, when the list showed 28 fatal, 66 serious and 94 minor accidents. This speaks well for the management of the mines, as the output of coal is nearly equal in the two years, and those affected by the strike were in bad condition when work was resumed, especially where the roof is at all inclined to break and fall from the action of the air. This has usually been a time when accidents were most numerous from various causes, some of which are set out in a circular sent out by this office about the time work was resumed after the strike, in September. A short account of the circumstances attending each fatal accident, as they were developed at the Coroner's inquest in each case, will be found following the list of accidents. With one exception, no charge of negligence could be made against the person in charge of the mine where an accident occurred, and but few where gross carelessness could be imputed to the injured person, or any of his fellow-workmen. A large proportion of them were from causes that were so hidden that they could not have been discovered by the closest observation. The same is true to a less extent in the other classes of accidents, but, as but few of them have been personally investigated by myself or assistant, I am not in a position to make comments upon them.

Fatal Accidents.

DATE.	NAME.	CAUSE.	INJURY.	MINE.	COUNTY.
Jan. 2	Robert Sills	Falling slate	Fatal bruises	Grant	Vigo.
Jan. 27	B. F. Watson	Falling slate		Star	Sullivan.
Jan. 28	J. Bristow	Explosion of powder	Fatal bruises	Union	Vanderburgh.
Mar. 16	Wm. Delgeman	Explosion of powder	Fatal bruises	Diamond	Vanderburgh.
May 29	Dd. Williams	Fall of slate	Fatal bruises	Eureka	Clay.
June —	Wm. Crawley	Falling slate	Fatal bruises	Nickel Plate	Clay.
Sept. —	B. Dunville	Falling roof	Fatal bruises	Oswalt	Gibson
Sept. 27	David Clark	Powder smoke	Death	Phenix No. 2	Sullivan.
Sept. 27	J. Anderson	Powder smoke	Death	Phenix No. 2	Sullivan.
Sept. 30	Geo. Hickson	Electric motor	Broken bones	Mecca	Parke.
Oct. 1	I. N. Williams	Fall in shaft	Bruises and burns	Parke No. 10	Vigo.
Oct. 5	Geo. Saurs	Shot in coal	Bruises and burns	Summit	Greene.
Oct. 7	John Hunter	Fall of slate	Bruises	Fluhart	Greene.
Nov. 13	D. Benzo	Falling roof	Fatal bruises	Brazil B. C. Co. No. 11	Clay.
Nov. 13	A. Miccillitte	Falling roof	Fatal bruises	Brazil B. C. Co. No. 11	Clay.
Nov. 24	Arthur West	Falling slate	Crushed head	Briar Hill	Clay.

Serious Accidents.

DATE.	NAME.	CAUSE.	INJURY.	MINE.	COUNTY.
Jan. 3	John Olson	Railroad car	Finger mashed	Brazil B. C. Co. No. 8	Clay.
Jan. 6	Ben. Dally	Explosion of shot	Body bruises	Brazil B. C. Co. No. 1	Clay.
Jan. 18	F. Jackson	Falling slate	Leg broken	Hector	Vigo.
Feb. 12	Chas. Walter	Falling roof	Spine hurt	Briar Hill	Clay.
Mar. 20	M. Winegar	Fall of slate	Collar bone	Lyford No. 2	Parke.
Mar. 23	N. Cowie	Explosion of fire-damp	Bad burns	Standard	Parke.
Mar. 31	H. Dubney	Fall of coal	Bones broken	Island No. 2	Greene.
April —	J. Demont	Draw slate	Ankle broken	Island No. 2	Greene.
April —	A. Hayman	Descending cage	Leg broken	Lancaster	Owen.
April 18	C. Nicola	Explosion of keg of powder	Badly burned	Pratt	Clay.
May —	John Quigley	Fall in shaft		Standard	Parke.
May 18	John Bain	Mine car	Finger cut off	Island No. 2	Greene.
June 21	Wm. Bedford		Arm broken	Hector	Vigo.
June 3	Thos. James		Leg broken	Hector	Vigo.
June 5	Sam Switz	Falling slate	Broken leg	Brazil B. C. Co. No. 1	Clay.
Sept. —	A. B. Buyher	Falling slate	Sprained leg	Hartwell	Pike.
Sept. —	J. Thompson	Falling slate	Leg broken	Columbia No. 4	Clay.
Oct. 7	M. Glover	Falling slate	Back broken	Brazil B. C. Co. No. 11	Clay.
Oct. 5	Geo. Tincher	Falling slate	Ankle mashed	Summit	Greene.
Oct. 15	Jac. Butler	Mule kick	Broken rib	Summit	Greene.
Oct. —		Falling slate	Broken limb	Ray	Vigo.
Oct. 26	Lee Wake	Blast	Burns and bruises	Diamond	Clay.
Oct. 27	Joe Williams	Falling slate	Back broken	Brazil B. C. Co. No. 1	Clay.
Nov. 6	Rubin Smith	Falling coal	Bone broken	Louise	Clay.

Minor Accidents.

DATE.	NAME.	CAUSE.	INJURY.	MINE.	COUNTY.
Jan. 11	John Burnett	Fall of slate	Bruised face	Brazil B. C. Co. No. 11	Clay.
Jan. 11		Coal off cars	Foot mashed	Chandler	Warrick.
Jan. 6	Chas. Marky	Falling slate	Bruises	Bicknell	Knox.
Jan. 10	Martin Guy	Draw slate	Bruises	Brazil B. C. Co. No. 11	Clay.
Jan. 28	L. Marbeto	Mine car	Foot hurt	Pratt	Clay.
Jan. 28	Wm. Kehoe	Premature explosion	Burns	Eureka	Clay.
Jan. 28	Thos. Kehoe	Explosion	Bad burns	Eureka	Clay.
Feb. 28	F. Smith	Mine car		Dugger	Sullivan.
Feb. 20	Chas. Brown	Falling slate	Back bruised	World's Fair	Clay.
Feb. 19	H. Ford	Fall of slate	Hip bruises	Parke No. 8	Parke.
Feb. 22	John Simes		Bruised leg	Crawford No. 1	Parke.
Feb. 27	A. Witty		Head cut	Brazil B. C. Co. No. 8	Clay.
Feb. 24	Wm. Barber	Draw slate	Bruised leg	Brazil B. C. Co. No. 8	Clay.
Feb. 1	Fred Walters	Falling slate	Bruises	Briar Hill	Clay.
Feb. 10	Adam Ebler		Bruises	Cabel No. 9	Daviess.
Mar. 31	T. Health	Fall of slate		Fluhart	Greene.
Mar. 26	H. Johnson	Draw slate		Summit	Greene.
Mar. 26	Sam Taylor	Fall of slate	Bruises	Parke No. 6	Parke.
Mar. 26	J. Handthom	Fall of state		Parke No. 6	Parke.
Mar. 26	John Yando		Toe hurt	Brazil B. C. Co. No. 8	Clay.
Mar. 4	John Tuttle	Slate		Diamond	Clay.
Mar. 4		Fall of slate		Montgomery No. 2	Daviess.
April 1	James Barnes	Falling coal		Island No. 2	Greene.
April 27	Wm. Lundwell	Mule	Bruised face	Phenix	Sullivan.
April 5	M. Albright	Moving coal	Bruised fingers	Brazil B. C. Co. No. 8	Clay.
April 12	L. Dormely	Railroad cars	Bruises	Brazil B. C. Co. No. 1	Clay.
April 12	Wm. Morton	Falling slate	Back hurt	Eureka No. 2	Clay.
June 12		Falling coal	Bruised foot	Oswalt	Gibson.
June 9	M. Templeton	Draw slate	Bruises	Templeton	Greene.
June 4	C. Robertson	Explosion of fire-damp	Burns	Prospect	Greene.
June 17	Guss Larr	Scales of iron	Eye burned	Brazil B. C. Co. No. 11	Clay.
June 8	Adam Metz	Fall of slate		Brazil B. C. Co.	Clay.
July 13	S. W. Druter	With car		S. W. Littles	Pike.
Aug. 13	John Muller	Fall of slate	Wrist cut	Sunnyside	Vanderburgh.
Aug. 24	J. Kretringer		Sprained foot	Union	Vanderburgh.
Sept. 9	Ben. Hunt	Mine car	Bruised hips	Oswalt	Greene.
Sept. 20	J. Goodman	Falling coal	Arm cut	Bicknell	Knox.
Sept. 27	Geo. Fockner	Mine car	Ankle hurt	Brazil B. C. Co. No. 8	Clay.
Sept. 2	B. McKey	Falling slate	Leg hurt	Gart No. 5	Clay.

Minor Accidents—Continued.

DATE.	NAME.	CAUSE.	INJURY.	MINE.	COUNTY.
Sept. 20	G. Everhart	Machine	Leg hurt	Brazil B. C. Co. No. 8	Clay.
Oct. 5	B. Decker	Mine car	Bruises	Blackburn	Pike.
Oct. 22	Geo. Rife	Cars off track	Foot hurt	Hazel Creek	Vermillion.
Oct. 1	G. Woodburn	Mine car	Toe mashed	Briar Hill	Clay.
Oct. 4	J. B. Jones	Slate in room	Head hurt	Crawford No. 2	Clay.
Oct. 6	Ira Hadly	Falling coal	Arm hurt	Crawford No. 2	Clay.
Oct. 8	Fred Enour	Falling coal	Leg hurt	Crawford No. 2	Clay.
Oct. 25	Richard Wake	Explosion of powder	Cut on side	Diamond No. 3	Clay.
Oct. 24	Geo. Church	Falling coal	Foot hurt	Crawford No. 3	Clay.
Oct. 14	Jos. Auman	Mine car	Leg hurt	Crawford No. 3	Clay.
Oct. 3	Mike Conner	Blast shot	Burns	Diamond	Clay.
Oct. 23	James Patrick	Falling coal	Foot hurt	Brazil B. C. Co	Clay.
Oct. 20	Chas. Scott	Fall of coal	Back and ribs	Brazil B. C. Co	Clay.
Nov. 11	Thos. Scully	Mine car	Bruised leg	Star No. 3	Sullivan.
Nov. 27	J. Cuthbertson	Falling down shaft	Eye and bruises	Diamond No. 3	Clay.
Nov. 24	Chas. West	Falling roof	Cut over eye	Briar Hill	Clay.
Nov. 11	Ted. Jones	Falling coal	Leg hurt		
Oct. 15	Chas. Wilson	Slate	Leg hurt	World's Fair	Clay.
Dec. —	C. R. Carlton	Draw slate	Sprained foot	South Linton	Greene.
Dec. —	J. Carpenter	Kicked by mule		Cable No. 9	Daviess.
Dec. —	H. Nickles	Fall of draw slate	Bruised body	Brazil B. C. Co. No. 1	Clay.
Dec. —	A Campbell	Falling slate	Foot mashed	Brazil B. C. Co. No. 11	Clay.
Dec. —	J. Schaniske	Fall of slate	Rib broken	Brazil B. C. Co. No. 11	Clay.
Dec. 1	O. Decamp	Fall of coal	Shoulder hurt	Crawford No. 2	Clay.
Dec. 3	T. Templeton	Empty cage	Bruised back	Templeton Mine	Greene.
Dec. 9	Christ Brown	Railroad car	Arm hurt	Gart No. 3	Clay.
Dec. 9	Erwin Young	Mine car	Foot mashed	Otter Creek, No. 1	Parke.
Dec. 13	M. Shoemaker	Car on track	Both legs hurt	Cox No. 3	Parke.
Dec. 13	S. Polavinski	Mine car	Five ribs broken	Cox No. 3	Parke.
Dec. 15	Geo. Dixson	Falling slate	Bruised back	Brazil B. C. Co. No. 8	Clay.
Dec. 18	Wm. Burnet	Draw slate	Arm hurt	Dugger	Sullivan.
Dec. 28	John Sims	Hurt by mule	F ce hurt	Eureka No. 2	Clay.
Dec. —	Wm. Marchel	Fall of coal	Leg broken	Louise	Clay.
Nov. 30	David Palid	Falling slate	Leg broken	World's Fair	Clay.

COMMENTS ON ACCIDENTS.

As required by law, either myself or my assistant, in conjunction with the Coroner of the county where each death in the mines occurred during the year, made a full investigation as to the cause of each accident resulting in death. I herewith give a brief resume of our findings in each case of fatal accident reported to this office during the year and reported in the above table:

John Sills died January 2d, from injuries received from falling roof in the Grant Mine, in Vigo County. His attention had been called to the dangerous condition of the roof by the mine boss shortly before the accident occurred, but he delayed taking the necessary steps to make it safe until he had finished the work he was engaged in at the time, and before he got ready to attend to it the slate fell, with the result above noted. A large proportion of all the accidents which occur in the mines of this State are caused by delaying to take the precautions which are known to be necessary to render working places reasonably safe, always with the intention of attending to it as soon as some other work of more seeming importance is finished. If workmen and their employers would learn that in all mining operations the unavoidable accidents are quite too frequent, and that safety should be cared for first, we should be called on to chronicle fewer that might have been prevented. In this particular case it seemed, from the evidence, that the deceased was entirely at fault himself, but this is not always the fact by any means.

B. F. Watson was caught under a falling stone on the main traveling way of the Star Mine, in Sullivan County, while on his way to work. From all the evidence obtainable, the roof at the point where the accident happened had been in apparently good condition the evening before, when it was last examined, and other workmen who had preceded Mr. Watson to work that morning had noticed no indications of danger at that point. An examination of the place after the accident by Mr. Epperson, Assistant Inspector of Mines, failed to show any of the usual indications that danger might have been apprehended. It was clearly a case of accident which ordinary foresight could not have prevented.

J. Bristow was fatally injured by the premature explosion of a blast which he had prepared and was in the act of lighting at the Union Mine, in Vanderburgh County. From the testimony of an eye-witness it was learned that he had placed a squib in the needle-hole and was holding the lamp to the match of the squib, but had not yet given warning of his intention to fire, when the shot exploded. The only reasonable theory to account for the accident is that the squib was defective and that powder had found its way into the match of the squib and become ignited shortly after the match had begun to burn.

Wm. Delgeman was injured at the Diamond Mine, also in Vanderburgh County, in a manner almost identical with the above, as far as could be learned from the testimony available at the inquest. There was no eye-witness in this case, but the decedent had prepared his shot some time before the time for firing, and been engaged in conversation with several of his fellow-workmen when firing time arrived. He left them and went to his working place, and had been there but a few seconds when the explosion occurred. From the position of the body, and his tools, it appeared that he had been in the act of firing his squib when the shot exploded. The squibs used in both of the above instances were what are known as the American brand of patent squibs, and examination of a number of others from the box used by Mr. Delgeman showed several so defective as to have caused the accident, if they had been used in the regular way.

David Williams was working on pillars in the Eureka No. 2 Mine, in Clay County, when the roof gave way and fell on him, inflicting fatal injuries. On investigation it appeared that the particular piece of slate that fell had been loosened by removing coal in the course of his work, and that it would have been impossible for any person to have foreseen the likelihood of an accident in time to have secured the place and prevented the accident.

William Crawley received fatal injuries in the Nickel Plate Mine, in Clay County, under circumstances very similar to the above. A miner who was working near him at the time of the accident testified that before Mr. Crawley began to remove the piece of coal that loosened the slate that fell on him, the place where he was working seemed to be perfectly safe, and that when it was loosened by the removal of the coal it fell without warning. The place where this accident occurred was one in which extraordinary precautionary measures were necessary, as it was at a point where a room had been turned, and top had been taken down on two sides of the block of coal he was mining, and it fell in triangular shape, breaking across from one "loose end" to the other.

Brady Dunville was injured by falling slate in his working place at the Oswalt Mine, in Gibson County. To an experienced miner the indications of danger were sufficient to have given warning of the danger to which he was exposed in ample time to have made the place safe. From the testimony taken in the case it seems that the deceased had been employed in mines but a short time, and that this fact was known to the company. The only blame that could be attached to any party or person is in allowing an inexperienced man to work in a dangerous place without keeping a careful watch over him. There is too much of this neglect in some parts of the State, and it should be discontinued, either by refusing employment to such as have not sufficient experience in mines to be able to care for themselves, or by allowing them to work only in company with an experienced miner, who should be responsible for the safety of such persons.

David Clark and John Anderson were suffocated by powder smoke in the Phenix No. 2 Mine, in Sullivan County. They and two other men were working a pair of parallel entries and also turning the rooms off them. On the afternoon of the accident their partners had gone home early, leaving the deceased to fire all shots that were to be discharged in both entries. On one of the entries a room was being turned inside of the last break-through. Two shots had been fired in this entry and two others were prepared in the room neck. On returning to fire these shots the men seemed to have lost their way and were overcome by the fumes of the powder already burnt, and were not discovered until about nine o'clock in the evening, when a searching party was organized to learn what had become of them. From the position of the bodies it is surmised that they had both gone into the room to fire the shots, instead of one waiting at the break-through while the other went in. Both had had considerable experience in mines and should have known the risks they were running in going into such a place.

George Hickson was engaged as motorman on an electric locomotive in the Otter Creek Coal Company's Mine at Mecca, in Parke County. While running into the mine with the train of empty cars one of them had, in some way, become uncoupled and remained on the road. When returning with his loaded cars he was riding on the front end of the motor and ran into the empty car on a curve at the bottom of a heavy grade. From the position in which he was found it appears that, after striking the empty car, he had reversed his motor and started to run into the mine again, when the empty car struck him again, crushing him severely and throwing the motor from the track. When discovered he was fastened between the motor and the side of the entry, his leg being caught in that position. The deceased had assisted in installing the electric plant at this mine, and had been in charge of the motor since it had been in use. The accident was caused by his failure to notice the number of cars he had when starting into the face of the mine from the bottom and the number that he had on arriving at the siding where he exchanged his empties for loads. This would have taken some time, but the result shows that it would have been time well spent.

Isaac N. Williams was the mine boss in charge of the Parke County Coal Company's No. 10 Mine, in Vigo County. The mine had been idle for some time and water had accumulated in it. Pumps were placed on the cages and lowered as the water was taken out. On the day of the accident which caused his death the pumps had not been working well and he had been assisting the engineer to keep them running. He had returned to the mine after suppper and remained till nearly midnight, when he told the engineer that he was going home. The engineer went into the boiler room and supposed that Mr. Williams had carried out his intention, but, in fact, in attempting to walk past the shaft he had fallen into it, and was found the next morning lying upon one of the pumps with bruises sufficient upon his body to indicate that he had been killed by the fall, but he was also badly burned by the escape steam from the pump. He had evidently been worn out by the work and worry of the day and had not been in a condition to see where he was going.

Dominic Benzo and Anton Miccillitti were both killed by the same fall of slate in a room in which they were working together at the No. 11 Mine of the Brazil Block Coal Company, near the town of Diamond. The accident occurred in the afternoon as the men were in the act of completing their day's work. One of the men was tamping a hole preparatory to firing and the other was gathering their tools to carry them back out of the way of flying coal. From the evidence of the driver, who had been in the place a few minutes before the accident occurred, the room was well timbered and there were no indications of danger. The fall which caught the men extended entirely across the room back to the row of props nearest the face, and was about three feet in thickness. The position of the bodies indicated that they had made no attempt to escape, and the probabilities are that the fall came without warning. In all my experience in coal mines I never before saw such a fall, and I am of the opinion that before the accident it would have been impossible to foresee the fall of the roof, as it occurred, for any considerable time before it occurred.

Arthur West was killed instantly by a fall of roof in the Briar Hill Mine, near Clay City, in Clay County. While he and his brother were engaged in loading a car of coal a circular or conical piece of slate, known as a "pot," fell from directly over the car, catching the head of the deceased, on a lump of coal which had been placed on the corner of the car crushing his skull. He made no sound after being hit. No indications of the existence of a pot were visible before the accident, and on being tested the roof appeared to be solid. As this lay directly over the roadway, no props were placed under any part of it. Stones of this character are of frequent occurrence in shale roofs overlying coal seams. They are very dangerous, from the fact that they are separated from the regular strata forming the roof by a thin layer of other material, forming a "slip" on all sides of the pot-shaped stone, which fits so closely that it gives no warning of danger until it suddenly falls without any of the sounds that usually accompany falling roof. Usually, by close examination, the outline of the slip can be detected in the roof material, but in this instance a layer of "draw slate" lay between the coal and the shale forming the roof, and the pot did not show through this. This accident, therefore, must be classed as one caused by the ordinary risks of the miners' occupation.

George Saur lived near Dugger, about four miles from Summit. He and his son worked together and traveled back and forth with a horse and buggy. At about fifteen minutes before firing time he sent his son out to have the team ready to start home when he came out, as he was going to stay and fire two shots, one near the left rib and the other near the middle of the room pointing toward the right rib.

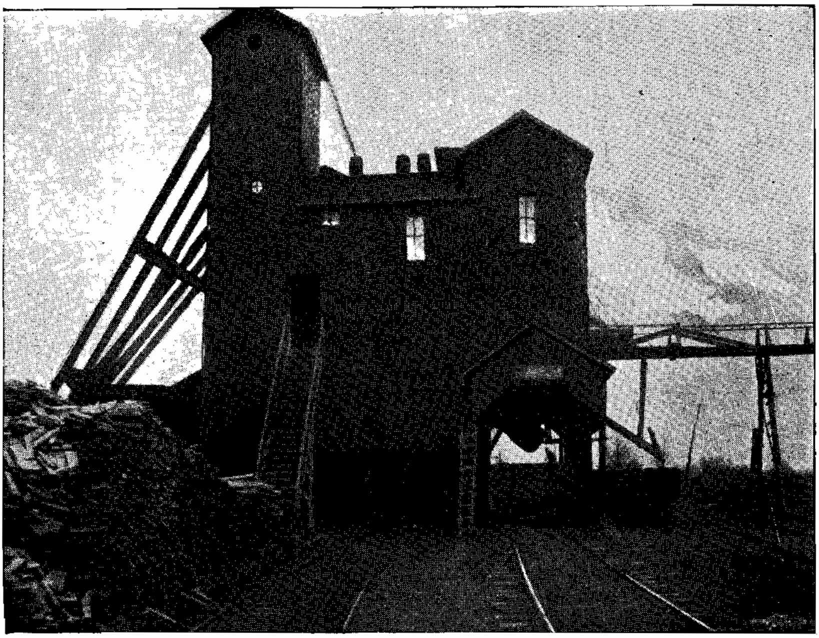
The son waited until after 5 o'clock and, as his father did not come out, he got uneasy, and, with three other miners, went back into the mine to look for him. They found him dead, lying near the right rib of the room, almost covered with large pieces of coal. Both shots had been fired, and the supposition was that the middle shot had caught him, but we had no means of learning how the accident occurred. It is possible that he had fired the shot on the left rib and had gone back and fired the other and got lost in the smoke when starting to run from the second one. It is also possible that he fired both shots at once, as is frequently done, and the middle shot holding fire from a defective squib, or some other reason, he had gone back to it. From the position he was found in, I think the latter was the cause of his death.

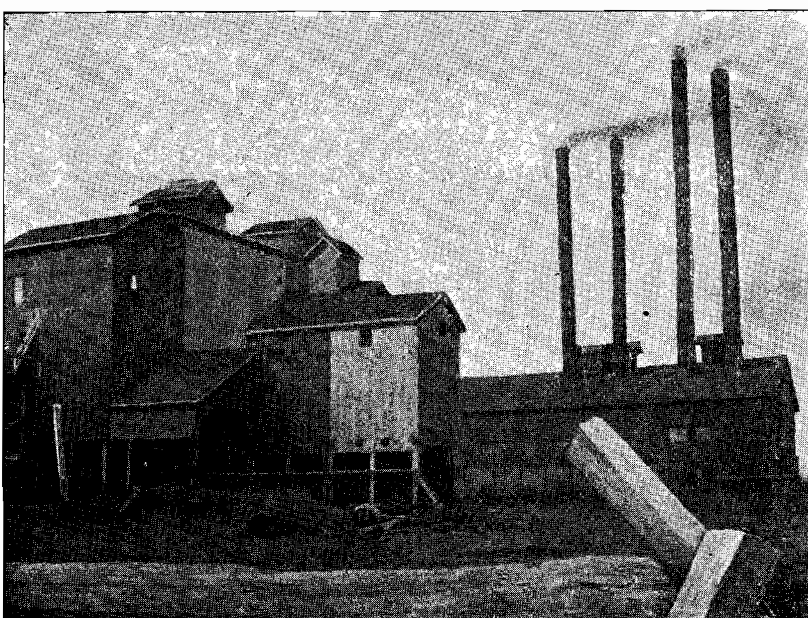
W. M. Hunter, aged 16 years, was working with his father on the morning of October 8th, 1897. At about 9 o'clock he was loading a car, when a large piece of slate fell, catching him with his breast across the car, crushing him terribly and killing him instantly. The timber on the side where the slate fell was back about 11 or 12 feet, while on the other side it was back only about 6 feet. Chas. Hunter, father of the deceased, claims to have examined the slate that morning and thought it safe, but, in my opinion, the condition of the top was such that it should have been timbered within 6 or 8 feet of the face, as the draw slate is very bad in this part of the mine. There were plenty of timbers on hand in the room.

COAL WASHING MACHINERY IN INDIANA.

All coals have more or less impurities in the vein. These consist principally of slate, sulphur and bone coal, each of which is heavier than the pure coal. In the larger sizes these are easily seen and separated by hand, either in the mine or when the coal reaches the surface, before being shipped to the market; but in the smaller sizes of coal, the impurities being also broken up, are too small to be seen or removed in this manner advantageously. The consequence has been that a great amount of fine coal was useless, fit only for the waste pile, and some of the nut and pea coal produced has lost a great deal of its value on account of the presence of these impurities. This has led inventors to work in the direction of machinery which will remove the impurities from small coal at a reasonable expense. The most successful have taken advantage of the difference in weight, referred to, and separate the materials by the use of water. This has been accomplished in various ways with more or less success. Of the different styles of washers in use are the jig washer, the percussive table, the trough washer, and those in which an upward current of water accomplishes the separation. Washers were originally introduced to clean the coal used in making coke. The superiority of the washed over the unwashed coal for other purposes has led to their introduction at many places to clean coal for the general market. Though very little coke is produced in this State (only the plant at Ayrshire having operated during the year, and that only partially), coal is washed for the market at Alum Cave and Coxville. Extensive improvements were made at the Coxville plant during the year, making it very complete, and, as a short description of the plant and its results may prove interesting to mining men, I give it herewith. The plant is so enclosed that a good photograph of the machinery is not obtainable:

The illustration on the opposite page shows the 400-ton Robinson coal-washing plant, in connection with the coal tipple and screening plant of the Brazil Block Coal Company, at Coxville, Ind., and is the most successful washing plant in this section of the country. The object in washing their nut and pea coal is to eliminate the coal from all impurities, thus creating a greater demand for their coal for commercial purposes. After placing their washed product on the market they





VIEWS OF PLANT OF COX NO. 3 MINE, COXVILLE, INDIANA.

have not only been able to find ready sale for their entire output, but have also been able to increase their price per ton on the washed coal. The installation of this washing plant has been a paying investment and should commend itself to the coal operators of the West.

The method of operating this washing plant in connection with the coal tipple is as follows:

The coal is first dumped over the lump screen; the coal passing into the lump car on railroad track, the screenings passing into the boot of the elevator. This product is then elevated and discharged into a large revolving screen of about $1\frac{1}{2}$-inch mesh, which is placed over a coal storage pocket. The tailings from this revolving screen is classed as egg or prime nut coal and is picked free from slate as it passes down the chute into the bin. The nut, pea and slack coal that passes through the meshes of this revolving screen is stored into a bin below; from the bottom of this bin a chute is arranged to conduct this product to the Jeffrey-Robinson washer. The coal is then discharged into the center of the washer, on the inside of a deflecting ring, with the current of water to the overflow or discharge spout of the cone tank. The slate, sulphur, sand and other material of greater specific gravity than the coal passes downward into the settling or slate chamber at the bottom of the cone tank. The washer is partially supplied with a fresh current of water pumped from the mine and discharged into a tank below the washer; from this tank the water is pumped by means of two large pulsometer pumps into the lower part of the washer, just above the slate chamber. The accumulation of the slate or refuse is removed from the lower slate chamber by means of valves at stated intervals, which depends entirely upon the per cent. of refuse in the coal. The refuse is deposited into a small mine car and carried to some convenient point and dumped. The good coal is discharged with the water into a revolving screen at the mouth of the washer. This screen is covered with wire cloth of about one-inch mesh. The coal in passing through the screen is thoroughly cleaned and presents a very fine appearance. The tailings or nut coal from this screen is elevated by means of chained buckets into a nut bin; from this bin it is discharged into railroad cars. The pea and slack coal which passes through the revolving screen passes over a fine perforated metal screen set at an angle of about 30 degrees. The material that passes over this screen is classed as pea coal, which is also elevated and discharged into a settling tank; from this tank an overflow pipe is connected to conduct the water back to the water tank below the washer, which is again pumped back into the washer, with the additional supply of fresh water from the mine. They gather enough fine coal from the settling tank to run their entire battery of boilers, and with this product they are never troubled with clinkers forming over the grate bars.

This plant has been in successful operation for several years. The construction and arrangement of machinery is very simple and effective, and is especially adapted to the washing of coal for commercial purposes. The Jeffrey Manufacturing Company, of Columbus, Ohio, has full control of the manufacture and patents of this Robinson coal-washing system, together with the screening, elevating and conveying machinery, and will promptly answer all inquiries relative to the installation of these plants, for the washing of coal for either commercial or coking purposes.

REPORT OF THE STATE SUPERVISOR OF OIL INSPECTION.

OFFICE OF THE STATE SUPERVISOR OF OIL INSPECTION,
ROOM 92, STATE HOUSE,
INDIANAPOLIS, IND.

PROF. W. S. BLATCHLEY,

State Geologist of Indiana:

DEAR SIR—

I herewith submit to you my third annual report, which shows the number of barrels of oil inspected by myself and deputies during the calendar year, 1897.

This report is made in accordance with the statute providing for the regulation of the use and sale of oils for illuminating purposes within the State. Yours, truly,

C. F. HALL,

State Supervisor of Oil Inspection.

REPORT OF THE STATE SUPERVISOR OF OIL INSPECTION.

During the year 1897, 268,195½ barrels of illuminating oil were inspected by myself and deputies. Of this number of barrels my deputies and assistants inspected 218,785½, while 49,410 were inspected by myself. But 123 barrels failed to pass the tests, showing that a very high grade of oil is, in general, being shipped into the State.

The standard test for all illuminating oils in Indiana is gravity test, Beaume's hydrometer, not below 46 degrees nor higher than 50 degrees. Said oils must bear a flash test not below 120° Fahrenheit, and a fire test not below 140° Fahrenheit. The reason our rejections are so few is on account of this test being higher than in several other States in the Union, and the lower grades of oil are therefore shipped to them.

No violations of the law regarding oil inspection have come to my notice during the year 1897.

But one or two minor accidents, resulting from the explosion of kerosene, have occurred within the State, and they were due to lamps having been accidentally upset, rather than to the quality of the oil.

From the report it will be seen that the number of stations at which the oil is inspected has largely increased during the year, the number being 89, as against 67 in 1896. This necessitates much more travel on the part of the deputies, with but little additional increase in fees, the number of barrels inspected in the State in 1897 being but 6,045½ greater than in 1896.

The following is a list of Deputy Supervisors in the State on December 31, 1897:

Zaring, Wm. C.	Evansville.
Weems, Robert F.	Vincennes.
Dorsey, C. B.	New Albany.
Bowman, M. J.	Madison.
Mills, L. B.	New Maysville.
Shirk, B. F.	Muncie.
Boltz, J. H.	Winchester.
Dorsey, W. C.	Terre Haute.
Carr, W. C.	Crawfordsville.
McGee, Wm. H.	Lafayette.
Davidson, James G.	Whiting.

Johnston, John M.	Logansport.
Daly, W. F.	Peru.
Sebring, W. D.	Portland.
Thorward, Theo.	Fort Wayne.
Schutt, M. A.	Michigan City.
Derr, Walter	South Bend.
Cornell, J. B.	Goshen.

INSPECTION BY STATIONS.

Stations.	Approved.	Rejected.	Total.
Evansville	16,980	....	16,980
Tell City	626	....	626
Derby	2	....	2
Mt. Vernon	4	....	4
Princeton	1,085	....	1,085
Huntingburg	728	....	728
Vincennes	6,584	....	6,584
Bedford	655	....	655
Jeffersonville	2,601	....	2,601
New Albany	3,588	....	3,588
Madison	4,324	....	4,324
Seymour	2,143	....	2,143
Aurora	2,363	....	2,363
Brookville	1,376	....	1,376
Greensburg	1,733	....	1,733
Rushville	1,894	....	1,894
Shelbyville	1,797	....	1,797
Batesville	343	....	343
Franklin	1,743	....	1,743
Martinsville	988	....	988
Danville	1,985	....	1,985
Columbus	2,129	....	2,129
Bloomington	686	....	686
Connersville	2,306	....	2,306
Muncie	1,939	....	1,939
New Castle	1,380	....	1,380
Union City	1,800	....	1,800
Richmond	3,870	....	3,870
Indianapolis	49,287	123	49,410
Crawfordsville	3,089	....	3,089
Terre Haute	10,871	....	10,871
Brazil	2,160	....	2,160
Rockville	1,946	....	1,946
Attica	1,495	....	1,495
Lafayette	9,760	....	9,760
Frankfort	2,705	....	2,705
Lebanon	2,018	....	2,018
Kokomo	2,607	....	2,607
Fowler	1,380	....	1,380
Logansport	7,281	....	7,281
Rochester	1,312	....	1,312
Delphi	1,150	....	1,150

INSPECTION BY STATIONS—Continued.

Stations.	Approved.	Rejected.	Total.
Whiting	14,103	....	14,103
Hammond	3,554	....	3,554
Valparaiso	1,575	....	1,575
Crown Point	806	....	806
Porter	399	....	399
Wabash	1,451	....	1,451
North Manchester	1,084	....	1,084
Peru	2,593	....	2,593
Bluffton	1,810	....	1,810
Marion	1,562	....	1,562
Huntington	2,800	....	2,800
Portland	1,440	....	1,440
Decatur	1,370	....	1,370
Columbia City	450	....	450
Eagle P. O.	5	....	5
Kendallville	900	....	900
Garrett	180	....	180
Fort Wayne	8,189	....	8,189
Angola	1,710	....	1,710
Auburn	1,440	....	1,440
Lagrange	1,080	....	1,080
Ligonier	630	....	630
Butler	450	....	450
South Bend	7,759	....	7,759
Argos	499	....	499
Plymouth	1,291	....	1,291
Bourbon	1,174	....	1,174
Walkerton	929	....	729
Goshen	2,582½	....	2,582½
Elkhart	4,272	....	4,272
Warsaw	1,281	....	1,281
Pierceton	602	....	602
Nappanee	907	....	907
New Paris	48	....	48
Michigan City	2,355	....	2,355
Laporte	2,082	....	2,082
Knox	357	....	357
Topeka	360	....	360
Louisville, Ky.	6,745	....	6,745
Monckfort, Ky.	2	....	2
Cincinnati, O.	3,373	....	3,373
Toledo, O.	1,864	....	1,864
Lima, O.	5,713	....	5,713
Mansfield, O.	2,125	....	2,125
Cleveland, O.	6,608	....	6,608
Chicago, Ill.	602	....	602
Danville, Ill.	248	....	248
Total No. Bbls. inspected for year...	268,072½	123	268,195½

INSPECTION BY MONTHS.

Month.	Approved.	Rejected.	Total.
January	30,845	....	30,845
February	26,543	....	26,543
March	20,326	....	20,326
April	19,423	....	19,423
May	14,968	....	14,968
June	13,185	....	13,185
July	11,192	....	11,192
August	13,821	....	13,821
September	22,032	....	22,032
October	24,824½	....	24,824½
November	34,076	123	34,199
December	36,837	....	36,837
Total No. Bbls. inspected by months..	268,072½	123	268,195½

TABLE SHOWING STATES WHERE OIL WAS MANUFACTURED.

Ohio	124,093
Indiana	118,184½
Pennsylvania	25,573
West Virginia	213
Missouri	73
Illinois	44
Kentucky	15
Total for Year by States	268,195½

TABLE SHOWING PLACE OF MANUFACTURE.

Whiting, Ind.	118,184½
Lima, O.	104,405
Cleveland, O	10,371
Toledo, O	7,356
Welker, O.	1,953
Marietta, O	8
Washington, Pa.	8,220
Oil City, Pa	7,293
Pittsburg, Pa.	4,045
Warren, Pa.	1,533
Titusville, Pa.	1,420
Reno, Pa.	856
Franklin, Pa	819
Taylorstown, Pa.	540
Emlenton, Pa	345
Altoona, Pa	279
Allegheny, Pa	129
South Chester, Pa.	94
Parkersburg, W. Va	213
St. Louis, Mo	73
Chicago, Ill.	44
Carrollton, Ky.	15
Total	268,195½

Very respectfully,

C. F. HALL.

SEPTEMBER DRAGONFLIES OF ROUND AND SHRINER LAKES, WHITLEY COUNTY, INDIANA.

BY E. B. WILLIAMSON, BLUFFTON, IND.

These lakes have been described by Mr. P. H. Kirsch (Report of Indiana State Fish Commissioner for 1896), so only a remark in this connection is necessary. The diversified character of the shores of these beautiful bodies of water is such that dragonflies of widely varying habits may find here suitable feeding and breeding grounds. Thus the shores of Round Lake, for example, may be divided into sections, each of which may have one or more species that are pretty closely confined to that particular section. The strong flying *Libellula incesta*, during two seasons, has been observed to be at all common only for a short distance along the northern shore of Round Lake. Here the species was very abundant. In the same way *Celithemis eliza* was observed commonly only along the eastern and northeastern shores of Shriner Lake.

By September many of the species which were so common during the earlier summer have disappeared, and more apparent still is the decrease in the number of individuals. In the patch of giant bulrushes where, during July days, myriads of blue and green forms waged defensive and offensive warfare, in September *Lestes vigilax* flutters languidly from stem to stem, or sits with listless wings as though meditating on "days that never come again." On account of this decrease in the number of species and individuals, it happens that some species, which, during the summer months, appeared comparatively common, in the fall come to appear comparatively rare or disappear altogether. During July *Argia putrida* is much more abundant than *Argia violacea.* In September *putrida* is rare and *violacea* is abundant.

The dragonflies mentioned below were observed and collected on September 2, 3 and 4, 1897. In the preparation of the list whenever there has been any doubt as to the identification of species, specimens of such species have been examined and named by Professor Kellicott and Mr. Hine of the Ohio State University.

A LIST OF DRAGONFLIES COLLECTED ON SEPTEMBER 2, 3 AND 4, ABOUT ROUND AND SHRINER LAKES, WHITLEY COUNTY INDIANA, BY E. B. WILLIAMSON.

1. *Hetærina americana* Fabr. Rare, three specimens, one male and two females, taken on Shriner Lake.
2. *Lestes rectangularis* Say. Only one specimen, a male, captured.
3. *Lestes unguiculata* Hagen. Common in patches of *Typha* and *Scirpus lacustris* and *S. americanus.*
4. *Lestes vigilax* Selys. Very common; found in company with *L. unguiculata;* often observed pairing.
5. *Argia putrida* Hagen. Rare.
6. *Argia violacea* Hagen. Abundant; observed pairing.
7. *Ischnura verticalis* Say. A few observed; seen pairing.
8. *Enallagma pollutum* Hagen. Two males were taken.
9. *Enallagma signatum* Hagen. Common, especially about the lily pads, flitting about until after sunset; observed pairing.
10.* *Enallagma laterale* Morse. One male.
11.† *Enallagma sp* (?) One female.
12. *Anax junius* Drury. Rather rare.
13. *Aeschna constricta* Say. Common; observed pairing.
14. *Tramea lacerata* Hagen. Two young males were taken.
15. *Celithemis eliza* Hagen. Abundant; observed pairing.
16. *Celithemis eponina* Drury. Common; observed pairing.
17. *Celithemis fasciata* Kirb. Rare; one specimen taken at Shriner Lake.
18. *Perithemis domitia* Druy. Common.
19. *Libellula basalis* Say. Common along the northern shore of Round Lake; observed ovipositing.

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*I have examined the specimen mentioned, and have compared the abdominal appendages with drawings made for me by Mr. Morse, and I feel sure that the identification is correct.—Prof. D. S. Kellicott.

†The single female is not sufficient to determine the species; there is little doubt but that it belongs to the subgenus *Agrion.* The color is bronze-black with yellow markings; there are large yellow areas on the rear of the head; a broad yellow ante-humeral stripe; sides of thorax yellow with a black line on the second lateral suture, and a half line on the first. The first and second abdominal segments are yellow, each with a dorsal black spot; the third, fourth, fifth, sixth and seventh segments are black except narrowed apical yellow rings; the dorsum of the eighth, ninth and tenth segments is mostly yellow. I think the species is unnamed.—Prof. D. S. Kellicott.

20. *Libellula incesta* Hagen. Common in company with *L. basalis;* observed ovipositing. The males of *L. basalis* persistently attack the females of *L. incesta* which are ovipositing. The males of *L. incesta* at once hasten to protect the females, and royal battles, involving perhaps half a dozen individuals, are thus being constantly waged.
21. *Mesothemis simplicicollis* Say. Common; observed ovipositing, the males always fluttering near. One individual was observed feeding on a *Lestes vigilax,* and another on a *Pamphila.*
22. *Diplax obtrusa* Hagen. Common.
23. *Diplax rubicundula* Say. Rare; one male taken.
24. *Diplax rubicundula assimilata* Uhler. One male captured.
25. *Diplax vicina* Hagen. Very abundant; frequently observed pairing.

A CATALOGUE

OF THE

FOSSILS OF INDIANA,

Accompanied by a Bibliography of the Literature Relating to Them.

BY EDWARD M. KINDLE.

In the present paper the writer has endeavored to present all of the information which is at present recorded concerning the geological range and distribution within the State of the species listed.

In such a list as the present one, which includes faunas from the Ordovician to the Pleistocene, it has not been possible to do more than present the results of the work of those who have occupied themselves in this field. The list is therefore offered only as a provisional one and as an aid to further study. Many fossils known from other States which are not here listed, as well as new species, will undoubtedly be added in the future; while some species may be found to have been based on incorrectly determined specimens. But it is hoped that it may be useful in aiding other students to add to our present imperfect knowledge of the range and distribution of species within the State, by indicating what has already been accomplished.

The writer wishes to acknowledge here his indebtedness to Prof. W. S. Blatchley for access to the collections of the State Museum, to Prof. H. S. Williams for valuable suggestions, and to Mr. A. C. Benedict for the loan of literature.

PART I. CATALOGUE OF INDIANA FOSSILS.*

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
PROTOZOA.												
**Endothyra baileyi* Hall. (*Rotalia baileyi*)								×				
Gosport, Greencastle, Owen County and Harrison County (Hall).												
**Fusilina cylindrica* Fischer									×	×		
Lodi (C. A. White), Harrison County.												
Rotalia baileyi												
see Endothyra baileyi.												
Moellerina greenei Ulrich				×								
Falls of the Ohio (E. O. Ulrich).												
COELENTERATA.												
Acervularia davidsoni E. & H., 11				×								
Jeffersonville (White).												
**Acrophyllum oneidaense* Billings, 12				×								
Falls of the Ohio (W. J. Davis).												
**Alveolites goldfussi* Billings, 11				×								
Louisville, Ky. (W. J. Davis), Delphi.												
Alveolites indianensis Hall, 11				×								
Delaware County (Phinney).												
Alveolites labiosa Billings				×								
Falls of the Ohio (Rominger).												
**Alveolites megastoma* Winch.				×								
Falls of the Ohio (Rominger).												
Alveolites squamosus Billings				×								
Falls of the Ohio (W. J. Davis).												
Amplexis cinctutus Miller, 18			×									
St. Paul.												
**Amplexis coralloides* Sow.								×				
Lanesville.												
Amplexus fragiles White & St John							×					
Crawfordsville, Providence, and Harrison County.												
Amplexus (?) rockfordensis M. & G.						×						
Rockford (Miller & Gurley).												

*NOTE.—Those fossils which are represented in the collections of the State Museum, according to the Sixteenth Annual Report of the State Geologist, are marked in the list with a star.

Numbers following the names of species refer to the volumes of the State Geological Survey which contain the authority for including them in the list. They have been numbered as follows:

(1).	Geological Report of Indiana, 1837–38	(11).	Geological Report of Indiana, 1881
(2).	" " " " 1859–60	(12).	" " " " 1882
(3).	" " " " 1869	(13).	" " " " 1883
(4).	" " " " 1872	(14).	" " " " 1884
(5).	" " " " 1873	(15).	" " " " 1885–86
(6).	" " " " 1874	(16).	" " " " 1888
(7).	" " " " 1875	(17).	" " " " 1891
(8).	" " " " 1876–78	(18).	" " " " 1893
(9).	" " " " 1879	(19).	" " " " 1894
(10).	" " " " 1880	(20).	" " " " 1895

When the State Reports are not cited as the authority for a species, the name of the authority is usually placed in parenthesis after the localities mentioned.

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Amplexus shumardi* Milne E. Louisville, Ky., and Charlestown (W. J. Davis).	....	....	×	....	....	....	....	....	....	....	....	....
**Amplexus yandelli* Milne E., 11 Falls of the Ohio, Madison (Rominger, Cornett).	....	....	....	×	....	....	....	....	....	....	....	....
**Astraeospongia hamiltonensis* M. & W. Clark County.	....	....	....	×	....	....	....	....	....	....	....	....
**Astylospongia burra* Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Astylospongia imbricato-articulata F. Roem. 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Astylospongia praemorsa* Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Astylospongia praemorsa var. *nuxmoschata* Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Astylospongia stellatim—sulcata Roem. Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Aulacophyllum convergens Hall, 12 Falls of the Ohio and Clark County.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum cruciforme Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum insigne Falls of the Ohio (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum pinnatum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum poculum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum praeciptum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum princeps Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum prateriforme Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum reflexum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
**Aulacophyllum sulcatum* d'Orb., 12 Louisville, Ky. (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum tripinnatum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulacophyllum trisulcatum Hall, 12 Charlestown and Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Aulopora arachnoidea Hall Franklin County, Richmond, Madison, (Rominger, (W. S. T. Cornett).	×	....	....	....	....	....	....	....	....	....	....	....
Aulopora cornuta Falls of the Ohio (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Aulopora edithana Falls of the Ohio (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
**Aulopora gigas* Rominger, 8 Owen County, Crawfordsville, Greencastle, Harrison County, Fordice, Lanesville, Washington County, Monroe County.	....	....	....	....	....	....	×	×	....	....	....	....
Aulopora precius Hall, 11 Louisville, Ky., Waldron (James Hall) (W. J. Davis).	....	....	×	....	....	....	....	....	....	....	....	....
Aulopora vanclevii Hall, 12 Indiana and Kentucky.	....	....	×	....	....	....	....	....	....	....	....	....
Aulopora serpens Goldfussi Falls of the Ohio (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Axophyllum rudis White & St. J., 13 Newport (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Baryphyllum d'orbignyi E. & H. Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Baryphyllum fungulus White Waldron (C. A. White).			×									
**Blothrophyllum acuminatum* (?) Hall Falls of the Ohio.				×								
Blothrophyllum approximatum, Nich. Falls of the Ohio.				×								
**Blothrophyllum decorticatum* Billings, 11 Falls of the Ohio, Rominger (W. J. Davis).				×								
Blothrophyllum promissum Hall, 12. Falls of the Ohio.				×								
Bucanophyllum gracile Ulrich Falls of the Ohio (Ulrich).				×								
Calamopora goldfussi d'Orb. Madison and Jennings County (Rominger).				×								
Calapoecia huronica Roming. Madison (Rominger).			×									
Calceola attenuatus V. W. Lyon Louisville, Ky. (V. W. Lyon).			×									
Calceola corniculum V. W. Lyon Louisville, Ky. (V. W. Lyon.)			×									
Calceola coxi V. W. Lyon Louisville, Ky. (V. W. Lyon).			×									
Calcisphaera lemoni Knowlton Falls of the Ohio (Knowlton.)				×								
Campophyllum torquium Owen, 13. Vanderburgh County.											×	
Chaetetes approximatus Nicholson see Monticullipora dalli.												
Chaetetes consimilis Hall, 11 see Monotrypella consimilis.	×											
Chaetetes corticans Nicholson see Spatiopora tuberculata.	×											
Chaetetes discoidens James see Amplexopora discoidea.	×											
Chaetetes frondosa d'Orb. see Monticulipora frondora.	×											
Chaetetes lycoperdon see Monticulipora lycoperdon.	×											
Chaetetes mammulatus see Monticulipora mammulatus.	×											
**Chaetetes milleporaceus* E. & H. Vanderburgh County, Newberg.											×	
Chaetetes newberryi Nich. see Prasopora Newberryi.	×											
Chataetes ortoni Nich. see Atactoporella ortoni.	×											
Chaetetes ponderosus Falls of the Ohio (C. Rominger), Madison (Cornett).	×			×								
Chaetetes pulchellus Edw. & Haime see Monticulipora andrewsi.	×											
Chaetetes subpulchellus Nicholson see Monticulipora subpulchellus.	×											
**Chaetetes tuberculata* see Spatiopora tuberculatus.	×											
**Chonophyllum magnificum* Billings Charlestown Landing, Falls of the Ohio, Logansport.				×								
**Chonophyllum niagarense* Hall Waldron, Falls of the Ohio (Rominger), Huntington County.			×									
**Chonophyllum ponderosum* Rominger Charleston.				×								

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Chonophyllum vadum Hall, 12 Louisville, Ky.			×									
Cladopora alpenensis Rominger Falls of the Ohio (W. J. Davis).				×								
**Cladopora aspera* Rominger Falls of the Ohio.				×								
Cladopora billingsi Louisville, Ky. (W. J. Davis).				×								
**Cladopora cryptodens* Bill. Falls of the Ohio.				×								
**Cladopora expatiata* Rominger Falls of the Ohio (W. J. Davis).				×								
**Cladopora fischeri* Billings Falls of the Ohio, Charleston Landing (Rominger).				×								
Cladopora imbricata Rominger Falls of the Ohio (Rominger) (Davis).				×								
Cladopora iowensis Falls of the Ohio (W. J. Davis).				×								
**Cladopora labiosa* Billings Falls of the Ohio (W. J. Davis).				×								
**Cladopora laqueata* Rominger Falls of the Ohio.			×									
Cladopora lichenoides Rominger Falls of the Ohio (Rominger).				×								
Cladopora linneana Roming., 11 Shelby County.				×								
**Cladopora ornata* Rominger Clark County.				×								
Cladopora pinguis Falls of the Ohio (W. J. Davis).				×								
Cladopora pulchra Rominger Falls of the Ohio (W. J. Davis).				×								
Cladopora reticulata Hall, 11 Louisville, Ky. (W. J. Davis), Delaware County.			×									
Cladopora rimosa Rominger Falls of the Ohio (W. J. Davis).				×								
**Cladopora robusta* Rominger Falls of the Ohio (W. J. Davis), Falls of the Ohio (Rominger).				×								
Cladopora roemeri Louisville, Ky. (W. J. Davis).				×								
Cladopora sarmentosa Hall, 11 Waldron.			×									
**Cladopora verticillata* W. & M. Louisville, Ky.			×									
Clisiophyllum conigerum Rominger, 12 Falls of the Ohio.				×								
Clisiophyllum oneidaense Billings, 11 *see* Acrophyllum oneidaense.												
Coenites crassus Rominger Louisville (W. J. Davis).			×									
Coenites laminatus Hall Louisville (W. J. Davis).			×									
Coenites ramulosa Hall (Rominger).			×									
Coenites verticillata Louisville, Ky. (W. J. Davis).			×									
Coenostroma monticulifera Winch. (Stromatopora monticulifera) Falls of the Ohio.				×								
Coleophyllum pyriforme Hall, 12 Falls of the Ohio (Hall).				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Columnaria inequalis Hall Madison (Cornett).	×											
Columnopora cribiformis Nich. *see* Calapoecia cribiformis.	×											
Constellaria antheloidea Hall. 11 *see* Stellipora antheloidea.												
* *Cyathophyllum arctifossa* Hall, 12 Falls of the Ohio.				×								
* *Cyathophyllum brevicorne* Rominger Falls of the Ohio (W. J. Davis).				×								
Cyathophyllum caliculum Osgood (Foerste).		×										
Cyathophyllum caespitosum Goldfuss Madison				×								
Cyathophyllum colligatum Louisville, Ky. (W. J. Davis).				×								
Cyathophyllum coralliferum Falls of the Ohio (W. J. Davis).				×								
* *Cyathophyllum corniculum* Milne E. 11 Falls of the Ohio (W. J. Davis) Shelby County.				×								
* *Cyathophyllum davidsoni* Milne E. 11 Falls of the Ohio (W. J. Davis) Shelby County.				×								
Cyathophyllum depressum Hall Falls of the Ohio.				×								
Cyathophyllum exiguum Falls of the Ohio (W. J. Davis).				×								
* *Cyathophyllum geniculatum* Rominger Bartholomew County.				×								
Cyathophyllum halli Falls of the Ohio (W. J. Davis).				×								
* *Cyathophyllum houghtoni* Rominger Hartsville.				×								
Cyathophyllum impositum Hall Falls of the Ohio.				×								
Cyathophyllum juvene Rominger, 11 Louisville, Ky. (W. J. Davis) Shelby County.				×								
Cyathophyllum radicula Rominger Charlestown (Rominger) Louisville Ky. (W. J. Davis).			×	×								
* *Cyathophyllum robustum* Falls of the Ohio (W. J. Davis).				×								
* *Cyathophyllum rugosum* Milne E., 12 Falls of the Ohio (Rominger) Jackson County, Jennings County and Madison.				×								
* *Cyathophyllum scyphus* Rominger, 11 Louisville, Ky. (W. J. Davis), Shelby County.				×								
Cyathophyllum tornatum Louisville, Ky. (W. J. Davis).				×								
* *Cyathophyllum validum* Hall Falls of the Ohio.				×								
Cyathophyllum vesiculatum Hall Falls of the Ohio.				×								
Cyclospongia discus Miller Bunker Hill.				×								
* *Cystiphyllum americanum* E. & H. Falls of the Ohio (W. J. Davis).			×									
Cystiphyllum cayugaensis Louisville, Ky. (W. J. Davis).				×								
Cystiphyllum grande Falls of the Ohio (W. J. Davis).				×								
Cystiphyllum greenii Miller, 18 Falls of the Ohio.				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Cystiphyllum niagarense* Hall, 11 Louisville, Ky. (W. J. Davis), Delaware County.			×									
Cystiphyllum ohioense Nich. Louisville, Ky. (W. J. Davis).				×								
Cystiphyllum pustulatum Hall, 12 Falls of the Ohio.				×								
**Cystiphyllum squamosum* Falls of the Ohio (W. J. Davis).				×								
Cystiphyllum sulcatum Billings, 11 Falls of the Ohio (Rominger).				×								
Cystiphyllum vesiculosum Goldf., 11 Falls of the Oh o (W. J. Davis).				×								
Dendrograptus chaunograptus novellus Hall, 11 Waldron.			×									
Dendropora alternans Louisville, Ky. (W. J. Davis).				×								
Dendropora neglecta Falls of the Ohio (Rominger), Louisville, Ky. (W. J. Davis).				×								
Dendropora proboscidalis Falls of the Ohio (W. J. Davis).				×								
Dictyostroma undulata Nicholson Louisville, Ky. (Nicholson).			×									
Diplotrypa milleri Ulrich Osgood (Ulrich).			×									
Diphyphyllum adnatum Hall, 12 Falls of the Ohio.				×								
Diphyphyllum archiaca Bill., 11 Louisville, Ky. (W. J. Davis) Shelby County.				×								
Diphyphyllum gigas Falls of the Ohio (W. J Davis).				×								
**Diphyphyllum apertum* Hall, 12 Falls of the Ohio.				×								
**Diphyphyllum angosum* E. & H. Falls of the Ohio (Rominger).				×								
**Diphyphyllum arundinaceum* Billings, 11 Logansport.				×								
**Diphyphyllum caespitoseum* Hall Delphi and Grant County.			×									
**Diphyphyllum huronicum* Billings Wabash.			×									
Diphyphyllum panicum Louisville, Ky. (W. J. Davis).				×								
Diphyphyllum simcoense Billings, 11 Falls of the Ohio (W. J. Davis), Shelby County.				×								
**Diphyphyllum stramineum* Billings, 12 Logansport and Falls of the Ohio.				×								
Diphyphyllum strictum Falls of the Ohio (W. J. Davis and Nicholson.)				×								
Diphyphyllum tumidulum Hall, 12 Falls of the Ohio.				×								
Diphyphyllum verneuilanum Louisville, Ky. (W. J. Davis).				×								
Drymopora intermedia Falls of the Ohio (W. J. Davis).				×								
Drymopora nobilis Falls of the Ohio (W. J. Davis).				×								
**Duncanella borealis* Nicholson Hartsville.			×									
Emmonsia cylindrica, 8 Madison (Cornett.)				×								

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Emmonsia hemispherica Troost, 8 Carroll Co., Madison (Cornett.)				×								
Eridophyllum arundinaceum *see* Diphyllum arundinaceum.				×								
Eridophyllum dividium *see* Diphyphyllum dividium.												
Eridophyllum huronicum *see* Diphyphyllum huronicum.												
Eridophyllum rugosum Edw. and Haime, 12 *see* Diphyphyllum rugosum.												
Eridophyllum simcoense, 12 *see* Diphyphyllum simcoense.												
Eridophyllum strictum Edwards and Haime, 11 *see* Diphyphyllum simcoense.				×								
Favistella stellata Hall 12 and 11 Madison (Rominger).	×											
**Favosites canadensis* Billings, 11 Falls of the Ohio (W.J.Davis) Shelby County.				×								
**Favosites cavernosa* Rominger Falls of the Ohio.				×								
**Favosites clausus* Rominger, 11 Falls of the Ohio (Rominger) (Davis).				×								
**Favosites cristatus* Louisville (Davis).			×									
Favosites cristatus var. *major* Falls of the Ohio (Davis).			×									
Favosites favosus Hall, 11 Delaware County.	×											
**Favosites digitatus* Rominger Louisville, Ky. (Davis).				×								
**Favosites emmonsi* Rominger, 12 Louisville, Charlestown, Falls of the Ohio (Davis).				×								
**Favosites epidermatus* Rominger, 11 Falls of the Ohio, Logansport, Bartholomew County.				×								
Favosites fibrosa Madison (Cornett).				×								
**Favosites favosus* Goldfuss, 12 Franklin County (Moore), Louisville (Davis)			×									
Favosites forbesi Louisville (Davis).			×									
**Favosites forbesi var. occidentalis* Hall, 11 Waldron, Franklin County (Moore).			×									
Favosites goldfussi *see* Calamopora goldfussi.												
Favosites gothlandicus Lamark, 8 Madison.				×								
**Favosites hemisphericus* Y. and S., 12 Falls of the Ohio, Franklin County (Moore).				×								
Favosites hisingeri Milne Edwards (Rominger).			×									
**Favosites hispidus* Rominger Delphi.			×									
Favosites intertextus Rominger Falls of the Ohio (Rominger).				×								
**Favosites limitaris* Rominger, 12 Falls of the Ohio (Rominger).				×								
Favosites maximus Troost Falls of the Ohio (Rominger).				×								
**Favosites niagarensis* Hall Louisville (Davis) Waldron, Madison, Charlestown, Wabash County, Huntington County, Miami County.			×									

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Favosites placenta* Rominger Falls of the Ohio (Davis).	....	....	....	×	....	....	....	....	....	....	....	....
**Favosites pleurodictyoides* Nicholson Charlestown.	....	....	....	×	....	...	....	....	....	....	....	....
Favosites polymorpha Goldfuss, 11 Madison.	....	....	....	×	....	....	....	....	....	....	....	....
**Favosites radiatus* Rominger Falls of the Ohio, Hartsville (Davis).	....	....	....	×	....	....	....	....	....	....	....	....
**Favosites radiciformis* Rominger Falls of the Ohio (Davis).	....	....	....	×	....	..	....	....	....	....	....	....
Favosites ramosa, 8 Madison.	....	....	....	×	....	....	....	....	....	....	....	....
**Favosites springerus* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
**Favosites spongilla* Rominger Louisville (Davis), St. Paul (Rominger).	....	....	×	....	....	....	....	....	....	....	....	....
**Favosites tuberosus* Rominger Charlestown, Falls of the Ohio (Rominger).	....	....	....	×	....	....	....	....	....	....	....	....
**Favosites turbinatus* Billings Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Favosites venustus Hall, 12 Louisville (Davis).	....	....	×	....	....	....	....	....	....	....	....	....
Favosites winchelli Rominger Falls of the Ohio (Rominger).	....	....	....	×	....	....	....	....	....	....	....	....
**Fistulipora acervulosa* Rominger Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Fistulipora canadensis Billings, 11 (Rominger).	....	....	....	×	....	....	....	....	....	....	....	....
Fistulipora intercellata Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Glossotrypa paliformis Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
**Hadrophyllum d'orbignyi* Louisville, Ky., Clark County (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
**Halysites catenulatus* Linn., 11 Franklin County (Moore), Wabash County, Carroll County, Huntington County, Osgood (Foerste).	....	×	×	....	....	....	....	....	....	....	....	....
**Halysites labyrinthicus* Goldf. Delphi.	....	....	×	....	....	....	....	....	....	....	....	....
Heliolites interstinctus Linn., 12 Huntington (Rominger).	....	....	×	....	....	....	....	....	....	....	....	....
Heliolites megastoma McCoy, 11 Louisville (W. J. Davis), Delaware County.	....	....	×	....	....	....	....	....	....	....	....	....
Heliolites pyriformis Guettard Louisville (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Heliolites subtubulatus McCoy Louisville (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum annulatum Hall, 12 Scott and Clark Counties.	....	....	....	×	....	....	....	....	....	....	....	....
**Heliophyllum coalitum* Rominger, 12 Delphi	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum compactum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum corniculum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum denticulatum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum distans Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum equum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
**Heliophyllum exiguum* Bill., 11 Falls of the Ohio, Shelby County.	....	....	....	×	....	....	....	....	....	....	....	....

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Heliophyllum fecundum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
****Heliophyllum gemmatum*** Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
****Heliophyllum germiniferum*** Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
****Heliophyllum halli*** E. & H., 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum incrassatum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum invaginatum Hall, 12 Falls of the Ohio	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum latericrescens Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum nettlerothi Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Heliophyllum sordidum Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
****Heliophyllum parvum*** Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
****Heliophyllum scyphulus*** Hall, 12 Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....
****Heliophyllum tenuimurale*** Hall, 12 Charlestown, Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Hippothoa inflata Hall *see* Stomatopora inflata.	....	....	....	....	....	....	....	....	....	....	....	....
Houghtonia huronica Rominger *see* Calapoecia huronica (Rominger).	....	....	....	....	....	....	....	....	....	....	....	....
Hydrophyllum orbignyii Edwd. and Haime, 8 Madison.	....	×	×	×	....	....	....	....	....	....	....	....
Intrepora preteolata Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Inocaulis divaricata Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Lichenalia alternata Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia (*Odontotrypa*) *alveata* Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia bistriata Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia (*Selenopora*) *circincta* Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia (*Pileotrypa*) *clivulata* Hall *see* Pileotrypa clivulata.	....	....	....	....	....	....	....	....	....	....	....	....
Lichenalia (*Selenopora*) *complexa* Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
**Lichenalia concentrica* Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Lichenalia conulata Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia (*Pileotrypa*) *denticulata* Hall *see* Pileotrypa denticulata.	....	....	....	....	....	....	....	....	....	....	....	....
Lichenalia geometrica Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia (*Lichenotrypa*) *longispina* Hall *see* Lichenatrypa longispina.	....	....	....	....	....	....	....	....	....	....	....	....
Lichenalia lunata (Rominger) Hall *see* Buscopora lunata.	....	....	....	....	....	....	....	....	....	....	....	....
**Lichenalia maculata* Hall Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Lichenalia ovata Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Lichenalia (?) (*Glossotrypa*) *paliformis* Hall *see* Glossotrypa paliformis.	....	....	....	....	....	....	....	....	....	....	....	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Lichenalia (*Pileotrypa*) *pyriformis* Hall Falls of the Ohio. (Hall).				×								
Lichenalia subcava Hall Falls of the Ohio.				×								
Lichenalia substellata Hall Falls of the Ohio.				×								
Lichenotrypa longispina Hall Falls of the Ohio (Ulrich).			×									
Limaria ramulosa Hall *sec* Coenites ramulosa.												
**Lithostrotian canadense* Castlenau, 8 Owen County, Putnam County, Orange County, Harrison County, Montgomery County								×				
Lithostrotian mamillatus Herzer, 8 Harrison County.								×				
**Lithostrotian proliferum* Hall, 8 Orange County, Owen County, Monroe County, Putnam County, Harrison County.						×	×	×				
Lophophyllum proliferum McChesney, 13 Throughout the coal measures.											×	
**Lyellia americana* E. & H., 11 Louisville (Davis).			×?									
Lyellia glabra Louisville (Davis).			×	×								
**Lyellia papillata* Rominger Louisville (Davis).			×									
**Lyellia parvituba* Rominger (Rominger).			×									
**Michelinia clappi* (Milne E.) Rominger Falls of the Ohio (Rominger).				×								
**Michelinia cylindrica* E. & H Falls of the Ohio (Davis).				×								
Michelinia eugeneae White, 13 Vermillion County (C. A. White).											×	
**Michelinia favistoidea* Billings Falls of the Ohio (Davis).				×								
**Michelinia insignis* Rominger Falls of the Ohio (Rominger).				×								
Monotrypella subquadrata Ulrich Osgood (Miller), (Ulrich).	×											
**Monticula approximata* Nicholson, 12 Madison.	×											
Monticulipora dalii E. & H., 8 Madison (Cornett).	×											
Monticulipora discoidea James (Hall), 12	×											
**Monticulipora fibrosa* Goldfuss North Vernon, Madison (Cornett).	×	×										
**Monticulipora filiasa* d'Orb. Richmond, Madison (James).	×											
**Monticulipora frondosa* d'Orb., 11 Madison.	×											
Monticulipora gracilis James (Hall)	×											
Monticulipora irregularis d'Orb. Hamilton County.	×											
**Monticulipora jamesi* Nich. Madison.	×											
**Monticulipora lycoperdon* Say Madison.	×											
Monticulipora mamulata d'Orb., 12	×											

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Monticulipora ortoni* Hall Madison.	×											
**Moticulipora papillata* McCoy Richmond.	×											
**Monticulipora petechialis* Nich. Richmond and Madison.	×											
**Monticulipora petropolitamus* Pander Madison.	×											
**Monticulipora pulchella* E. & H. Madison.	×											
Monticulipora (*Fistulipora*) *rustica* Ulrich (James).	×											
Monticulipora simulatrix Ulrich (James).	×											
**Monticulipora subpulchella* Nich. Richmond.	×											
Monticulipora tuberculata E. & H. (Hall), 12	×											
**Ophyma verrucosa* Louisville, Ky. (W. J. Davis).			×									
**Palaeophyllum divaricans* Nich., 11 Franklin County (Moore).	×											
Palaeacis cuneata M. & W., 11 Harrison County, Washington County, Spergen Hill.								×				
Paleacis enormis M. & W., 8 Rockford, Harrison County.								×				
**Paleacis obtusus* M. & W. Harrison County, Lanesville.							×	×				
**Phillipsastrea gigas* Owen Charlestown.				×								
**Phillipsastrea verneuili* E. & H. Madison, Jasper County.				×								
**Phillipsastrea yandelli* Rominger Charlestown, Falls of the Ohio (Rominger).				×								
**Plasmopora elegans* Louisville (Davis).			×									
**Plasmopora follis* Milne-Edwards Pauls Station, Charlestown Landing (Rominger).			×									
Plasmopora scita? Milne-Edwards Pauls Station (Rominger).			×									
Prismopora sparsipora Hall Falls of the Ohio (Ulrich).			×									
Prismopora triquetra Hall Falls of the Ohio (Hall).				×								
Protarea vetusta Hall, 11 Madison (W. S. T. Cornett), Richmond (Winchell & Schuchert).	×											
Ptychophyllum stokesi Louisville, Ky. (W. J. Davis).			×									
**Receptaculites elrodi* Miller, 18 Hartsville.				×								
**Receptaculites hemisphericus* Hall Grant County and Delphi.			×									
**Receptaculites sacculus* Hall 11			×									
**Receptaculites subturbinatus* Hall, 11 Hartsville.			×									
Romingeria umbillifera Falls of the Ohio (W. J. Davis).				×								
Sphenopterium cuneatum *see* Paleacis cuneatum.												

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Sphenopterium enorme M and N. *see* Paleacis enorme.												
**Stellipora antheloides* Hall Madison (Cornett).	×											
Stenopora fibrosa *see* Monticulipora fibrosa.												
Stenopora petropolitana Madison (W.S.T. Cornett).	×											
Stomatopora inflata Hall (Hippothoa inflata) Franklin County (Moore).	×											
Streptelasma (*Duncanella*) *borealis* Hall, 11 Waldron (Hall).			×									
Streptelasma coarctaum Hall, 12 Louisville Ky.				×								
**Streptelasma crassum* Hall Richmond.	×											
**Streptelasma corniculum* Hall, 11 Madison, Richmond (Rominger), Franklin County (Moore).	×		×									
Streptelasma inflatum Hall, 12 Falls of the Ohio.				×								
Streptelasma mammiferum Hall, 12 Falls of the Ohio.				×								
Streptelasma obliquius Foerste Hanover.		×										
Streptelasma papillatum Hall, 12 Falls of the Ohio.				×								
Streptelasma parvulum Madison (W. S. T. Cornett).	×											
**Streptelasma radicans* Hall, 11 Waldron (Hall), Franklin County (Moore).	×		×									
Streptelasma rusticum Bill. Richmond, (Winchell and Schuchert).	×											
Streptelasma simplex Hall, 12 Falls of the Ohio.				×								
**Streptelasma spongiaxis* Rominger Hartsville, Grant County, and St. Paul.			×									
Streptelasma tenue Hall, 12 Falls of the Ohio.				×								
**Striatopora cavernosa* Rominger Falls of the Ohio.				×								
Striatopora gorbyi Miller, 18 St. Paul			×									
Striatopora huronensis Rominger Falls of the Ohio (Davis).				×								
Striatopora linnaeana Billings, 11 Falls of the Ohio (Rominger).				×								
**Stromatopora concentrica* Goldfuss Madison (Cornett).		×		×								
**Stromatopora constellata* Hall Logansport, Falls of the Ohio.				×								
**Stromatopora densum* Nich., 12 Charlestown.				×								
**Stromatopora granulata* Nich. Falls of the Ohio.				×								
Stromatopora indianensis James Connersville (James).	×											
**Stromatopora mammillata* Nich. Clark County.				×								
**Stromatopora monticulifera* W. & M. *see* Coenostroma monticulifera.												
**Stromatopora nodulata* Nich., 11 Shelby, Clark and Cass Counties.				×								

	Ordovician	Silurian.		Devonian.		Carboniferous						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Stromatopora perforata* Nich. Cass County.				×								
**Stromatopora substriatella* Nich. Falls of the Ohio.				×								
**Stromatopora cylindrica* James Madison.												
Stromatopora tuberculata Nich., 11 Shelby County.				×								
**Strombodes mamillaris* D. D. Owen Charlestown (Rominger).			×									
**Strombodes pentagonus* Louisville, Ky. (W. J. Davis).			×									
Strombodes pygmoeus Louisville, Ky. (W. J. Davis).			×									
Strombodes separatus Ulrich Louisville, Ky. (Ulrich).		×										
**Strombodes striatus* d'Orb Indiana (Rominger).			×									
Syringopora attenuata, Rominger, 7 Montgomery County.									×			
Syringopora bouchardi Falls of the Ohio (W. J. Davis) (Rominger).				×								
**Syringopora hisingeri* Billings (Rominger).				×								
**Syringopora maclurii* Billings, 11 Falls of the Ohio.				×								
**Syringopora multattenuata* McChesney, 8 Washington County, Orange County, Harrison County, Monroe County, Greencastle.								×	×			
**Syringopora perelegans* Billings, 11 and 12 Falls of the Ohio (W. J. Davis).				×								
Syringopora ramulosa? Goldfuss, 8 Warsaw, Greencastle, Harrison County, Monroe County.								×	×			
**Syringopora tabulata* E. & H. Madison, and Falls of the Ohio (Rominger).				×								
Syringopora tenella Rominger (Rominger).			×									
**Syringopora tubiporoides* Y. & S. Madison (Cornett), Falls of the Ohio (W. J. Davis).				×								
Syringopora verticillata Goldfuss, 12				×								
**Tetradium fibratum* Safford Ripley County, Jennings County, Madison (Cornett).	×		×									
Thamniscus nanus Hall Falls of the Ohio (Ulrich).			×									
**Theca major* Rominger 12 Charlestown Landing (Rominger).			×									
Theca minor Rominger Louisville (Rominger).			×									
**Theca ramosa* Rominger Falls of the Ohio (Rominger).				×								
**Theca swindernana* Goldfuss Louisville (Davis).			×									
Thecostegitis bonchardi Milne E. *see* Syringopora bonchardi.												
**Zaphrentis bilateralis* Hall Madison (Cornett).		×										
Zaphrentis cassedayi Milne Ed. 15 Washington County.								×				
Zaphrentis celator Hall, 11 Waldron, Wabash County (James Hall).			×									

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Zaphrentis centralis E. and H., 8 Harrison County.								×				
Zaphrentis compressa Rominger, 12 Falls of the Ohio (W. J. Davis).				×								
Zaphrentis concava Hall, 12 Falls of the Ohio.				×								
Zaphrentis conigera Rominger, 11 Falls of the Ohio (Rominger).				×								
**Zaphrentis convoluta* Hall, 12 Falls of the Ohio.				×								
**Zaphrentis cornicula* Leseur Falls of the Ohio, Charlestown (Rominger), Madison.				×								
Zaphrentis cornucopia, 10 Putnam County and Monroe County.						×	×					
Zaphrentis (Amplexus) cruciforme Hall, 12 Falls of the Ohio.				×								
Zaphrentis cyathiformis Hall, 12 Falls of the Ohio.				×								
**Zaphrentis dalei* E. and H. Monroe County, Putnam County, Harrison County, Owen County, Greencastle, Crawfordsville.						×	×					
**Zaphrentis davisana* Miller Falls of the Ohio.				×								
Zaphrentis declinus Miller New Providence (Miller).							×					
Zaphrentis deformis Hall, 12 Charlestown.				×								
Zaphrentis duplicata Hall, 12 Falls of the Ohio.				×								
Zaphrentis elegans Hall, 12 Falls of the Ohio.				×								
Zaphrentis elliptica White, 8 Harrison County, Spergen Hill (R. P. Whitfield).								×				
Zaphrentis exiguum Billings Falls of the Ohio.				×								
Zaphrentis foliata Hall, 12 Falls of the Ohio.				×								
Zaphrentis gibsoni White Vermillion County (C. A. White).											×	
**Zaphrentis gigantia* Rafinesque, 11 Madison, Jennings County, Falls of the Ohio (Rominger).				×								
**Zaphrentis herzeri* Hall, 12 Charlestown.				×								
Zaphrentis nitida Hall, 12 Falls of the Ohio.				×								
Zaphrentis nodulosa Rominger Falls of the Ohio (W. J. Davis).				×								
Zaphrentis ovalis Hall, 12 Falls of the Ohio.				×								
Zaphrentis planima Hall, 12 Falls of the Ohio.				×								
Zaphrentis ponderosa Hall, 12 Falls of the Ohio.				×								
**Zaphrentis profunda* Hall, 12 Falls of the Ohio.				×								
**Zaphrentis prolifica* Billings Louisville, Ky. (W. J. Davis).				×								
Zaphrentis radicans Louisville, Ky. (W. J. Davis).			×									

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Zaphrentis rafinesque* E. & H., 11 Falls of the Ohio, Jennings County, Madison (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
Zaphrentis subcompressa Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
**Zaphrentis spinulifera* Hall, 8 Harrison County, Lanesville, Reelsville, Putnam County, Greencastle, and Washington County.	....	....	....	....	....	....	×	×	×	....	....	....
**Zaphrentis spinulosa* E. & H., 8 Spergen Hill (R. P. Whitfield), Montgomery County, Orange County, Bloomington and Harrison County.	....	....	....	....	....	....	....	×	×	....	....	....
Zaphrentis spira Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Zaphrentis spongiaxis Louisville, Ky. (W. J. Davis)	....	....	×	....	....	....	....	....	....	....	....	....
**Zaphrentis stokesi* E. & H. Grant County.	....	....	×	....	....	....	....	....	....	....	....	....
Zaphrentis terebrata Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Zaphrentis torta Hall, 12 Falls of the Ohio and Clark County.	....	....	....	×	....	....	....	....	....	....	....	....
Zaphrentis trisutura Hall, 12 Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Zaphrentis umbonata Rominger Louisville (Rominger).	....	....	×	....	....	....	....	....	....	....	....	....
**Zaphrentis ungula* Rominger, 12 Falls of the Ohio (Rominger).	....	....	....	×	....	....	....	....	....	....	....	....
Zaphrentis yandelli E. & H. Falls of the Ohio (W. J. Davis).	....	....	....	×	....	....	....	....	....	....	....	....
ECHINODERMATA.												
Abrotocrinus cymosus Miller, 16 Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
Actinocrinus abnormis Lyon *see* Megistocrinus abnormis.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus agassizi Troost, 8 Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Actinocrinus biturbinatus, 8 *see* Bactocrinus biturbinatus.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus bronteus Hall, 8 Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Actinocrinus calyculus Hall, 8 *see* Batocrinus calyculus.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus cassedayi Lyon, 8 *see* Germaeocrinus cassedayi.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus coreyi Lyon & Casseday Washington County (L. & C.)	....	....	....	....	....	....	×	....	....	....	....	....
Actinocrinus gibsoni M. & G. Indian Creek near Crawfordsville (Miller & Gurley).	....	....	....	....	....	....	×	....	....	....	....	....
Actinocrinus gouldi *see* Dorycrinus gouldi.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus grandis Miller, 16 Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
Actinocrinus indianensis L. & C., 8 *see* Batocrinus indianensis.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus kentuckensis Schumard *see* Gemalocrinus cornigerus.	....	....	....	....	....	....	....	....	....	....	....	....
Actinocrinus lagunculus *see* Batocrinus laguncculus.	....	....	....	....	....	....	....	....	....	....	....	....

	Ordovician	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Actinocrinus lowii* Hall, 8 Hindostan, Monroe County, Harrison County.							×					
Actinocrinus magnifica Troost, 8 Harrison County.							×					
Actinocrinus meekii Lyon *see* Macrostylocrinus meeki.												
Actinocrinus nashvillae Troost, 8 Harri·on County.							×					
**Actinocrinus pernodosus* Hall Crawfordsville.							×					
Actinocrinus ramulosus Hall, 8 *see* Eretmocrinus ramulosus.												
Actinocrinus unicornis O. & S. *see* Dorycrinus unicornis.												
Actinocrinus wachsmuthi, 10 *see* Batocrinus wachsmuthi.												
Aethocystites sculptus Miller, 18 St. Paul.			×									
Agaricocrinus americanus Rominger, 15 Washington County (Gorby).								×				
Agaricocrinus calyculus Hall, 15 Washington County (Gorby).								×				
Agaricocrinus gorbyi Miller, 17 Montgomery County.							×					
Agaricocrinus indianensis Miller, 17 Washington County.							×					
Agaricocrinus nodosus M. & W. Washington County.							×					
Agaricocrinus pentagonus Hall Washington County.							×					
Agaricocrynus splendens Miller & Gurley, 16 Crawfordsville (Miller & Gurley).							×					
Agaricocrinus springeri White, 16 and 11 Crawfordsville.							×					
Agaricocrinus tuberosus Troost, 8 Harrison County.							×					
**Agaricocrinus wortheni* Hall, 8 Washington County.							×					
**Agassizocrinus conicus* Owen & Schmard, 8 Harrison County, Orange County (Collett).									×			
Agassizocrinus conoideus, 8 Harrison County (Collett).									×			
**Agassizocrinus dactyliformis* Troost, 8 Harrison County (Collett).									×			
Agassizocrinus pentagonis Worthen, 8 Reelsville, Putnam County, Orange County, Harrison County.								×	×			
Agelacrinus faberi Miller Osgood and Versailles (M. & F.).	×											
Agelacrinus squamosus Meek & Worthen, 16 Crawfordsville and Harrison County.							×					
Agaricocrinus splendens Miller Crawfordsville.							×					
**Agricocrinus wortheni* Hall Harrison County, Washington County.							×					
Allocrinus benedicti Miller, 17 St. Paul.			×									
**Alloprosallocrinus conicus* Cassaday & Lyon Lanesville and Monroe County.								×				
Ampheristocrinus typus Hall, 11 Waldron.			×									
**Amphoracrinus vininalis?* Hall Fountain County.							×					

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Ancyrocrinus bulbosus* Hall Falls of the Ohio.				×								
Ancyrocrinus spinosus Hall Clark County.				×								
Archaeocidaris agassizi Hall, 8 Harrison County.							×	×				
**Archaeocidaris keokuk* Hall Bono.							×					
**Archaeocidaris norwoodi* Hall, 8 Harrison County.							×					
**Archaeocidaris wortheni* Hall, 8 Harrison County and Orange County.							×	×				
Barycrinus elrodi Miller & Gurley Spergen Hill (Miller & Gurley).								×				
Barycrinus formosus M. & G. Washington County (Miller & Gurley).							×					
**Barycrinus herculeus* M. & W., 16 Crawfordsville, Harrison County.							×					
Barycrinus hoveyi Hall, 8 (*Cyathocrinus hoveyi*), 16 Harrison County, Crawfordsville (Meek & Worthen).							×					
**Barycrinus magister* Hall. (Cyathocrinus magister,) 8 Harrison County, Spergen Hill & Lanesviile (R. P. Whitfield).							×					
**Barycrinus pentagonus* Worthen, 8 Harrison County and Crawfordsville.							×					
Barycrinus princeps Miller, 16 Crawfordsville.							×					
Barycrinus sculptiles Hall. (Cyathocrinus sculptiles) Clark County.				×								
Barycrinus spectabilis M. & W., 8 Harrison County.							×					
**Barycrinus stellatus* Troost Crawfordsv lle.							×					
Barycrinus stellifer Miller, 18 Harrison County.							×					
Barycrinus tumidus Hall Monroe County.							×					
Barycrinus washingtonensis Miller & Gurley, 27 Washington County (Miller & Gurley).							×					
**Batocrinus aequalis* Hall Smithville.							×					
Batocrinus agnatus Miller, 17 Montgomery County.							×					
Batocrinus arcula Miller & Gurley Washington County (Miller & Gurley).								×				
Batocrinus asteriscus M. & W., 8 Harrison County.								×				
**Batocrinus biturbinatus* Hall. (Actinocrinus biturbinatus) Spergen Hill, Monroe and Harrison Counties (R. P, Whitfield).							×	×				
Batocrinus cantonensis Miller, 16 Canton.							×					
**Batocrinus caroli* Hall Lanesville.								×				
Batocrinus cistula Miller & Gurley Lanesville (Miller & Gurley).								×				
Batocrinus crawfordsvillensis Miller, 17 Crawfordsville.							×					
Batocrinus calyculus Hall, 15 Washington County.								×				

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Batocrinus decorus Miller, 17 Spergen Hill.								×				
Batocrinus decrepitus, 18 Montgomery County.								×				
Batocrinus facetus Miller, 16 Canton.							×					
**Batocrinus icosidactylus* Casseday, 8 Spergen Hill, Monroe County, Harrison County (R. P. Whitfield), Greencastle, Washington County.								×				
**Batocrinus indianaensis* Casseday & Lyon (Actinocrinus indianaensis), 16 Crawfordsville, Harrison County, Monroe County and Washington County.							×					
**Batocrinus inaequalis* Hall, 8 Harrison County.								×				
**Batocrinus irregularis* Casseday, 8 Spergen Hill, Monroe County, Washington County, Harrison County.								×				
Batocrinus jucundus Miller & Gurley, 16 Crawfordsville (Miller & Gurley).							×					
**Batocrinus lagunculus* Hall (Actinocrinus lagunculus) Washington and Monroe counties.								×				
Batocrinus marinus Miller & Gurley, 16 Crawfordsville (Miller & Gurley).							×					
Batocrinus montgomeryensis Worthen Crawfordsville (A. H. Worthen).							×					
**Batocrinus mundulus* (?) Hall Washington County.							×	×				
Batocrinus pileus Miller & Gurley Washington County (Miller & Gurley).								×				
Batocrinus pistillum M. & W., 15 Washington County and Edwardsville.							×					
**Batocrinus plano-discus* Hall, 15 Washington County, Bono.							?	×				
**Batocrinus pyriformis* Schumard Washington County.							×					
Batocrinus sacculus Miller & Gurley Washington County (Miller & Gurley).								×				
Batocrinus spergensis Miller, 17 Spergen Hill.								×				
Batocrinus wachsmuthi White (Actinocrinus wachsmuthi), 16 Crawfordsville.							×					
**Batocrinus whitii* Wachs. & Spr. Bono (Wachs. & Springer).							×					
Calceocrinus? bradleyi Meek *see* Deltacrinus bradleyi.												
Calceocrinus indianensis Miller, 17 St. Paul and Jefferson County.			×									
Calceocrinus nodosus Hall *see* Deltacrinus nodosus.												
Calceocrinus stigmatus Hall, 11 *see* Deltacrinus stigmatus.												
Callicrinus beachleri W. & S St. Paul (Wachs & Spr).			×									
Caryocrinus ellipticus Miller & Gurley Osgood (Miller & Gurley).			×									
**Caryocrinus ornatus* Say Madison, Jennings County, Utica, Clark County and Ripley County.		×	×	×								
**Catillocrinus bradleyi* M. & W., 8 Harrison County, Crawfordsville.						×	×					

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Catillocrinus tennesseae Troost, 15 Washington County.								×				
Catillocrinus wachsmuthi M. & W. (Synbathocrinus wachsmuthi) 8 Harrison County.							×					
Codaster americanus Shumard Falls of the Ohio (Shumard).				×								
Codaster attenuatus Lyon Falls of the Ohio (Lyon).				×								
Codaster pentalobus Hall, 11 Waldron.			×									
Codaster pulchellus Miller & Dyer, 11 Waldron (Miller & Dyer).			×									
Codaster pyramidatus Shumard Falls of the Ohio (Shumard).				×								
Cyathocrinus (*Poteriocrinus*) *aemulus* Hall, 11 Waldron.			×									
**Cyathocrinus arboreus* M. & W., 16 Crawfordsville.							×					
Cyathocrinus benedicti Miller, 17 Hartsville.			×									
Cyathocrinus crawfordsvillensis Miller Crawfordsville (Miller).							×					
Cyathocrinus decadactylus L. & C. Washington County, Montgomery County (Lyon & Cassady).							×					
Cyathocrinus gorbyi Miller, 18 Gosport, Owen County.							×					
Cyathocrinus gurleyi Miller, 17 Washington County.							×					
Cyathocrinus harrisi Miller, 16 Crawfordsville (Miller).							×					
Cyathocrinus hexadactylus Lyon & Cassaday *see* Vasocrinus lyoni.												
Cyathocrinus hoveyi Hall *see* Barycrinus hoveyi.												
Cyathocrinus inspiratus? Lyon, 16 Crawfordsville.							×					
Cyathocrinus lyoni Hall *see* Vasocrinus lyoni.												
Cyathocrinus magister Hall, 8 *see* Barycrinus magister.												
**Cyathocrinus multibrachiatus* L. & C., 16 and 11 Washington County and Crawfordsville.							×	×				
Cyathocrinus nucleus Hall, 11 Waldron (James Hall).			×									
Cyathocrinus opinus Miller, 16 Crawfordsville.							×					
Cyathocrinus polyxo Hall, 11 Waldron (James Hall).			×									
Cyathocrinus(?) poterium M. & W., 16 Crawfordsville (Meek & Worthen).							×					
Cyathocrinus sculptilis Lyon *see* Barycrinus sculptilis.												
Cyathocrinus signatus M. & G. Washington County (Miller & Gurley).							×					
Cyathocrinus tumidulus M. & G. Indian Creek, near Crawfordsville (Miller & Gurley).							×					
Cyathocrinus waldronensis Miller & Gurley Hartsville (Miller & Gurley).			×									
Cyclicocrinus canaliculatus Miller, 18 St. Paul.			×									

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Cyclicocrinus (?) *indianensis* Mill. & G. St. Paul (Miller & Gurley).			×									
Cyphocrinus gorbyi Miller, 18 St. Paul.			×									
Dendrocrinus ancilla Hall, 11 Waldron.			×									
**Dendrocrinus polydactylus* Shumard (Homocrinus polydactylus) Richmond, Madison and Franklin Counties (Shumard).	×											
Dichocrinus constrictus M. & W., 8 Monroe County, Harrison County and Washington County.								×				
Dichocrinus cornigerus Shumard, 8 Harrison County.									×			
Dichocrinus dichotomus Hall, 15 Washington County.								×				
**Dichocrinus expansus* M. & W. Harrison County.							×					
**Dichocrinus ficus* Cassaday & Lyon, 16 Harrison County, Montgomery County, Crawfordsville (C. & L.).							×	×				
Dichocrinus lineatus M. & W., 8 Harrison County.							×	×				
Dichocrinus pisum Meek & Worthen, 8 Harrison County.								×				
Dichocrinus polydactylus Cassaday & Lyon, 16 Montgomery County (Cassaday & Lyon).							×					
Dichocrinus sculptus C. & L., 10 Monroe County.							×					
Dichocrinus sexlobatus Shumard, 8 *see* Talarocrinus sexlobatus.												
**Dichocrinus simplex* Shumard, Harrison County, Bloomington, Washington County, Monroe County, Spergen Hill (Whitfield).							×	×				
Dichocrinus spinifera, 10 Reelsville, Putnam County.									×			
Dichocrinus striatus O. & S., 8 Harrison County.							×					
Dichocrinus ulrichi Miller, 16 Bono.							×					
Dolatocrinus amplus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus aplatus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus approximatus (Miller & Gurley) Louisville, Ky. (Miller & Gurley).				×								
Dolatocrinus argutus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus bellulus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus bellarugosus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus bradleyi (Calceocrinus bradleyi), 16 Crawfordsville (Meek).							×					
Dolatocrinus bulbaceus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus caelatus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus charlestownensis Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus corporosus Miller & Gurley Charlestown (Miller & Gurley).				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Dolatocrinus exornatus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus grandis Miller & Gurley Louisville, Ky. (Miller & Gurley).				×								
Dolatocrinus greenei Miller & Gurley Louisville, Ky. (Miller & Gurley).				×								
Dolatocrinus indianensis Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus lacus Lyon Falls of the Ohio and Silver Creek, Clark County (Lyon).				×								
Dolatocrinus lineolatus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus magnificus Miller & Gurley Falls of the Ohio (Miller & Gurley).				×								
Dolatocrinus marshi Lyon Falls of the Ohio and Charlestown.				×								
Dolatocrinus neglectus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus nodosus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus ornatus var. *asperatus* (Miller & Gurley) Charlestown (Miller & Gurley).				×								
Dolatocrinus pulchellus (Miller & Gurley) Charlestown (Miller & Gurley).				×								
Dolatocrinus sacculus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus salebrosus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus spinosus Miller & Gurley Charlestown (Miller & Gurley).				×								
Dolatocrinus stellifer Miller & Gurley Louisville, Ky. (Miller & Gurley).				×								
Dolatocrinus stigmatus Hall (Calceocrinus stigmatus) Waldron (J. Hall).			×									
**Dorycrinus gouldi* Hall (Actinocrinus gouldi) Monroe County.								×				
**Dorycrinus unicornus* O. & S. (Actinocrinus unicornus) Washington County.								×				
Ectenocrinus simplex Hall Madison.	×											
Elentherocrinus cassedayi Y. & S. Clark County.				×								
Emperocrinus indianensis Miller & Gurley St. Paul (Miller & Gurley).			×									
Eretmocrinus adultus Wachs. & Spr. Canton and Edwardsville (Wachs. & Spr.).							×					
Eretmocrinus intermedius Wachs. & Spr. Bono (Wachs. & Spr.).							×					
Eretmocrinus originarius Wachs. & Spr. Bono (Wach. & Springer).				×								
**Eretmocrinus ramulosus* Hall (Actinocrinus ramulosus) Monroe and Harrison Counties.							×					
Eretmocrinus praegravis Miller, 18 Washington County.							×					
**Eucalyptocrinus caelatus* Hall, 11 Utica, Clark County, Waldron (James Hall).			×									
Eucalyptocrinus constrictus Hall, 11 Waldron.			×									

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Eucalyptocrinus crassus* Hall, 11 Miami County, Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Eucalyptocrinus ellipticus Miller, 17 Hartsville.	....	....	×	....	....	....	....	....	....	....	....	....
**Eucalyptocrinus elrodi* Miller, 17 Hartsville, Waldron (Gorby).	....	....	×	....	....	....	....	....	....	....	....	....
**Eucalyptocrinus ovalis* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
**Eucalyptocrinus splendidus* Troost Charlestown.	....	....	×	....	....	....	....	....	....	....	....	....
Eucalyptocrinus subglobosus Miller, 17 Hartsville.	....	....	×	....	....	....	....	....	....	....	....	....
Eucalyptocrinus tuberculatus Miller & Dyer Waldron (Miller & Dyer).	....	....	×	....	....	....	....	....	....	....	....	....
Eupachycrinus boydi (Meek & Worthen), 8 Harrison County.	....	....	....	....	....	....	....	....	×	....	....	....
Evactinopora grandis M. & W., 8	....	....	....	....	....	....	×	....	....	....	....	....
Evactinopora sexradiata M. & W., 8 Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Forbesocrinus meeki Hall, 8 *see* Taxocrinus meeki.	....	....	....	....	....	....	....	....	....	....	....	....
Forbesocrinus ramulosus Hall, 8 *see* Taxocrinus ramulosus.	....	....	....	....	....	....	....	....	....	....	....	....
Forbesocrinus shumardanus Hall, 8 *see* Taxocrinus shumardanus.	....	....	....	....	....	....	....	....	....	....	....	....
Forbesocrinus speciosus Miller, 16 Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
Forbesocrinus washingtonensis Miller & Gurley Washington County (Miller & Gurley).	....	....	....	....	....	....	×	....	....	....	....	....
Forbesocrinus wortheni Hall, 16 Spergen Hill, Harrison County, Crawfordsville (Whitfield).	....	....	....	....	....	....	×	×	×	....	....	....
Gazacrinus inornatus Miller, 18 St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
Gennaeocrinus cornigerus L. & C. (Actinocrinus kentuckensis) Clark County.	....	....	....	×	....	....	....	....	....	....	....	....
Gilbertsocrinus greeni Miller & Gurley Charlestown (Miller & Gurley).	....	....	....	×	....	....	....	....	....	....	....	....
Gilbertsocrinus indianensis M. & G. Charlestown (Miller & Gurley).	....	....	....	×	....	....	....	....	....	....	....	....
**Glyptaster inornatus* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Glyptaster occidentalis Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Glyptaster occidentalis* var. *crebescens* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Glyptocrinus baeri Meek *see* Xenocrinus baeri.	....	....	....	....	....	....	....	....	....	....	....	....
Glyptocrinus carleyi Hall, 11 *see* Mariacrinus carleyi.	....	....	....	....	....	....	....	....	....	....	....	....
**Glyptocrinus decadactylus* Hall Madison (?) (Meek.).	×	....	....	....	....	....	....	....	....	....	....	....
**Glyptocrinus dyeri* Meek Madison.	×	....	....	....	....	....	....	....	....	....	....	....
Goniasteroidocrinus lyonanus M. & G. Indian Creek, near Crawfordsville (Miller & Gurley).	....	....	....	....	....	....	×	....	....	....	....	....
**Goniasteroidocrinus tuberosus* L. & C., 17 Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Granatocrinus curtis Shumard, 15 Washington County.	....	....	....	....	....	....	....	×	....	....	....	....

	Ordovician	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Granatocrinus ficus, 10 Hindostan, Monroe County.	....	....	....	....	....	....	×	....	....	....	....	....
Granatocrinus granulosus M. & W., 10 Hindostan, Monroe County.	....	....	....	....	....	....	×	....	....	....	....	....
**Granatocrinus norwoodi* Owen & Shumard Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
Graphiocrinus wachsmuthi Meek & Worthen (Scaphiocrinus wachsmuthi) Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
**Heterocrinus heterodactylus* Hall Ripley County.	×	....	....	....	....	....	....	....	....	....	....	....
Heterocrinus subcrassus *see* Iocrinus subcrassus.	....	....	....	....	....	....	....	....	....	....	....	....
**Holocystites abnormis* Hall Madison.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites adipatus Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites affinis Miller & Faber Madison (Miller & Faber).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites amplus Miller, 18 Madison (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites asper Miller & Gurley Madison (Miller & Gurley).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites brauni Miller Jefferson County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites benedicti Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites baculus Miller Ripley County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites colletti Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites commodus Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
**Holocystites cylindricus* Hall Madison.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites dyeri Miller Ripley County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites elegans Miller Jefferson County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites globosus Miller Jefferson County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites gorbyi Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites indianensis Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites madisonensis Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites ornatissimus Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites ornatus Miller Jefferson County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
**Holocystites ovatus* Hall Madison.	....	....	×	....	....	....	....	....	....	....	....	....
**Holocystites papulosis* Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites parvulus Miller, 17 Jefferson County.	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites perlongus Miller Ripley County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites plenus Miller Jefferson County (Miller).	....	....	×	....	....	....	....	....	....	....	....	....
Holocystites pustulosus Miller Waldron (Miller).	....	....	×	....	....	....	....	....	....	....	....	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia	Mansfield.	Coal Measures.	Drift.
Holocystites rotundus Miller Ripley County (Miller).			×									
Holocystites scitulus Miller, 17 Jefferson County.			×									
Holocystites spangleri Miller, 17 Jefferson County.			×									
Holocystites sphæroidalis M. & G. Madison (Miller & Gurley).			×									
Holocystites splendens M. & G. Madison (Miller & Gurley).			×									
Holocystites subovatus Miller, 17 Jefferson County.			×									
Holocystites subrotundus Miller Ripley County (Miller).			×									
Holocystites tumidus Miller Ripley County (Miller).			×									
Holocystites turbinatus Miller Osgood and Ripley County (Miller).			×									
Holocystites ventricosus Miller Ripley County (Miller).			×									
Holocystites wetherbyi Miller Ripley County (Miller).			×									
Holocystites wykoffi Miller, 17 Jefferson County.			×									
Homocrinus polydactylus *see* Dendrocrinus polydactylus.												
Hydreionocrinus armiger M. & W., 8 (Zeacrinus armiger) Harrison County.									×			
Hydreionocrinus mucrospinus McChesney (Zeacrinus mucrospinus) Rush Creek (McChesney).											×	
Hyptiocrinus typus W. & S. St. Paul (Wachs. & Spr.).			×									
Ichthyocrinus clarkensis Miller & Gurley Clark County (Miller & Gurley).							×?					
**Ichthyocrinus simplex* Hall Waldron.			×									
Ichthyocrinus spinosulus Miller & Gurley Clark County (Miller & Gurley).				×								
Ichthyocrinus subangularis Hall, 11 Waldron (James Hall).			×									
Ichthyocrinus pusillus (?) Hall Waldron (J. Hall).			×									
Idiocrinus elongatus W. & S. St. Paul (Wachs. & Spr.).			×									
Idiocrinus subcrassus Meek & Worthen Heterocrinus subcrassus (W. S. T. Cornett).	×											
Idiocrinus ventricosus W. & S. St. Paul (Wachs. & Spr.).			×									
Indianocrinus punctatus M. & G. St. Paul (Miller & Gurley).			×									
Lampterocrinus parvus Hall, 11 Waldron.			×									
Lecanocrinus greenei Miller & Gurley Louisville, Ky. (Miller & Gurley).			×									
**Lecanocrinus pusillus* Hall, 11 Waldron (James Hall).			×									
Lepodocrinus moorei Meek Richmond (Meek).	×											
Lepidesthes colletti White, 16 Crawfordsville, Washington County, Salem and Harrison Counties (C. A. White).							×	×				
Lepidesthes coreyi M. & W., 16 Crawfordsville (Meek & Worthen).							×					

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Lichenocrinus dyeri* Hall Ripley County.	×	....	....	....	....	....	....	....	....	....	....	....
Lichenocrinus pattersoni Miller Versailles (?) (Miller).	×	....	....	....	....	....	....	....	....	....	....	....
Lichenocrinus tuberculatus Miller Ripley County, three miles south of Osgood (Miller).	×	....	....	....	....	....	....	....	....	....	....	....
Lyriocrinus melissa Hall, 11 (Rhodocrinus melissa) (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
**Macrostylocrinus fasciatus* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Macrostylocrinus indianensis M. & G. St. Paul (Miller & Gurley).	....	....	×	....	....	....	....	....	....	....	....	....
Macrostylocrinus meeki Lyon (Actinocrinus meeki) Utica, Clark County.	....	....	×	....	....	....	....	....	....	....	....	....
**Macrostylocrinus ornatus* Hall Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Macrostylocrinus striatus Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Macrostylocrinus striatus* var. *granulosus* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Mariacrinus aureatus Miller, 17 St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
Mariacrinus carleyi Hall (Glyptocrinus carleyi) Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Mariacrinus granulosus Miller, 17 St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
**Mariacrinus obconicus* Hall Waldron and Clark County.	....	....	×	....	....	....	....	....	....	....	....	....
**Marsupiocrinus tennesseensis* Roemer Delphi.	....	....	×	....	....	....	....	....	....	....	....	....
Megistocrinus abnormis Lyon (Actinocrinus abnormis) Clark County and Falls of the Ohio (Lyon).	....	....	....	×	....	....	....	....	....	....	....	....
Megistocrinus expansus Miller & Gurley Louisville, Ky. (Miller & Gurley).	....	....	....	×	....	....	....	....	....	....	....	....
Megistocrinus hemisphericus M. & G. Clark County (Miller & Gurley).	....	....	....	×	....	....	....	....	....	....	....	....
Megistocrinus knappi (Lyon & Cassaday) Falls of the Ohio (Lyon).	....	....	....	×	....	....	....	....	....	....	....	....
Megistocrinus ornatus Miller & Gurley Clark County (Miller & Gurley).	....	....	....	×	....	....	....	....	....	....	....	....
**Megistocrinus rugosus* L. & C. Clark County, Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Megistocrinus spinosulus Lyon Falls of the Ohio (Lyon).	....	....	....	×	....	....	....	....	....	....	....	....
Melocrinus equalis Miller, 18 St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
Melocrinus obconicus Hall, 11 Utica, Clark County, Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Melocrinus oblongus W. & S. St. Paul (Wachs. & Spr.).	....	....	×	....	....	....	....	....	....	....	....	....
Melocrinus parvus W. & S. St. Paul (Wachs. & Spr.).	....	....	×	....	....	....	....	....	....	....	....	....
Melonites indianensis M. & G. Greenville, Harrison Co. (Miller & Gurley.)	....	....	....	....	....	....	....	×	....	....	....	....
**Melonites multiporis* Owen & Norwood, 8 Harrison County.	....	....	....	....	....	....	×	×	....	....	....	....
Nucleocrinus angularis Lyon (Olivanites angularis) Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Nucleocrinus greenei M. & G. Louisville, Ky. (Miller & Gurley).				×								
**Nucleocrinus verneuili* Troost (Olivanites verneuili) Falls of the Ohio.				×								
Nucleocrinus venustus M. & G. Louisville, Ky. (Miller & Gurley).				×								
**Oligoporus danae* M. & W. Lawrence County.							×					
**Oligoporus nobilis* M. & W., 8 Harrison County and Greencastle.							×					
Olivanites angularis Lyon *see* Nucleocrinus angularis.												
Olivanites verneuili Troost *see* Nucleocrinus verneuili.												
Ollacrinus tuberosus Lyon & Cass., 16 Crawfordsville.							×					
Onychaster flexilis M. & W., 16 Crawfordsville, Harrison County, Meek & Worthen.							×					
Onychocrinus cantonensis Miller, 16 Canton.							×					
**Onychocrinus exculptus* (Lyon & Casseday), 16 and 11 Washington County and Montgomery County (L. & C.), Crawfordsville.							×	×				
Onychocrinus parvus M & G. Shoals. Martin County (Miller & Gurley).									×			
**Onychocrinus ramulosus* L. & C., 16 and 11 Crawfordsville.							×					
Onychocrinus ulrichi Miller & Gurley, 16 Crawfordsville (Miller & Gurley).							×					
Onychocrinus whitfieldi Hall, 8 Harrison County.								×				
Palaeaster crawfordsvillensis Miller Crawfordsville (Miller).							×					
Palaeaster speciosa M. & D Richmond (James).	×											
Paleaster wykoffi M. & G. Madison (Miller & Gurley).	×											
**Pentremites burlingtonensis* M. & W., 8 Harrison County, Hindostan, Monroe County							×					
**Pentremites calycinus* Lyon Orange County.								×				
**Pentremites cervinus* Hall Orange County.								×				
**Pentremites cherokeus* Troost Orange County.									×			
**Pentremites conoideus* Hall, 12 and 10 Owen County, Montgomery County, Harrison County, Washington County, Greencastle, Spergen Hill, Bloomington, Jackson Co.							×	×				
Pentremites globosus Say, 8 Harrison County.									×			
**Pentremites godoni* DeFrance, 8 and 10 Reelsville, Putnam County, Harrison County, Owen County, Clay County, Orange County, Dubois, Crawford.?									×			
Pentremites grosvenori Shumard *see* Troostocrinus grosvenori.												
**Pentremites koninckianus* Hall, 12 Monroe County, Greencastle, Spergen Hill, Bloomington, Washington County and Harrison County (Hall).								×				

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Pentremites laterniformis* Owen & Shumard, 8.. Harrison County and Bedford.	....	....	....	....	....	....	....	×	....	....	....	....
Pentremites lineatus Troost, 8....... see Troostocrinus lineatus.	....	....	....	....	....	....	....	....	....	....	....	....
Pentremites longicostalis Hall, 15....... Washington County.	....	....	....	....	....	....	....	×	....	....	....	....
**Pentremites obesus* Lyon, 8....... Owen County, Clay County, Montgomery County, Harrison County.	....	....	....	....	....	....	....	×	×	....	....	....
Pentremites obliquatus, 8....... see Tricollocrinus obliquatus.	....	....	....	....	....	....	....	....	....	....	....	....
Pentremites pyramidatus Hall, 8....... Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
**Pentremites pyriformis* Say, 8 and 10....... Orange County, Reelsville, Putnam County, Montgomery County, Harrison County, Down Hill, Crawford County.	....	....	....	....	....	....	....	....	×	....	....	....
Pentremites quadrilateralis? Hall? 8....... Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
Pentremites reinwardti Troost....... see Troostocrinus reinwardti.	....	....	....	....	....	....	....	....	....	....	....	....
Pentremites robustus Lyon....... Orange County.	....	....	....	....	....	....	....	....	×	....	....	....
Pentremites subconoideus M. & W., 8....... Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
**Pentremites sulcatus* Roemer, 8....... Harrison County and Orange County.	....	....	....	....	....	....	....	×	×	....	....	....
**Pentremites symmetricus* Hall, 8....... Harrison County and Orange County.	....	....	....	....	....	....	....	....	×	....	....	....
Pentremites varsouvienesis, 8....... see Tricoelocrinus varsouvienesis.	....	....	....	....	....	....	....	....	....	....	....	....
Pentremites woodmani M. & W., 8....... see Tricoelicrinus woodmani.	....	....	....	....	....	....	....	....	....	....	....	....
Pentremites wortheni Hall, 8....... Harrison County, Owen County, Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Pisocrinus baccula Miller & Gurley....... St. Paul (Miller & Gurley).	....	....	×	....	....	....	....	....	....	....	....	....
Pisocrinus benedicti Miller....... Marion, Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
Pisocrinus campana Miller, 17....... Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
**Pisocrinus gemmiformis* Miller....... Wabash County, Madison and Osgood.	....	....	×	....	....	....	....	....	....	....	....	....
**Pisocrinus globosus* Ringueberg....... St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
Pisocrinus gorbyi Miller, 17....... Wabash County and Marion.	....	....	×	....	....	....	....	....	....	....	....	....
**Platycrinus bonœnsis* White....... Bono, Lawrence County (C. A. White).	....	....	....	....	....	....	×	....	....	....	....	....
**Platycrinus discordens* Owen & Shumard....... Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
**Platycrinus halli* Shumard....... Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
**Platycrinus hemisphericus* M. & W., 16 and 11... Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
**Platycrinus leai* Lyon....... Jeffersonville.	....	....	....	×	....	....	....	....	....	....	....	....
Platycrinus lodensis M. & W., 15....... Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Platycrinus planus Owen & Shumard, 15....... Harrison County, Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
Platycrinus saffordi Troost, 8....... Monroe County, Greencastle.	....	....	....	....	....	....	....	×	....	....	....	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Platycrinus sarae* Hall Lanesville.								×				
**Platycrinus siluricus* Hall, 11 Waldron.			×									
Platycrinus subspinosus? Hall, 8 Harrison County.									×			
**Platycrinus yandelli* Owen & Shumard, 7 Crawfordsville (Collett).							×					
Poteriocrinus amoenus Miller, 17 Montgomery.							×					
Poteriocrinus arcanus Miller, 16 Washington County.							×					
Poteriocrinus bisselli Worthen, 8 Harrison County and Orange County.									×			
Poteriocrinus? calyx Hall, 11 Waldron.			×									
Poteriocrinus cantonensis Miller, 16 Canton.							×					
Poteriocrinus casei Meek Richmond (Meek).	×											
Poteriocrinus chesterensis Meek & Worthen, 8 Harrison County.									×			
Poteriocrinus circumtextus M. & G. Crawfordsville (Miller & Gurley).							×					
Poteriocrinus concinnus M. & W., 16 Crawfordsville (Meek & Worthen).							×					
**Poteriocrinus coreyi* Worthen, 16 Crawfordsville.							×					
Poteriocrinus coryphaeus Miller, 17 Montgomery County.							×					
Poteriocrinus crawfordsvillensis Miller & Gurley, 16 Crawfordsville (Miller & Gurley).							×					
Poteriocrinus davisanus Miller Deputy (Miller).				×								
Poteriocrinus depressus M. & W., 16 Crawfordsville.							×					
Poteriocrinus divaricatus Hall, 15 Washington County.								×				
Poteriocrinus gibsoni White, 16 Crawfordsville.							×					
Poteriocrinus grandis W. & S., 16 Crawfordsville.							×					
Poteriocrinus granilineus Miller & Gurley, 16 Crawfordsville (Miller & Gurley).							×					
Poteriocrinus gurleyi White, 16 Crawfordsville.							×					
**Poteriocrinus hoveyi* Worthen Crawfordsville.							×					
**Poteriocrinus indianensis* M. & W., 16 Harrison County and Crawfordsville.							×					
Poteriocrinus missouriensis Shumard, 8 Harrison County.								×				
Poteriocrinus nettelrothanus Miller Deputy (Miller).				×								
Poteriocrinus nodobrachiatus H., 16 Crawfordsville.							×					
**Poteriocrinus pencilliformis* Worthen Crawfordsville.							×					
Poteriocrinus (Dendocrinus) polydactylus (Shumard) *see* Homocrinus polydactylus.												
Poteriocrinus robustus H., 16 Crawfordsville.							×					

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Poteriocrinus subaequalis W. & S., 16. Crawfordsville.							×					
Poteriocrinus subramosus Miller, 16. Crawfordsville.							×					
Poteriocrinus unicus H., 16. Crawfordsville.							×					
Poteriocrinus versus Miller, 16. Crawfordsville.							×					
Protaster granuliferus Meek Moore's Hill (Meek).	×											
Protaster gregarius M. & W., 16. Crawfordsville.							×					
Rhodocrinus benedicti Miller, 18. Harrison County.							×					
Rhodocrinus (*Lyriocrinus*) *melissa* Hall. *see* Lyriocrinus melissa.												
Sabatocrinus swallovi Hall, 8. Harrison County.						×						
Saccocrinus benedicti Miller, 18. St. Paul.			×									
**Saccocrinus christyi* Hall, 11. Utica, Clark County, Waldron (Jas. Hall).			×									
Saccocrinus gorbyi Miller. 17. Decatur County.			×									
Saccocrinus howardi Miller, 18. St. Paul.			×									
Saccocrinus umbrosus M. & G. St. Paul (Miller & Gurley).			×									
**Scaphiocrinus aequalis* Hall, 8. Crawfordsville and Harrison County.							×					
Scaphiocrinus arrosus M. & G. Washington County (Miller & Gurley).							×					
Scaphiocrinus bellus Miller, 16. Bono.							×					
Scaphiocrinus bonoensis Miller, 16. Bono.							×					
**Scaphiocrinus coreyi*. Crawfordsville (Meek & Worthen).							×					
**Scaphiocrinus decadactylus* Meek & Worthen, 8. Harrison County.							×					
**Scaphiocrinus depressus* M. & W. Crawfordsville (Meek & Worthen).							×					
Scaphiocrinus disparilis Miller, 16. Crawfordsville.							×					
Scaphiocrinus equalis Hall Crawfordsville (Meek & Worthen).							×					
**Scaphiocrinus gibsoni* White, 10. Bono, Lawrence County, Crawfordsville.							×					
**Scaphiocrinus gurleyi* White, 10. Crawfordsville (C. A. White).							×					
Scaphiocrinus granuliferus Miller, 16. Crawfordsville.							×					
Scaphiocrinus graphicus Miller, 16. Crawfordsville.							×					
Scaphiocrinus lacunosus Miller, 16. Bono.							×					
Scaphiocrinus lyoni Miller. Montgomery County.							×					
Scaphiocrinus maniformis Miller, 18. Washington County.							×					
Scaphiocrinus manus (Miller & Gurley) 16. Crawfordsville (Miller & Gurley).							×					
Scaphiocrinus martinensis M. & G. Shoals, Martin County (Miller & Gurley).									×			

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Scaphiocrinus nodobranchiatus Hall, 7 Crawfordsville.							×					
Scaphiocrinus porrectus Miller ? Crawfordsville.			×									
Scaphiocrinus praemorsus Miller, 16 Washington County.							×					
Scaphiocrinus repertus Miller, 16 Bono.							×					
**Scaphiocrinus robustus* Hall, 17 Crawfordsville (Hall).							×					
Scaphiocrinus unicus Hall, 8 Crawfordsville, Harrison County.							×					
Scaphiocrinus wachsmuthi *see* Graphiocrinus wachsmuthi.												
Steganocrinus benedicti Miller, 18 Canton, Washington County.							×					
Steganocrinus spergensis M. & G. Spergen Hill (Miller & Gurley).								×				
Stenaster grandis Meek Richmond (Meek).	×											
Stephanocrinus cornetti Miller, 18 Madison.			×									
Stephanocrinus elongatus Miller, 17 Madison.			×									
Stephanocrinus gemmiformis Hall, 11 Waldron (James Hall).			×									
Stephanocrinus hammelli Miller, 17 Madison.			×									
Stephanocrinus obpyramidalis Miller, 17 Madison.			×									
Stephanocrinus osgoodensis Miller 17 Osgood and Madison (Miller).			×									
Stereocrinus indianensis M. & G. Charlestown (Miller & Gurley).			×									
Stribalocystites gorbyi Miller, 18 St. Paul.			×									
Stribalocystites tumidus Miller, 17 St. Paul.			×									
Stribalocystites spheroidalis M. & G. St. Paul (Miller & Gurley).			×									
Strotocrinus perumbrosus Hall, 8 Harrison County.								×				
Synbathocrinus dentatus, O. & S., 8 Harrison County.								×				
Synbathocrinus oweni Hall Rockford (James Hall).						×						
Synbathocrinus? robustus Shumard, 8 Harrison County.							×	×				
**Synbathocrinus swallovi* Hall, 8 Harrison County, Spergen Hill (Whitfield).							×	×				
Synbathocrinus wachsmuthi M. & W., 8 *see* Catillocrinus wachsmuthi.												
Synbathocrinus wortheni Hall, 8 Harrison County.							×					
Talarocrinus cornigerus Shumard Harrison County.									×			
**Talarocrinus sexlobatus* Shumard (Dichocrinus sexlobatus) Harrison County and Crawford County.								×	×			
Taxocrinus crawfordsvillenis M. & G. Crawfordsville (Miller & Gurley).							×					
**Taxiocrinus meeki* Hall (Forbesocrinus meeki) Harrison County.							×					

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield	Coal Measures	Drift.
**Taxiocrinus multibrachiatus* L. & C., 16. Crawfordsville							×					
**Taxiocrinus multplicatus* var. *colletti*. Crawfordsville.							×					
**Taxiocrinus ramulosus* Hall (Forbesocrinus ramulosus, 8. Harrison County.							×					
Taxiocrinus shumardanus Hall (Forbesocrinus shumardanus), 8. Harrison County.							×					
Taxiocrinus shumardi Hall, 8. Harrison County.							×					
Taxiocrinus ungula Miller & Gurley. Crawfordsville (Miller & Gurley).							×					
Taxiocrinus subovatus Miller, 16. Canton.							×					
Taxiocrinus splendens M. & G. Crawfordsville (Miller & Gurley).							×					
Tricoelocrinus obliquatus Roemer (Pentremites obliquatus). Spergen Hill, Monroe and Harrison County (R. P. Whitfield).								×				
Tricoelocrinus varsouviensis Worthen (Pentremites varsouviensis). Greencastle.								×				
Tricoelocrinus woodmani M. & W. (Pentremites woodmani), 15. Washington County.								×				
Troostocrinus grosvenori Shumard (Pentremites grosvenori). Spergen Hill.								×				
Troostocrinus lineatus Shumard (Pentremites lineatus), 8. Harrison County.							×					
Troostocrinus nitidulus Miller & Gurley, 16. Lanesville.							×					
Troostocrinus reinwardti Troost (Pentremites reinwardti). Utica, Clark County.												
**Vasocrinus lyoni* Hall (Cyathocrinus hexadactylus), 16. Crawfordsville (J. Hall, Lyon & Casseday).							×					
Vasocrinus sculptus Lyon. Falls of the Ohio (Lyon).				×								
Xenocrinus baeri (Glyptocrinus baeri). Richmond (Meek).	×											
Zeacrinus armiger Meek & Worthen, 8. see Hydreionocrinus armiger.												
Zeacrinus bellulus M. & G. Shoals, Martin County (Miller & Gurley).									×			
Zeacrinus doverensis M. & G. Dover Hill (Miller & Gurley).							×					
Zeacrinus dubius Miller, 16. Bono.							×					
Zeacrinus intermedius Hall, 8. Harrison County.								×				
**Zeacrinus maniformis* Y. & S. Harrison County.								×				
Zeacrinus mucrospinus McChesney. see Hydreionocrinus mucrospinus.												
Zeacrinus ramosus Hall, 8. Harrison County.							×					
Zeacrinus salemensis M. & G. Salem (Miller & Gurley).							×					

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield	Coal Measures.	Drift.
Zeacrinus troostianus M. & W., 8. Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Zophocrinus howardi Miller, 17. St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
VERMES.												
Cornulites elevata Cozzens. (Cozzens).	....	....	....	×	....	....	....	....	....	....	....	....
**Cornulites proprius* Hall, 11. Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Ortonia minuta. Madison (W. S. T. Cornett).	×	....	....	....	....	....	....	....	....	....	....	....
Spirorbis annulatus Hall, 12. Spergen Hill, Bloomington, Harrison and Washington Counties.	....	....	....	....	....	....	....	×	....	....	....	....
Spirorbis annulatus var. *nodulosus*. Spergen Hill (Hall).	....	....	....	....	....	....	....	×	....	....	....	....
Spirorbis carbonarius Dawson. Newberg.	....	....	....	....	....	....	....	....	....	....	×	....
Spirorbis inornatus Hall, 11. Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Spirorbis nodulosus Hall, 12. Spergen Hill and Lanesville.	....	....	....	....	....	....	....	×	....	....	....	....
MOLLUSCOIDEA.												
BRYOZOA.												
Archimedes arctica (Ethridge).	....	....	....	....	....	....	....	×?	....	....	....	....
**Archimedes laxus* Hall, 11 and 8. Harrison County.	....	....	....	....	....	....	....	...	×	....	....	....
Archimedes meekanus Hall. Orange County and Crawfordsville.	....	...	....	....	....	....	....	×	×	....	....	....
**Archimedes owenanus* Hall, 16. Greencastle, Montgomery County, Crawfordsville, Owen County and Harrison County.	....	....	....	....	....	....	×	×	×	....	....	....
**Archimedes reversus* Hall, 16. Crawfordsville, Harrison County and Washington County.	....	....	....	....	....	....	×	×	....	....	....	....
**Archimedes swallovanus* Hall, 8. Harrison County.	....	....	....	....	....	....	....	×	×	....	....	....
Archimedes wortheni Hall, 8. Harrison County, Orange County and Washington County.	....	....	....	....	....	....	....	×	×	....	....	....
Beatricia nodulata Billings. Richmond (James).	×	....	....	....	....	....	....	....	....	....	....	....
Beatricia nodulosae Bill. Connersville (James).	×	....	....	....	....	....	....	....	....	....	....	....
Buscopora dentata Ulrich. *see* Buscopora lunata, Rominger.	....	....	....	....	....	....	....	....	....	....	....	....
Buscopora lunata Rominger (Buscopora dentata) Ulrich. Falls of the Ohio (Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
Callopora cervicornis Hall, 11. Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Callopora ? diversa Hall, 11. Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
Callopora elegantula Hall, 11. Osgood (Ulrich), Waldron.	....	....	×	....	....	....	....	....	....	....	....	....

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Callopora exsul Hall, 11 Waldron (Jas. Hall).			×									
Callopora singularis Hall, 11 Waldron (Jas. Hall).			×									
Ceramopora agellus Hall, 11 Waldron.			×									
Ceramopora confluens Hall, 11 Waldron.			×									
Ceramopora ? (Lichenalia) *explanata* H. 11 Waldron.			×									
Ceramopora labecula Hall, 11 Waldron.			×									
Ceramopora (*Paleschara?*) *nothus* H., 11 Waldron.			×									
Ceramopora raripora Hall, 11 Waldron.			×									
Clathropora frondosa Hall Osgood, Hanover (Foerste).		×										
Cleodictya gloriosa Hall, 16 Crawfordsville.							×					
Cleodictya? mohri Hall, 16 Crawfordsville.							×					
Clenopora semireducta Hall Falls of the Ohio (Ulrich).			×									
Coscinatrypa cribriformis var. *carinata* Hall Falls of the Ohio (Hall).				×								
**Coscinium asterium* Prout., 8 Harrison County and Washington County.							×	×				
Coscinium elegans Prout., 8 Washington County and Harrison County.							×	×				
Coscinium escharense Prout., 8 Spergen Hill (R. P. Whitfield).								×				
**Coscinium escharoides* Prout., 8 Harrison County, Edwardsville and Washington County.							×	×				
Coscinium keyserlingi Prout., 15 Washington County.								×				
**Coscinium michelinia* Prout., 8 Harrison County and Monroe County.							×	×				
Coscinium tuberculatum Prout., 8 Harrison County.								×				
**Coscinium wortheni* Prout., 8 Harrison County and Monroe County.							×	×				
**Cycloporo discordea* Prout Lanesville.								×				
Cyclopora polymorpha Prout., 8 Harrison County.									×			
Cystopora geniculata Hall Falls of the Ohio (Hall).				×								
Dictyophyton cattiliforme Whitf. *see* Phrogmodictya cattiliforme.												
Dictyophyton cylindricum Whitf., 16 Crawfordsville (Whitfield).							×					
Discotrypa devonica Ulrich Falls of the Ohio (Ulrich).				×								
Ectenodictya excentrica Hall, 16 Crawfordsville.							×					
Eridopora minima Ulrich Falls of the Ohio (Ulrich).				×								
Escharopora (*Ptilodyctia*) *angusta* Hall, 11 Waldron.			×									
Evactinopora grandis M. & W., 8 Harrison County.							×					

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Evactinopora sexradiata M. & W., 8							×					
Harrison County.												
Fenestella (*Unitrypa*) *acanlis* Hall												
see Unyeriypa acanlis.												
Fenestella (*Unitrypa*) *acanlis* var. *inclinis* H.				×								
Falls of the Ohio.												
Fenestella (*Polypora*) *aculeata* Hall				×								
Falls of the Ohio (Hall).												
Fenestella (*Polypora*) *adnata* Hall												
see Polypora adnata.												
Fenestella acmea Hall, 11			×									
Waldron (James Hall).												
Fenestella ambigua Hall, 11												
see Loculipora ambigua.												
Fenestella bellistriata Hall, 11			×									
Waldron.												
Fenestella bifurca Ulrich				×								
Falls of the Ohio (A. E. Ulrich).												
Fenestella bigeneris Ulrich				×								
Falls of the Ohio (A. E. Ulrich).												
Fenestella biimbricata Hall				×								
Falls of the Ohio (Hall).												
Fenestella biserrulata Hall				×								
Falls of the Ohio (Hall).												
Fenestella (*Polypora*) *celsipora* var. *minima* Hall.												
see Polypora celsipora var minima.												
Fenestella conferta Hall, 11			×									
Waldron.												
Fenestella confertipora Hall				×								
Falls of the Ohio (Hall).												
Fenestella (*Hemitrypa*) *cribrosa* Hall				×								
Falls of the Ohio (Hall).												
Fenestella (*Polypora*) *cultellata* Hall												
see Polypora cultellata.												
Fenestella cultrata Hall				×								
Falls of the Ohio (Hall).												
Fenestella curvijunctura Hall				×								
Falls of the Ohio (Hall).												
**Fenestella delicata* Meek							×					
Edwardsville.												
Fenestella depressa Hall				×								
Falls of the Ohio (Hall).												
Fenestella equalis Hall				×								
Falls of the Ohio (Hall).												
Fenestella (*Unitrypa*) *fastigata* Hall												
see Unitrypa fastigata.												
Fenestella hemitrypa Prout								×				
Spergen Hill (R. P. Whitfield).												
Fenestella interrupta Hall				×								
Falls of the Ohio (Hall).												
Fenestella (*Polypora*) *laevistriata* Hall												
see Polypora laevistriata.												
Fenestella (*Polypora*) *laevinodata* Hall												
see Polypora laevinodata.												
Fenestella latijunctura Hall				×								
Falls of the Ohio (Hall).												
Fenestella lunulata Hall				×								
Falls of the Ohio (Hall).												
**Fenestella parvulipora* Hall, 11			×									
Wabash County and Waldron (James Hall).												
Fenestella patellifera Ulrich				×								
Falls of the Ohio (A. E. Ulrich).												
Fenestella perplexa Hall				×								
Falls of the Ohio (Hall).												

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Fenestella permarginata Hall Falls of the Ohio (Hall).				×								
Fenestella pertenuis Hall, 11 Falls of the Ohio.				×								
Fenestella plumosa Prout. *see* Hemytrypa plumosa.												
Fenestella (*Unitrypa*) *projecta* Hall Falls of the Ohio (Hall).				×								
Fenestella prolixa Hall, 11 Waldron.			×									
Fenestella prisca Madison.		×										
Fenestella pulchella Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Fenestella punctostriata Hall, 11 Waldron (James Hall).			×									
Fenestella (*Polypora*) *quadrangularis* Hall Falls of the Ohio (Hall).				×								
Fenestella sculptilis Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Fenestella semirotunda Hall Falls of the Ohio (Hall).				×								
Fenestella serrata Hall Falls of the Ohio (Hall).				×								
Fenestella shumardi Prout., 8 Harrison County.							×	×				
Fenestella singularitas Hall Falls of the Ohio (Hall).				×								
Fenestella stellata Hall Falls of the Ohio (Hall).				×								
Fenestella (*Unytrypa*) *stipata* Hall *see* Unytrypa stipata.												
Fenestella (*Polypora*) *striatopora* Hall *see* Polypora striatopora.												
Fenestella (*Polypora*) *submutans* Hall *see* Polypora submutans.												
Fenestella tantulus Hall, 11 Waldron (Jas. Hall).			×									
Fenestella (*Unytrypa*) *tegulata* Hall *see* Unitrypa tegulata.												
Fenestella tenella Hall Falls of the Ohio (Hall).				×								
Fenestella (*Unytrypa*) *transversa* Hall Falls of the Ohio (Hall).				×								
Fenestella variopora Hall Falls of the Ohio (Hall).				×								
Fenestella verrucosa Hall Falls of the Ohio (Hall).				×								
Fistulipora halli Rominger Waldron (C. Rominger).			×									
Fistulipora neglecta Rominger *see* Lichenalia concentrica.												
Fistulipora normalis Ulrich Falls of the Ohio (Ulrich).								×				
Fistulipora spergensis Rominger Spergen Hill (Rominger).								×				
Hiderella canadensis Hall Falls of the Ohio (Hall).				×								
Hemitrypa plumosa Prout., 15 (Fenestella plumosa) Washington County.								×				
Idiotrypa parasitica Ulrich Osgood (Ulrich).								×				
Labechia montifera Ulrich Madison (James).	×											

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Lichenalia concentrica* Hall (Fistulipora neglecta) Waldron (Rominger).	....	....	×	....	....	....	....	....	....	....	....	....
Lichenalia concentrica var. *maculata* Hall Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Lichenalia concentrica var. *parvula* Hall Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Lichenotrypa cavernosa Ulrich Falls of the Ohio (Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
Lyrodictya romingeri Hall Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Orthopora rhombifera Hall (Trematopora orthopora rhombifera). Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Paleschara incrassata Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Paleschara maculata Hall, 11 Waldron and Wabash County (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Paleschara offula Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Paleschara? (*Chetetes?*) *sphaerion* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Paleschara tuberculata Prout Spergen Hill (R. P. Whitfield).	....	....	....	....	....	....	....	×	....	....	....	....
Phractopora cristata Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Phractopora cristata var. *lineata* Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Phaenopora multifida (*Van Cleve*) Hall Hanover (Foerste).	....	×	....	....	....	....	....	....	....	....	....	....
Phragmodictya catillaformis Whitfield, 16 Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Phragmodictya lineata Hall, 16 Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Phragmodictya patilliformis, 16 Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Physospongia dawsoni Whitf. (*Uphantaenia dawsoni*) Crawfordsville (Whitfield).	....	....	....	....	....	....	×	....	....	....	....	....
Pileotrypa clivulata Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Pileotrypa denticulata Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Polypora adnata Hall (*Fenestella* (*Polypora*) *adnata*) Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Polypora blandida Ulrich Falls of the Ohio (Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
Polypora celsipora var. *minima* Hall. (*Fenestella* (*Polypora*) *celsifrora* var. *minima*) Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Polypora cultellata Hall (*Fenestella* (*Polypora*) *cultellata*) Falls of the Ohio (Ulrich).	....	....	×	....	....	....	....	....	....	....	....	....
Polypora halliana Prout, 8 Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
Polypora laevistriata Hall (*Fenestella* (*P.*) *laevistriata*) Falls of the Ohio (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Polypora laevinodata Hall (*Fenestella* (*Polypora*) *laevinodata*) Falls of the Ohio (Ulrich).	....	....	×	....	....	....	....	....	....	....	....	....
**Polypora strangula* White Dubois County.	....	....	....	....	....	....	....	....	....	....	×	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Polypora submarginata* Meek. Dubois County.	....	....	....	....	....	....	....	....	....	....	×	....
Polypora submutans Hall (*Fenestella* (*P.*) *submutans*) Falls of the Ohio (Ulrich).	....	....	×	....	....	....	....	....	....	....	....	....
Polypora quadrangularis Hall (*Fenestella* (*Polypora*) *quadrangularis*) Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Polypora transversa Ulrich Falls of the Ohio (A. E Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
Prismopora serrata Meek (*Stictopora serrata*), 8. Harrison County.	....	....	....	....	....	....	×	×	....	....	....	....
Ptilodictya carbonaria, 8. *see* Stictopora carbonaria.	....	....	....	....	....	....	....	....	....	....	....	....
Ptilodictya falciformis Nich., 12	×	....	....	....	....	....	....	....	....	....	....	....
Ptilopora prouti Hall, 8. Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Rhinopora verrucosa Hall. Hanover (Foerste).	....	×	....	....	....	....	....	....	....	....	....	....
Sagenella elegans Hall Wabash County and Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Scalaripora scalariformis Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Scalaripora subconcava Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Semicoscinium infraporosa Ulrich Falls of the Ohio (A. E. Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
Semicoscinium obliquatam Ulrich Falls of the Ohio (A. E. Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
Semicoscinium rhomboideum Prout Falls of the Ohio (Prout).	....	....	....	×	....	....	....	....	....	....	....	....
Semicoscinium tuberculatum Prout Falls of the Ohio (Prout).	....	....	....	×	....	....	....	....	....	....	....	....
Stictopora carbonaria Meek, 8 Harrison County.	....	....	....	....	....	....	×	....	....	....	....	....
Stictopora gilberti (Meek) Ulrich Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Stictopora orbipora Hall, 11 Waldron (Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Stictopora ovatipora Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Stictopora serrati Meek, 8. *see* prismopora serrati.	....	....	....	....	....	....	....	....	....	....	....	....
Stictopora similis Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Stictopora vermicula Hall Falls of the Ohio (Hall).	....	....	....	×	....	....	....	....	....	....	....	....
**Stomatopora auloporoides* Nich. Richmond.	×	....	....	....	....	....	....	....	....	....	....	....
**Stomatopora frondosa* James Madison.	×	....	....	....	....	....	....	....	....	....	....	....
**Stomatopora inflata* Hall Madison.	×	....	....	....	....	....	....	....	....	....	....	....
Stromatocerium richmondense Miller Richmond (Miller).	×	....	....	....	....	....	....	....	....	....	....	....
**Subretepora angulata* Hall Delaware County.	....	....	×	....	....	....	....	....	....	....	....	....
Synocladia biserialis Swallow, 13 Throughout the coal measures (C. A. White) Harrison County.	....	....	....	....	....	....	....	×	×	....	×	....
Thamniscus niagarensis Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....

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Trematella annulata (*Trematopora* (*Trematella*) *annulata*) Falls of the Ohio (Hall).				×								
Trematopora (*Trematella*) *annulata* Hall *see* Trematella annulata.												
Trematopora (*Trematella*) *arborea* Hall Falls of the Ohio (Hall).				×								
Trematopora (*Chaetetes*) *crebripora* Hall, 11 Waldron.			×									
Trematopora echinata Hall, 11 Waldron (James Hall).			×									
Trematopora spiculata Hall, 11 Waldron (James Hall).			×									
Trematopora granulifera Hall, 11 Waldron and Wabash County (James Hall).			×									
Trematopora halli Ulrich Waldron (Ulrich).			×									
Trematopora hirsuta Hall Clark County.				×								
Trematopora infrequens Hall, 11 Waldron (James Hall).			×									
Trematopora minuta Hall, 11 Waldron (James Hall).			×									
Trematopora osculum Hall, 11 Waldron (James Hall).			×									
Trematopora (*Orthopora*) *regularis* Hall Falls of the Ohio (Hall).				×								
Trematopora (*Orthopora*) *rhombifera* Hall *see* Orthopora rhombifera.												
Trematopora spiculata Hall Waldron (James Hall).			×									
Trematopora varia Hall, 11 Waldron and Wabash County (James Hall).			×									
Trematopora? (*Trachypora?*) *macropora* H., 11 Waldron.			×									
Trematopora variolata Hall, 11 Waldron (James Hall).			×									
Trematopora whitfieldi Ulrich Waldron (Ulrich).			×									
Unytrypa acaulis (*Fenestella* (*Unytrypa*) *acaulis*). Falls of the Ohio (Hall).				×								
Unytrypa conferta Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Unytrypa fastigata Hall (*Fenestella* (*Unytrypa*) *fastigata*) Falls of the Ohio (Hall).				×								
Unytrypa retrosa Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Unytrypa stipata Hall (*Fenestella* (U.) *stipata*) Falls of the Ohio (Hall).				×								
Unytrypa tegulata Hall (*Fenestella* (U.) *tegulata*). Falls of the Ohio (Hall).				×								
Uphantaenia dawsoni Whitf. *see* Physiospongia dawsoni.												
†BRACHIOPODA.												
Ambocœlia umbonata Conrad, 11 Shelby County.				×								
Anastrophia internascens Hall, 11 Waldron (James Hall).			×									
**Anastrophia verneuili* Hall Waldron.			×									

†The author regrets that he has been unable to adopt in the present list the revised nomenclature of the *Brachiopoda* used by Mr. Schuchert in Bull. 87 U. S. G. S., owing to the appearance of that work after the present paper was in the hands of the printer.

	Ordovician	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Athyris ambigua Sowerby, 8 and 10. Orange County, Owen County, Putnam County, Montgomery County.								×	×			
Athyris densa H. & C. Washington County (Hall & Clark).								×				
**Athyris hirsuta* Hall, 12. Greencastle, Washington County, Bloomington, Harrison and Monroe County.								×	×			
Athyris incrassata Hall, 8. Harrison County.								×				
**Athyris lamellosa* L'Eveillé, 8. Harrison County, Washington County, Greencastle and Monroe County, Crawfordsville (Hall & Clark).							×	×				
Athyris planosulcatus Phillips, 8. Warren County.								×				
Athyris royissi Leveille, 8. Harrison County, Crawfordsville and Orange County.							×	×	×			
**Athyris subquadrata* Hall, 8. Harrison County.								×				
**Athyris spiriferoides* Eaton. Utica, Clark County and Charlestown.			×	×								
**Athyris sublamellosa* Hall, 8. Greencastle, Harrison County, Reelsville and Putnam County.							×		×			
**Athyris subtilita* Hall, 13. Vanderburgh County, Harrison County, Orange County, Owen County, Montgomery County, Clay County (C. A. White).									×		×	
**Athyris trinuclea* Hall (*Terebratula trimuclea*), 12. Greencastle, Spergen Hill, Monroe County, Harrison County, Washington County, Bloomington (Hall).								×				
Athyris vittata Hall, 11. Falls of the Ohio. Charlestown Ldg. (Nettleroth).				×								
**Atrypa aspera* Schlotheim. Falls of the Ohio, Charlestown, Clark County (Nettleroth).			×	×								
Atrypa cuspidata see Triplesia cuspidata.												
Atrypa ellipsoida Nettleroth. Falls of the Ohio (Nettleroth).				×								
Atrypa marginalis Dalman. Hanover (Foerste).		×										
Atrypa marginalis var. *multi-striata* Foerste. Hanover (Foerste).		×										
**Atrypa reticularis* Linn., 11. Henry County, Utica, Clark County, Madison, Falls of the Ohio, Wabash County, Charlestown, Carroll County, Waldron (Hall).		×	×	×								
Atrypa latacorrugata Foerste. Ripley County (Foerste).		×										
Atrypa reticularis var. *niagarensis* Nettleroth. Clark County (Nettleroth).			×									
**Camarophoria subtrigona* Meek & Worthen. Harrison County and Crawfordsville.							×					
Camarospira eucharis Hall. Cass County (Hall & Clark).				×								
Camarotoechia carolina Hall. Falls of the Ohio (Hall & Clark).				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Chonetes acutiradiatus Hall Falls of the Ohio, Utica and Clark County (James Hall) (Nettleroth).				×								
Chonetes coronata Conr. Scott County, New Albany (Borden).				×	×							
**Chonetes fisheri* N. & P. Montgomery County.					×							
**Chonetes granuliferus* Owen, 8 Harrison County and Vigo County.									×		×	
**Chonetes lepidus* Hall New Albany, Scott County, Lexington and, Jennings County (Whitfield).					×							
Chonetes logani Norwood & Pratten, 8 Harrison County.						×	×					
Chonetes mesolobus N. & P. Clay County and Vanderburg County.											×	
Chonetes nana de Verneuil Falls of the Ohio (Norwood & Pratten).				×								
Chonetes nova-scotia Hall, 11 Waldron (James Hall).			×									
**Chonetes planumbonus* M. & W., 8 Clark County, Crawfordsville, Washington and Harrison Counties.						×	×	×				
Chonetes subquadrata Nettleroth Falls of the Ohio (Nettleroth).				×								
Chonetes undulatus, Hall, 11 Waldron (James Hall).			×									
Chonetes verneuilianus N. & P., 13 Every county in coal measures (C. A. White).											×	
**Chonetes yandellanus* Hall, 11 Falls of the Ohio, Utica and Clark County (Nettleroth).			×									
Cleiothyris hirsuta Hall Washington County (Hall & Clark).								×				
Coelospira disparilis Hall, 11 Waldron (Hall).			×									
Crania bordeni Hall & Whitf. Watson (Nettleroth).				×								
Crania greenii Miller, 18 Falls of the Ohio.				×								
**Crania laelia* Richmond and Versailles (M. & F.).	×											
Crania modesta White and St. John, 13 Vermillion and Sullivan Counties (C. A. White).											×	
Crania reticularis Miller Brookville (Miller).	×											
**Crania setifera* Hall, 11 Waldron (James Hall).			×									
Crania siluriana Hall, 11 Waldron (James Hall).			×									
Crania spinigera Hall, 11 Waldron.			×									
Cryptonella leos Hall Clark County.				×								
Cryptonella ovalis Miller, 17 Bunker Hill.				×								
Cyrtina crassa Hall Falls of the Ohio, Utica (Nettleroth).				×								
**Cyrtina hamiltonensis* Hall Clark County (Nettleroth).				×								
Cyrtina hamiltoniae var. *recta* Hall Falls of the Ohio (Nettleroth.)				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Derbya crassa Meek & Hayden (H. crassus), 8 and 13									×		×?	
Harrison County.												
Derbya ruginosa Hall & Clarke							×					
New Providence (Hall).												
Delthyris acutilirata Conr.												
see Orthis acutilirata.												
**Discina ampla* Hall				×								
Charlestown.												
**Discina convexa* Shumard, 13											×	
Dubois County.												
Discina doria Hall				×								
Clark County (Nettleroth).												
**Discina grandis* Hall				×								
Watson and Charlestown (Nettleroth).												
Discina seneca Hall				×								
Charlestown.												
**Discina nitida* Phillips, 8											×	
Harrison County? (Collett), (C. A. White).												
Eichwaldia reticulata Hall, 11			×									
Waldron (James Hall).												
Eumetria verneuiliana Hall (Retzia verneuiliana) 12								×				
Harrison County, Bloomington and Spergen Hill (Hall), Greencastle.												
**Eumetria vera* Hall, 8								×	×			
Harrison, Montgomery and Orange Counties.												
Hemipronites crassus Meek & Hayden, 13												
see Derbya crassa.												
Hemipronites crenistriatum Phillips												
see Streptorhynchus crenistriatum.												
Hemipronites subtenta Conr.												
see Streptorhynchus subtentum.												
Hemipronites sulcata de Verneuil												
see Streptorhynchus sulcatum.												
**Leiorhynchus limitare* Vanuxem 6					×							
Scott County.												
**Leiorhynchus quadricostatum* Vanuxem, 8				×	×	×						
Harrison County, New Albany, Jennings County, Scott County (Whitfield) (Nettleroth).												
**Leptaena sericea* Sowerby? (Foerste)	×	×										
Ripley County, Madison, Richmond, etc. (Cornett).												
Leptaena transversalis? Wahlenberg, 6	×											
Madison.												
Leptaena transversalis var. *elegantula* Foerste		×										
Hanover (Foerste).												
Lingula crawfordsvillensis Gurley							×					
Crawfordsville (Gurley).												
Lingula gibbosa Hall, 11			×									
Waldron.												
Lingula indianensis M. & G.							×					
Crawfordsville (Miller & Gurley).												
**Lingula spatulata* Vanuxem				×								
Jennings County and New Albany.												
Lingula subspatulata M. & W.			×									
Clark County.												
Lingula triangulata Nettleroth				×								
Falls of the Ohio (Nettleroth).												
Lingula umbonata Cox, 13											×	
Vermillion County (C. A. White).												
Lingula vanhorni Miller	×											
Versailles and Ripley County (Miller).												

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Meekella striatocostata Cox, 13 Vigo County.											×	
**Meristella harkinsi* Hall Charlestown.				×								
**Meristella nasuta* Hall Falls of the Ohio (Nettleroth).				×								
Meristella rectirostra Hall, 11 Waldron			×									
Meristella umbonata? Billings Hanover (Foerste).		×										
**Meristella unisulcata* Conrad Utica, Clark County and Falls of the Ohio (Nettleroth).			×									
Meristina maria Hall, 11 Waldron (James Hall) (Nettleroth).			×									
**Meristina nitida* Hall, 1[illegible] Waldron and Wabash County (James Hall).			×									
Nucleospira concinna Hall Utica, Clark County and Falls of the Ohio (Nettleroth).			×									
Nucleospira indianensis Miller, 17 Bunker Hill.				×								
**Nucleospira pisiformis* Hall, 11 Waldron (James Hall).			×									
**Orthis* (*Platystr.*) *acutilirata* Conr., 10 Richmond, Madison, and Clarksville (Miller & White).	×											
Orthis benedicti Miller, 17 Wabash County and Hartsville).			×									
Orthis biforata Schlotheim Hanover, Madison and Osgood (Foerste).		×	×									
**Orthis biloba* Linn., 11 Wabash County.			×									
**Orthis borealis* Billings Madison.	×											
Orthis calligrama Dalman Hanover (Foerste).		×										
Orthis (*Orthis dinorthis*) *calligrama* Dalman Hanover (Foerste).		×										
**Orthis centrosa* Miller Madison.	×											
**Orthis dentata* Pander Madison and Ripley County.	×											
**Orthis dubia* Hall, 12 Harrison County, Spergen Hill, Bloomington, Greencastle, and Washington County (Hall)							×	×				
**Orthis ella* Hall Madison.	×											
**Orthis elegantula* Dalman, 11 Waldron (James Hall), Hanover (Foerste), Wabash County.		×	×									
**Orthis emacerata* Hall Madison and Franklin County (Moore).	×											
Orthis emacrerata var. *multisecta*, 6 Madison.	×											
**Orthis fissicosta* Hall Madison and Lawrenceburg (Miller).	×											
Orthis goodwini Nettleroth Falls of the Ohio (Nettleroth).				×								
**Orthis hybrida* Sowerby, 11 Waldron (James Hall).			×									
Orthis insculpta Hall, 6 Madison, Franklin County (Moore).	×											

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Orthis iowensis Hall, 10. Charlestown.				×								
* *Orthis keokuk* Hall (O. umbraculum). Jackson County, Smithville and Spergen Hill (Hall).							×	×				
* *Orthis laticosta* Meek Madison.	×											
* *Orthis leucosia* Hall Charlestown.				×								
* *Orthis livia* Billings. Utica, Clark County (Nettleroth).				×								
* *Orthis lynx* Eichwald Ri ley County, Madison and Franklin County.	×											
Orthis michelina L'Eveille, 8. Washington County, Harrison County, Scott County (Borden).						×	×					
Orthis occasus Hall Rockford (James Hall).					×							
Orthis occidentalis Hall, 10. Richmond, Madison, Ripley, Madison and Franklin County (Moore).	×											
Orthis pecosi Marcou, 13. Vermillion County (C. A. White).											×	
Orthis penelope Hall Scott County (Borden).						×						
Orthis plicata var. *vanuxemi* *see* Spirifer vanuxemi.												
* *Orthis plicatella* Hall Madison.	×											
* *Orthis resupinata* Martin Montgomery County.									×			
* *Orthis retrossa* Salter ? Madison (Meek).	×											
Orthis subnodosa Hall, 11 Waldron (Hall).			×									
* *Orthis sinuata* Hall Ripley County, Madison, Versailles and Weisberg.	×											
* *Orthis subquadrata* Hall, 10. Richmond, Versailles and Madison (Miller), Franklin County (Moore), Richmond and Madison (Meek).	×											
* *Orthis testudinaria* Dalman Newton County and Ripley County.	×		×?									
* *Orthis tricenaria* Conr. Madison.	×											
Orthis umbraculum DeKoninck *see* Orthis keokuk.												
Orthis vanuxemi Hall Clark County (Hall).				×								
Pentamerella arata Hall Clark County, Falls of the Ohio (Hall).				×								
Pentamerella papillionensis Hall Falls of the Ohio (Nettleroth).				×								
Pentamerella thusnelda Nettleroth Falls of the Ohio (Nettleroth).				×								
Pentamerus aratus *see* Pentamerella aratus Conrad.												
Pentamerus chicagoensis Winch. & Marcy Carroll County.			×									
Pentamerus colletti Miller, 17. Kokomo.			×									

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield	Coal Measures	Drift.
Pentamerus fornicatus var., Hall, 11 Waldron.			×									
**Pentamerus galeatus* Dalman Huntington.			×									
**Pentamerus knighti* Sowerby Carroll County and Clark County. (Nettleroth).			×	×								
Pentamerus l queatus Conr. Del hi (Conrad).			×									
Pentamerus nysius Hall. 11 Charleston and Huntington.			×									
**Pentamerus oblongus* Sowerby. 11 Huntington and Jefferson Counties and Delaware county.			×									
Pentamerus occidentalis Hall Carroll County.			×									
**Pentamerus ventricosus* Hall Madison.			×									
Pholidops calceola Hall & Clark, 11 Falls of the Ohio (Clark & Hall).			×									
Pholidops ovalis Hall, 11 Waldron (James Hall).			×									
Productella semiglobosa Nettleroth Falls of the Ohio (Nettleroth .				×								
**Productella spinulicosta* Hall (Productus spinulicos a), 11 Charlestown and Shelby County.				×								
**Productella subalata* Hall Falls of the Ohio.				×								
Productella subaculeata Hall Jeffersonville (Hall).			×	×								
Productella subaculeatea var. *cataracta* H. & W. Utica. Clark County (Nettleroth).			×									
**Productus æquicostatus* Shumard Dubois County.											×	
Productus alternatus Norwood & Pratt.. 8 Harrison County and Crawfordsville.							×					
Productus altonensis N. & P., 8 Harrison County.								×	×			
**Productus biseriatus* Hall. 12 Washington County, Bloomington and Tippecanoe County.								×				
Productus buchianus de Koninck Posey County (Norwood & Pratt).											×	
Productus burlingtonensis M. & W. Harrison ounty.							×					
**Productus cestriensis* Worthen									×			
Productus cora d'Orbigny. 8 Owen County. Reelsville. Putnam County, Crawfordsville, Clay County, Orange County, Greencastle, Vanderburgh County, Montgomery County, Monroe County. Harrison County, Quincy, Jackson ounty.							×	×	×			
**Productus cora* var., *mogoyoni* Marcon Spergen Hill.								×				
**Productus costatus* Sowerby, 13 and 10 Throughout the coal measures.											×	
Productus fimbriatus Sowerby Posy County (Norwood & Pratt.)											×	
Productus flemingi Sowerby Leavenworth (Norwood & Pratt.) and Harrison County.							×		×?			

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Productus indianenesis Hall, 12 Spergen Hill (Hall), Tippecanoe County and Washington County.								×				
Productus inflatus McChesney *see* P. semireticulatus.												
**Productus keokuk* Hall Putnam County.							×					
Productus lonispinus Sowerby, 13 Throughout the coal measure region (C. A. White).											×	
**Productus magnus* M. & W., 16 Crawfordsville and Harrison County.						×	×					
Productus marginicinctus Prout Spergen Hill.								×				
**Productus mesialis* Hall Crawfordsville.							×					
**Productus nebrascensis* Owen, 13 Fountain, Vermillion, Pike and Vigo Counties (C. A. White).											×	
**Productus ovatus* Hall New Providence (Hall & Clark), Greencastle and Washington County.								×				
**Productus punctatus* Martin, 16 and 11 Crawfordsville (Vermillion, Vigo and Sullivan Counties, C. A. White), Montgomery, Clay County, Harrison County, Washington County, Greencastle, Owen County, Vanderburgh County and Monroe County.							×	×	×		×	
Productus reticulatus Gabb Scott County (Borden).						×						
**Productus semireticulatus* Martin, 13 Spergen Hill (R. P. Whitfield), Clay County, Tippecanoe County, Jacksonville, Montgomery County, Crawfordsville, Reelsville, Putnam County, Harrison County, Orange County, Washington County. Throughout the coal measures (C. A. White).							×	×	×		×	
**Productus setigerus* Hall Crawfordsville							×					
Productus splendens Nor. & P. Posey County (Norwood & Pratt.)											×	
**Productus tenuicostatus* Hall, 8 Washington County, Greencastle and Harrison County.								×				
Productus undiferous de Kon. Posey County (Norwood & Pratt.)											×	
Productus vittatus Hall, 8 Spergen Hill (R. P. Whitfield), Harrison County, Crawfordsville.								×				
Productus wabashensis Nor. & P. New Harmony (Norwood & Pratt.)											×	
**Productus wortheni* Hall Putnam County.							×					
Rensselaeria ovoides Eaton Madison (Cornett).				×								
**Retzia evax* Hall, 11 Waldron (James Hall)			×									
Retzia mormonii Marcou, 13 Widely distributed (C. A. White).											×	
**Retzia vera* *see* Eumetria vera.												
**Retzia verneuilana* Hall *see* Eumetria verneuilana.												

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Rhynchonella acinus var. *convexa* Foerste Hanover (Foerste).		×										
**Rhychonella acinus* Hall, 11 Waldron (James Hall).			×									
**Rhychonella capax* Conrad, 10 Ripley County, Madison, Boone County, Franklin County (Moore), Richmond and Madison (Meek).	×											
Rhynchonella carolina Hall Falls of the Ohio.				×								
Rhychonella colletti Miller, 18 Wabash County.			×									
Rhynchonella cuneata Sow., 11 Delaware County.			×									
**Rhychonella dentata* Hall, 10 Richmond, Madison (Meek).	×											
Rhychonella explanata McChesney New Harmony (McChesney).									×		×	
Rhychonella greeniana Ulrich New Albany (Ulrich).						×						
**Rhychonella grosvenori* Hall, 12 Spergen Hill, Bloomington (Hall), Washington County, Harrison County, Lanesville.								×				
**Rhychonella indianensis* Hall, 11 Waldron (James Hall).			×									
Rhychonella kokomoensis Miller, 18 Kokomo (Miller).			×									
Rhynchonella louisvillensis Nettleroth Falls of the Ohio (Nettleroth).				×								
**Rhynchonella macra* Hall, 12 Washington County.								×				
**Rhynchonella missouriensis* Shumard Rockford (Meek and Worthen).						×						
**Rhynchonella mutata* Hall, 12 Washington County. Harrison County, Monroe County, Montgomery County, Orange County and Greencastle.							×	×	×			
**Rhynchonella neglecta* Hall, 11 Waldron (Hall), Madison.		×	×									
Rhynchonella (*Etonia*) *obsolescens* Hall Rockford (Hall).						×						
Rhynchonella osagensis, 8 *see* R. utah.												
**Rhynchonella ricinula* Hall, 12 Spergen Hill (Hall) Greencastle, Washington Co., Harrison Co. and Monroe Co.								×				
**Rhynchonella stricklandii?* Sowerby, 11 Waldron (James Hall) (Nettleroth).			×									
**Rhynchonella subcuneata* Hall, 12 Spergen Hill and Bloomington (Hall), Montgomery County, Orange County, Owen County, Greencastle, Crawfordsville, Quincy, Putnam County, Harrison County and Monroe County.							×	×	×			
Rhynchonella tennesseensis Roemer, 10 Waldron (White).			×									
Rhynchonella tenuistriata Nettleroth (Nettleroth).				×								
Rhynchonella tethys Billings, 11 *see* tenochisma tethys.												
**Rhynchonella utah* Marcou (R. osagensis), 13 and 8 Throughout the coal measures (C. A. White), Harrison County.									×		×	

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Rhynchonella ventricosa* Hall Madison.	×	....	....	....	....	....	....	....	....	....	....	....
**Rhynchonella whitii* Hall, 11 Wal ron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Rhynchonella wortheni Hall, 15 Washington County	....	....	....	....	....	....	....	×	....	....	....	....
**Rhynchonotreta cuneata* var. *americana* Hall, 11. (Rhynchonella cuneata var. americana). (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
**Schizocrania filosa* Hall Madison.	×	....	....	....	....	....	....	....	....	....	....	....
**Spirifer acuminata* Conrad 10 Falls of the Ohio (Hall), Clark, Scott, Jefferson. Jennings and Jackson Counties (Kindle).	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer angusta* Hall, 11 Charlestown and Shelby County.	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer arctisegmenta* Hall Clark County. (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer aspera Hall, 8 H rrison County.	....	....	....	....	....	×	....	....	....	....	....	....
Spirifer atwaterana Miller Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer auritisma Carroll County.	....	....	....	....	....	....	....	....	....	....	....	....
Spirifer bicostata? var. *petila* Hall, 11 Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Spirifer bifurcata* Hall, 12 Spergen Hill (Hall), Washington County.	....	....	....	....	....	....	....	×	....	....	....	....
**Spirifer biplicata* Hall Morgan County.	....	....	....	....	....	×	....	....	....	....	....	....
Spirifer byrnesi Nettleroth Clark County (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer camerata* Morton, 13 and 10 Throughout the coal measures (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
**Spirifer carteri* Hall, 8 *see* Syringothyris carteri.	....	....	....	....	....	×	×	....	....	....	....	....
**Spirifer consobrina* d'Orbigny Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer crispa* Hisinger, 11 Waldron (James Hall), Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
Spirifer crispa var. *simplex* Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Spirifer cuspidatus, 7 Owen County.	....	....	....	....	....	....	×	....	....	....	....	....
Spirifer davisi Nettleroth Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer divaricata* Hall Clark County and Bunker Hill (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer duodenaria Hall Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer eudora Hall, 11 Miam County, Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
**Spirifer euruteines* Owen, 11 Falls of the Ohio (Hall), Charlestown (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer euruteines var. *fornacula* Hall Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer fastigata M & W., 16 *see* S. mortonana.	....	....	....	....	....	....	....	....	....	....	....	....
Spirifer fimbriata Conrad Clark County (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer forbesi* N. & P. Gosport.	....	....	....	....	....	....	....	×	....	....	....	....

	Ordovician	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Spirifer fultonensis Worthen, 8. Harrison County.								×				
Spirifer glabra Martin, 15. Washington County.								×				
**Spirifer gregaria* Clapp. 10. Falls of the Ohio (Hall), Scott County, Clark County.			×	×								
Spirifera grieri H 11. Falls of the Ohio (Nettleroth).				×								
Spirifer grimesi Hall, 8. Washington County and Harrison County.							×					
Spirifer hobbsi Nettleroth. Falls of the Ohio (Nettleroth).				×								
Spirifer incrassatus. 7. Montgomery County.								×				
Spirifer increbescens Hall, 8. Harrison County.									×			
Spirifer kentuckensis, 7. Vanderburgh County and Owen County.									×			
**Spirifer keokuk* Hall, 16. Greencastle, Crawfordsville, Washington County, Harrison County, Quincy, Putnam County, Owen County, Scott County (Borden).						×	×	×				
Spirifer lateralis Hall. 8. Greencastle, Washington County and Harrison County.							×	×				
Spirifer leidyi N. & P., 8. Spergen Hill (R. P. Whitfield), Quincy, Putnam County, Harrison County, Owen County and Orange County.								×	×			
**Spirifer lineata* Martin, 11 and 13. Throughout the coal measures (C. A. White), Montgomery County and Orange County.							×	×	×		×	
**Spirifer logani* H 11. Crawfordsville.							×					
Spirifer macconathii Nettleroth. Falls of the Ohio (Nettleroth).				×								
Spirifer manni Hall. Clark County.				×								
Spirifer marionensis Schumard, 8. Harrison County (Collett), Falls of the Ohio (Nettleroth).				×		×						
Spirifer medialis Hall. Falls of the Ohio, Clark County (Nettleroth).			×									
**Spirifer mortonana* Miller (Sp. fastigatus). Crawfordsville and Harrison County (Meek & Worthen).							×					
**Spirifer mucronata* Conrad? Clark County (Nettleroth).				×								
Spirifer neglecta Hall, 8. Greencastle, Harrison County, Edwardsville, Owen County, Monroe County and Washington County.							×					
Spirifer niagarensis Hall, 11. Delaware County.			×									
Spirifer norwoodiana Hall, 15. Spergen Hill (Hall), Washington County?								×				
**Spirifer opimus* (Hall). see S. rockymontana. New Harmony (McChesney).											×	
**Spirifer oweni* Hall, 11. Falls of the Ohio (Hall) and Charlestown.				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield	Coal Measures.	Drift.
Spirifer peculiaris Shumard, 8. Harrison County.	....	....	....	....	....	×	....	....	....	....	....	....
Spirifer (Martinia) *planoconvexa* Shumard, 13. Throughout the coal measures (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
**Spirifer plena* Hall. Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
Spirifer propinqua Hall, 15. Washington County.	....	....	....	....	....	....	....	×	....	....	....	....
**Spirifer pseudolineata* Hall, 8. Greencastle, Jackson County, Edwardsville, Owen County, Harrison and Monroe Counties.	....	....	....	....	....	....	×	×	....	....	....	....
**Spirifer radiata* Sowerby, 11 Waldron (James Hall), Allen County, Miami County and Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Spirifer raricosta* Conrad. Clark County, Falls of the Ohio (Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Spirifer rockymontana Marcou (Sp. opimus). New Harmony.	....	....	....	....	....	....	....	....	....	....	×	....
Spirifer (*Cyrtia*) *rostellum* Hall, 8. Louisville, Ky. (Foerste), Greencastle and Harrison County and Alters.	....	....	×	....	....	....	....	....	....	....	....	....
Spirifer sculptilis Hall. Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Spirifer setigera* Hall, 8. Wayport, Harrison County and Greencastle.	....	....	....	....	....	....	....	×	....	....	....	....
Spirifer segmenta Hall, 11. Falls of the Ohio and Charlestown Landing (Hall), Shelby County.	...	....	....	×	....	....	....	....	....	....	....	....
Spirifer semiplicata Hall Rockford (James Hall).	....	....	....	....	....	×	....	....	....	....	....	....
**Spirifer spinosa* N. & P. *see* Spiriferina spinosa.	....	....	....	....	....	....	....	....	....	....	....	....
Spirifer suborbicularis Hall, 8. Crawfordsville and Harrison County.	....	....	....	....	....	....	×	×	....	....	....	....
Spirifer subcardiformis Hall, 8 Washington County and Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
**Spirifer subcuspidatus*, 8. *see* Sp. cuspidatiformis.	....	....	....	....	....	....	....	....	....	....	....	....
**Spirifer striatiformis* Meek Tippecanoe County.	....	....	....	....	....	....	....	×	....	....	....	....
Spirifer striata Martin, 8. Clay County, Montgomery County, Harrison County, Crawfordsville, Owen County, Washington County and Orange County.	....	....	....	....	....	....	×	....	×	....	....	....
**Spirifer texta* Hall, 10. *see* Syringothyris texta.	....	....	....	....	....	....	....	....	....	....	....	....
**Spirifer tenuicostata* Hall, 8. Spergen Hill (R. P. Whitfield), Washington County, Harrison County and Orange County.	....	....	....	....	....	....	....	×	....	....	....	....
**Spirifer tullia* Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer vanuxemi Hall (Orthis vanuxemi) Ripley County.	×	....	....	....	....	....	....	....	....	....	....	....
**Spirifer varicosa* Hall, 11. Charlestown Landing (Hall), Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Spirifer (?) *waldronensis* Miller & Dyer. Waldron (M. & D.).	....	....	×	....	....	....	....	....	....	....	....	....
Spiriferina kentuckensis Shumard, 13. Vermillion, Vigo Knox, Gibson, Posey, Vanderburg, Dubois and Spencer Counties (C. A. White), Harrison County.	....	....	....	....	....	×?	....	....	×	....	×	....

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Spiriferina norwoodana Hall, 12. Spergen Hill.								×				
**Spiriferina spinosa* Norwood and Pratton (Spirifer spinosa), 8. Bloomington (Hall), Spergen Hill (R. P. Whitfield), Harrison County.								×				
Spirigera hirsuta see Athyris hirsuta.												
Stenochisma tethys Billings (Rhynchonella tethys) Clark County and Falls of the Ohio.				×								
Streptorhynchus chemungensis var. *arctostriata* H. Falls of the Ohio (Nettleroth).												
Streptorhynchus crenistriatum Phillips, 8. Spergen Hill (R. P. Whitfield), Harrison County, Park County, Greencastle, Washington County, Reelsville and Putnam County.						×	×	×	×?			
Streptorhynchus (*Strophomena*) *elongatum* James. (James).	×											
Streptorhynchus keokuk Hall, 8 Scott County (Borden), Harrison County.						×						
**Streptorhynchus nutans* Meek Madison.	×											
Streptorhynchus planumbonum Hall (Strophomena planumbonum) Richmond (Meek), Madison (Hall).	×											
**Streptorhynchus planoconvexum* Hall S. E. Indiana.	×											
Streptorhynchus pectinaceum H. New Albany (Hall).						×	×					
**Streptorhynchus subtentum* Conrad (Strophomena plicata) Richmond and Madison.	×											
Streptorhynchus subplanum Conrad, 11 Waldron (James Hall).			×									
Streptorhynchus tenue Hall, 11 Waldron (James Hall).			×									
**Streptorhynchus umbraculum* Von Buch., 12 New Providence.						×						
Streptorhynchus (*Strophomena*) *vetustum* James (James).	×											
Strophodonta arcuata Hall, 11 Shelby County.				×								
**Strophodonta concava* Hall Charlestown.				×								
Strophodonta demissa Conrad, 11 Charleston and Shelby County (Nettleroth).				×								
**Strophodonta hemispherica* Hall Falls of the Ohio (Hall), Clark County.			×	×								
**Stropheodonta inequistriata* Conrad Falls of the Ohio (Nettleroth).				×								
Stropheodonta nacrea Hall Falls of the Ohio (Nettleroth).				×								
Stropheodonta perplana Conrad Falls of the Ohio (Nettleroth).				×								
Stropheodonta plicata Hall Falls of the Ohio (Nettleroth).				×								
Stropheodonta profunda Hall, 11 and 16 Waldron (James Hall), Allen County.			×									
**Stropheodonta semifasciata* Hall Waldron			×									
**Strophodonta striata* Hall, 11 Waldron (James Hall).			×									

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Strophomena alternata Conrad, 10 S. E. Indiana.	×	....	....	....	....	....	....	....	....	....	....	....
Strophomena alternata var. *alternistriata* Hall Madison.	×	....	....	....	....	....	....	....	....	....	....	....
Strophomena filitexta Madison.	×	....	....	....	....	....	....	....	....	....	....	....
**Strophomena fracta* Meek, 6 Madison.	×	....	....	....	....	....	....	....	....	....	....	....
Strophomena hanoverensis Foerste Hanover (Foerste).	....	×	....	....	....	....	....	....	....	....	....	....
Strophomena incurvata (Shepard) Ripley County (Borden).	×	....	....	....	....	....	....	....	....	....	....	....
**Strophomena nasuta* Conrad Madison.	×	....	....	....	....	....	....	....	....	....	....	....
Strophomena nutans see Streptorhynchus nutans.	....	....	....	....	....	....	....	....	....	....	....	....
Strophomena patenta Hall Hanover (Foerste).	....	×	....	....	....	....	....	....	....	....	....	....
Strophomena planoconvexa Hall see Streptorhynchus planoconvexum.	....	....	....	....	....	....	....	....	....	....	....	....
Strophomena planumbona Hall, 10 see Streptorhynchus planumbonum.	....	....	....	....	....	....	....	....	....	....	....	....
Strophomena plicata see Streptorhynchus subtentum.	....	....	....	....	....	....	....	....	....	....	....	....
**Strophomena rhomboidalis* Wilckens, 11 Madison (Meek). Waldron (James Hall), Hartsville, Franklin County, Jasper County, Wabash County, Clark County (Nettleroth).	×	×	×	×	....	....	×	....	....	....	....	....
Strophomena rugosa Dalman, 6 Madison.	....	×	×	....	....	....	....	....	....	....	....	....
Strophomena striata see Strophodonta striata.	....	....	....	....	....	....	....	....	....	....	....	....
Strophomena sulcata de Verneuil Richmond (Meek), Madison.	×	....	....	....	....	....	....	....	....	....	....	....
**Strophomena tenuistriata* Sowerby Richmond.	×	....	....	....	....	....	....	....	....	....	....	....
Strophomena tenuis Hall Hanover (Foerste).	....	×	....	....	....	....	....	....	....	....	....	....
Strophonella semifasciata Hall, 11 Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Syntrielasma hemiplicata Hall, 13 Coal Measures (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Syringothyris carteri Hall, (?) 8 (Sp. carteri) Monroe, Harrison and Clark Counties	....	....	....	....	....	×	....	....	....	....	....	....
Syringothyris texta Hall, 8 Scott County (Borden), Borden and New Albany (Hall), Jackson County and Harrison County	....	....	....	....	....	....	....	....	....	....	....	....
**Terebratula bovidens* Morton, 13 Widely distributed throughout the Coal Measures (C. A. White), Greencastle, Orange County, Montgomery County, Vanderburgh County, Harrison County, Parke County and Monroe County.	....	....	....	....	....	....	....	×	×	....	×?	....
Terebratula calvini Hall and Whitfield, 8 Harrison County	....	....	....	....	....	×	....	....	....	....	....	....
**Terebratula formosa* Hall, 12 Spergen Hill and Bloomington (Hall), Greencastle, Harrison County, Washington County, Monroe County.	....	....	....	....	....	....	....	×	....	....	....	....
Terebratula gorbyi Miller, 17 Edwardsville.	....	....	....	....	....	....	×	....	....	....	....	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Terebratula harmonia H. Falls of the Ohio (Hall).				×								
**Terebratula hastata* Sowerby, 8 Owen County, Greencastle and Harrison County.							×	×				
Terebratula inornata McChesney, 8 Harrison County.							×	×				
**Terebratula jucunda* Hall Falls of the Ohio (Nettleroth).				×								
**Terebratula lincklaeni* Hall Falls of the Ohio (Nettleroth).				×								
Terebratula romingeri Hall Clark County (Nettleroth).				×								
Terebratula sacculus Martin, 16 Crawfordsville.							×					
Terebratula subcuneata *see* Athyris trinuclea.												
Terebratula subtilita Hall *see* Athyris subtilita.												
Terebratula trinuclea Hall Spergen Hill (Hall), Washington County, Owen County and Greencastle.								×				
**Terebratula turgida* Hall, 12 Bloomington and Spergen Hill (Hall), Washington County, Greencastle, Harrison and Monroe Counties.								×				
Trematospira hirsuta Hall Utica and Clark County and Falls of the Ohio.			×	×								
Trematospira mathewsoni McChesney Madison (McChesney).			×									
**Trematospira nobilis* Hall Charlestown.				×								
Triplesia cuspidata Hall (Atrypa cuspidata), 6 Madison.	×											
Triplesia putillus Hall, 11 Waldron.			×									
**Triplesia waldronensis* M. & D. Waldron.			×									
**Tropidoleptus carinatus* Conrad Scott County (Borden), Clark County (Nettleroth).				×	×							
**Whitfieldia maria* Hall Waldron.			×									
**Zygospira headii* Billings Madison (W. S. T. Cornett), Madison (Meek)	×											
Zygospira minima Hall, 11 Waldron.			×									
**Zygospira modesta* Say Madison (W. S. T. Cornett), Richmond and Madison (Meek), Franklin County (Moore)	×											
**Zygospira modesta* var. *cincinnatiensis* James Madison.	×											

MOLLUSCA.

LAMELLIBRANCHIATA.

	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Actinopteria boydi Conr. Falls of the Ohio (Nettleroth) (Hall).				×								
**Allorisma cuneatum* Swallow Warren County.											×	
**Allorisma sinuatum* McChesney, 8 Harrison County.								×				

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Allorisma subcuneatum* Meek & H., 13 and 10 Throughout the coal measures (C. A. White)											×	
**Ambonychia acutirostra* Hall, 11 and 17 Waldron (James Hall), Wabash County.			×									
Ambonychia alata *see* Anomalodonta alata.												
Ambonychia amygdaloidea, 6 Madison (Cornett).	×											
**Ambonychia bellistriata* Hall Franklin County.	×											
**Ambonychia carinata* Goldfuss Madison (W. S. T. Cornett).	×											
**Ambonychia radiata* Hall Richmond, Madison.	×											
**Amphicoelia costata* Meek Huntington County.			×									
Amphicoelia leidyi Hall, 11 Waldron (James Hall).			×									
**Anatina leda* Hall Rockford (James Hall).						×						
Anadontopsis ? milleri Meek Versailles.	×											
**Angellum cuneatum* Miller Richmond (Miller).	×											
Anomalodonta casei M. & W., 7 Richmond (Miller).	×											
Anomalodonta gigantea Miller Versailles and Richmond (Miller).	×											
**Astartella concentrica* McChesney, 8 Big Creek and Sullivan County.											×	
Astartella vera Hall Coal measures (Hall)											×	
**Aviculopecten amplus* M. & W. Owen County and Edwardsville.							×					
**Aviculopecten aviculatus* Swallow Dubois County.											×	
**Aviculopecten carboniferous* Stevens, 13 Fountain and Vermillion County and Dubois County (C. A. White).											×	
**Aviculopecten colletti* Worthen Crawfordsville (A. H. Worthen).							×					
**Aviculopecten crassicostatus* Hall Falls of the Ohio (Nettleroth).				×								
Aviculopecten fasciculatus Hall Falls of the Ohio (Nettleroth).				×								
**Aviculopecten indianensis* Meek & Worthen, 16 Spergen Hill (R. P. Whitfield), Harrison County and Crawfordsville, Edwardsville, Greencastle.							×	×				
**Aviculopecten intercostalis* Winchell Charlestown.				×								
**Aviculopecten oblongus* M. & W. Edwardsville.							×					
Aviculopecten occidentalis Shumard, 13 Pike and Gibson Counties (C. A. White).											×	
**Aviculopecten pecteniformis* Conrad Falls of the Ohio, Charlestown (Nettleroth).				×								
Aviculopecten princeps Conrad Falls of the Ohio (James Hall).				×								
**Aviculopecten providencensis* Cox Dubois County.											×	
Aviculopecten rectilaterarius Cox Vanderburg County, Vigo County and Clay County.											×	

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Aviculopecten spinuliferous Worthen Crawfordsville (A. H. Worthen).											×	
Aviculopecten winchelli Meek, 8 Harrison County.							×					
Avicula corrugata James *see* Pterinea corrugata.												
Avicula demissa *see* Pterinea demissa.												
Avicula insueta *see* Pterinea insueta.												
Byssonychia tenuistriata Ulrich Richmond (Ulrich).	×											
Cardiamorpha missouriensis Shumard, 7 Vanderburg County.											×	
Cardiamorpha radiata M. & W. *see* Cardiopsis radiata.												
Cardiamorpha subglobosa Meek Washington County.						×						
Cardiola radianes? *see* Panenka radians.												
Cardiopsis radiata Meek & Worthen (Cardiamorpha radiata) Rockford (Meek & Worthen).						×						
Chaenomya rhomboidea? M. & W., 7 Orange County.								×				
Clidophorus fabula Hall Versailles (Miller).	×											
Clinopistha antiqua Meek Clark County (Nettleroth).				×								
Clinopistha radiata Hall, 13 (C. A. White.											×	
Clinopistha striata Nettleroth Clark County (Nettleroth).				×								
Clinopistha subnasuta (H. & W.) Hall Louisville, Ky. (James Hall), Clark County (Nettleroth).				×								
Clionychia excavata Ulrich Richmond (Ulrich).	×											
**Conocardium attenuatum* Conrad Waldron.			×									
**Conocardium carinatum* Hall, 12 Bloomington, Spergen Hill, Harrison and Washington Counties.								×				
Conocardium catastonum Hall, 12 Spergen Hill (Hall), Washington County.								×				
Conocardium constrictum Hall, 8 Harrison County.								×				
**Conocardium cuneata* Hall, 12 Bloomington and Spergen Hill (Hall), Monroe and Washington Counties, Greencastle and Harrison County.								×				
‡*Conocardium cuneus* Conr. Pendleton.												
Conocardium elrodi Miller, 17 Hartsville.			×									
Conocardium equilaterale Hall, 12 Spergen Hill (Hall), Washington County.								×				
Conocardium exiguum Miller, 17 Bunker Hill.				×								
Conocardium indianense Miller, 17 Crawfordsville.							×					
Conocardium meekanum Hall, 12 Washington County.								×				

‡ Schoharie-grit (James Hall).

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Conocardium ohioense Meek. Falls of the Ohio (James Hall), Madison.	....	....	....	×	....	....	....	....	....	....	....	....
Conocardium parvulum Miller, 17. Bunker Hill.	....	....	....	×	....	....	....	....	....	....	....	....
Conocardium prattenanum Hall, 12. Washington County.	....	....	....	....	....	....	....	×	....	....	....	....
**Conocardium trigonale* Hall, 11. Madison (Meek) Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Crenipecten retiferus Shumard (Lima retifera). Knox, Gibson and Posey Counties (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Cycloconcha milleri Meek. Versailles (Ulrich).	×	....	....	....	....	....	....	....	....	....	....	....
Cypricardella nucleata Hall, 12. Spergen Hill (Hall), Harrison County and Washington County.	....	....	....	....	....	....	×	×	....	....	....	....
Cypricardella oblonga Hall, 12. Spergen Hill and Bloomington (Hall), Washington County.	....	....	....	....	....	....	....	×	....	....	....	....
Cypricardella plicata see Goniophora plicata.	....	....	....	....	....	....	....	....	....	....	....	....
Cypricardella subelliptica Hall, 12. Washington County.	....	....	....	....	....	....	....	×	....	....	....	....
Cypricardia indianensis see Cypricardinia indianensis.	....	....	....	....	....	....	....	....	....	....	....	....
Cypricardia subplana see Edmondia subplana.	....	....	....	....	....	....	....	....	....	....	....	....
Cypricardia undulata Gurley. Vermillion County (Gurley).	....	....	....	....	....	....	....	....	....	....	×	....
Cypricardia ventricosa Hall. Rockford (James Hall).	....	....	....	....	....	×	....	....	....	....	....	....
Cypricardites hainesi Miller. Richmond (Miller).	×	....	....	....	....	....	....	....	....	....	....	....
**Cypricardites sterlingensis* M. & W. (?). Richmond (Miller & Meek).	×	....	....	....	....	....	....	....	....	....	....	....
Cypricardinia arata Hall, 11. Waldron (James Hall).	....	....	×	....	....	....	....	....	....	....	....	....
Cypricardinia cataracta Conr. Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Cypricardinia (?) *cylindrica* H. & W. Lou sville, Ky. (James Hall), Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Cypricardinia indenta (Con.) Hall. Falls of the Ohio (James Hall).	....	....	....	×	....	....	....	....	....	....	....	....
Cypricardinia indianensis Hall (Cypricardia indianensis, 12. Spergen Hill (Hall).	....	....	....	....	....	....	....	×	....	....	....	....
Cypricardissia inflata var. *subequivalvis* H. & W. Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Cythere carbonaria Hall. Spergen Hill (Hall), Greencastle and Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
Edmondia subplana Hall (Cypricardia subplana), 12. Spergen Hill (Hall).	....	....	....	....	....	....	....	×	....	....	....	....
Entolium aviculatum Swallow, 13. Fountain, Vermillion, Vigo Pike, Dubois, Perry and Spencer Counties (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Glyptodesma cancellata Nettleroth. Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Glyptodesma occidentale Hall. Falls of the Ohio (James Hall).	....	....	....	×	....	....	....	....	....	....	....	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Goniophora plicata Hall (Cypricardella plicata), 12 Bloomington (Hall).								×				
Goniophora speciosa Hall, 11 Waldron.			×									
Goniophora truncata Hall Falls of the Ohio (Nettleroth).				×								
Grammysia arcuata (Con). H. Falls of the Ohio (James Hall).				×								
Grammysia gibbosa H. & W. Falls of the Ohio (Nettleroth).				×								
Grammysia rhomboydalis M. & W. Washington County.						×						
Grammysia ventricosa Meek Washington County.						×						
Ischyrodonta decipiens Richmond (Ul ich).	×											
Ischyrodonta elongata Ulrich Richmond (Ulrich).	×											
Ischyrodonta miseneri Ulrich Richmond (Ulrich).	×											
Ischyrodonta modioliformis Ulrich Richmond (Ulrich).	×											
Ischyrodonta ovalis Ulrich Richmond (Ulrich).	×											
Leda bellistriata *see* Nuculana bellistriata.												
Leda nasuta Hall, 12 Spergen Hill and Lanesville.								×				
Lima retifera Shumard, 13 *see* Crenipecten retiferus.												
Limoptera cancellata Hall Falls of the Ohio (James Hall).				×								
**Lithophaga lingualis* Phillips, 16 Crawfordsville and Harrison County.							×					
Lithophaga pertenuis M. & W. Lanesville.								×				
Lunulicardium fragile Hall Scott County (James Hall).					×							
Macrondon obsoletus Meek Spergen Hill (R. P. Whitfield).								×				
Megaptera casei M. & W., 10 Richmond.	×											
Megambonia lyoni Rockford (James Hall).						×						
Modiolodon declivis Ulrich Richmond (Ulrich).	×											
Modiolodon subrectus Ulrich Richmond (Ulrich).	×											
Modiolodon subovalis Ulrich Versailles (Ulrich).	×											
Modiolodon truncatus Hall Versailles (Ulrich).	×											
**Modiolopsis cincinnatiensis* H. & W. Richmond.	×											
Modiolopsis concentrica Hall & White (Ulrich).	×											
**Modiolopsis modiolaris* Madison and Richmond.	×											
**Modiolopsis perlata* Hall, 11 Waldron (James Hall).			×									
**Modiolopsis pholadiformis* Hall Richmond (Miller).	×											

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	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Modiolopsis subulata Hall, 11 Waldron (James Hall).			×									
Modiolopsis versaillesensis Miller Versailles (Miller).	×											
Modiomorpha affinis Hall Clark County (James Hall).				×								
Modiomorpha alta Hall Falls of the Ohio and Charlestown (James Hall).				×								
Modiomorpha charlestownensis Nettleroth Clark County (Nettleroth).				×								
Modiomorpha concentrica Hall Falls of the Ohio and Charlestown (James Hall).				×								
Modiomorpha mytiloides Conr. Clark County (Nettleroth).				×								
Modiomorpha recta Hall Clark County (James Hall).				×								
Monopteria longispina Cox Dubois County.											×	
Monopteria gibbosa M. & W., 13 Vermillion, Sullivan and Posey Counties (C. A. White).											×	
Monotis (?) *gregaria* M. & W. Crawfordsville (Meek & Worthen).							×					
Myalina concentrica M. & W. Spergen Hill (Meek & Worthen).								×				
**Myalina keokuk* Worthen, 8 Harrison and Washington Counties and Crawfordsville.						×	×	×				
Myalina subquadrata Shumard, 13 Knox, Gibson and Posey Counties (C. A. White).											×	
**Myalina swallovi* McChesney, 13 Park, Vermillion and Vigo Counties (C. A. White), Dubois County.											×	
Mytilarca sigilla Hall, 11 Waldron (James Hall).			×									
Nucula hyans Hall Rockford (James Hall.					×							
Nucula inflata, 7 Vanderburgh County.											×	
Nucula lirata Conrad, 11 Shelby County.				×								
Nucula neda H. & W. Louisville, Ky. (James Hall), Falls of the Ohio (Nettleroth).				×								
**Nucula niotica* H. & W. Falls of the Ohio (James Hall) (Nettleroth).				×								
Nucula herzeri Nettleroth Falls of the Ohio (Nettleroth).				×								
Nucula nasuta Hall *see* Nuculana nasuta.												
Nucla shumardana Hall, 15 Washington County.								×				
Nucula ventricosa Hall, 11 Sullivan County (C. A. White).											×	
Nuculana bellistriata Stevens, 13 Vermillion, Sullivan, Vanderburgh and Warrick Counties (C. A. White).											×	
Nuculana nasuta Hall (Nucula nasuta) Washington County (Hall).								×				
Nuculana shumardana, 12 Spergen Hill (Hall).								×				

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Opisthoptera casei White Richmond (Ulrich).	×											
Opisthoptera obliqua White Richmond (Ulrich).	×											
Orthodesma canaliculatum Ulrich (Ulrich).	×											
**Orthodesma parallelum* Hall Madison.	×											
**Orthodesma rectum* H. & W. Madison.	×											
Orthodesma subangulatum Richmond (Ulrich).	×											
Ortonella hainesi Miller Richmond (Ulrich).	×											
Palaeoneilo bedfordensis Meek Washington County.						×						
Panenka radians Conrad (Cardiola radians) Scott County (Whitfield).					×							
**Paracyclas elliptica* Hall, 10 Falls of the Ohio, and Clark County (James Hall).				×								
**Paracyclas elliptica* var. *occidentalis* Hall Centreville.				×								
Paracyclas elongata Nettleroth Clark County (Nettleroth).				×								
**Paracyclas lirata* (Con.) Hall Falls of the Ohio and Clark County (James Hall.)				×								
Paracyclas octerlonii Nettleroth Falls of the Ohio (Nettleroth).				×								
Paracyclas ohioensis Meek Clark County (Nettleroth).				×								
Pinna subspatulata Worthen, 8 Washington and Harrison Counties.							×	×				
**Pinna peracuta* Shumard, 13 Orange County (C. A. White).									×		×	
**Pterinea brisa*, Hall, 11 *see* Pterinea striaecosta.												
Pterinea corrugata James (Avicula corrugata) Wayne County (James).	×											
**Pterinea concentrica* Con. Charlestown.				×								
**Pterinea demissa* Conrad (Avicula demissa) Madison (W. S. T. Cornett).	×											
**Pterinea flabellum* Conr., 11 Falls of the Ohio and Shelby County.				×								
Pterinea grandis Hall Scott County (James Hall).				×								
Pterinea insueta Emmons (Avicula insueta) Madison (Cornett).	×											
Pterinea striaecosta McChesney (Pterinea striaecosta) Waldron (James Hall).			×									
Pterinopecten nodosus Hall Falls of the Ohio (James Hall).				×								
Pterinopecten reflexus Hall Falls of the Ohio (James Hall).				×								
Pteronites spergensis Whitfield Spergen Hill and Bloomington (R. P. Whitfield)								×				
Ptychodesma knappianum H. & W. Falls of the Ohio (James Hall).				×								
Rhytimya byrnesi Miller Richmond (Ulrich).	×											

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	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Sanguinolites ? multistriatus Worthen Crawfordsville (A. H. Worthen).							×					
Schizodus medinensis Meek Washington County.						×						
**Solenomya anodontoides* Meek Dubois County.											×	
Solenomya (Janeia) vetusta Meek Falls of the Ohio (James Hall).				×								
Sphenolium richmondense Miller Richmond (Miller & Faber).	×											
Tellinomya cingulata Ulrich Madison (Ulrich).	×											
Tellinomya hilli Miller Osgood (Miller).	×											
Whitella obliquata Ulrich (Ulrich).	×											
Yoldia ? oweni McChesney New Harmony (McChesney). Rush Creek.											×	
Yoldia rushensis McChesney New Harmony (McChesney).											×	
Yoldia ? valvulus H. & W. Clark County (Nettleroth).				×								
SCAPHOPODA.												
Dentalium acutisulcatum Gurley Newport and Vermillio County (Gurley).											×	
Dentalium primarium Hall, 8 Greencastle, Montgomery County, Crawfordsville, Harrison County and Orange County.							×	×	×			
Dentalium primevum, 7 Owen County.							×					
Dentalium venustum, M. & W., 8 Harrison County.								×				
GASTROPODA.												
**Bellerophon bilobatus* Sowerby	×											
Bellerophon cancellatus Hall Bloomington and Spergen Hill (Hall).								×				
**Bellerophon carbonarius* Cox, 13 Vanderburgh County, Sullivan County, Orange County and Vigo and Harrison Counties.									×		×	
Bellerophon crassus M. & W., 13 Sullivan and Posey Counties (C. A. White).											×	
Bellerophon crenistria Hall Clark County.				×								
**Bellerophon cyrtolites* Hall Rockford (Hall), (Meek & Worthen).						×						
Bellerophon exiguus Foerste Hanover (Foerste).		×										
**Bellerophon gibsoni* White, 11 Washington County, Greencastle and Orange County.								×				
Bellerophon gorbyi Miller, 17 Dearborn County.	×											
Bellerophon leda H. H. Clark County (Nettleroth).				×								

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	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Bellerophon levis, 7	....	....	....	....	....	....	....	×	....	....	....	....
Orange County.												
Bellerophon lineolatus Hall	....	....	....	....	....	×	....	....	....	....	....	....
Rockford (James Hall).												
Bellerophon lyra Hall	....	....	....	×	....	....	....	....	....	....	....	....
Falls of the Ohio (Hall).												
Bellerophon marcouanus (?) Geinetz, 8	....	....	....	....	....	....	....	×	....	....	....	....
Harrison County.												
Bellerophon mohri Miller	×	....	....	....	....	....	....	....	....	....	....	....
Richmond (Ulrich).												
**Bellerophon montfortanus* N. & P., 7	....	....	....	....	....	....	....	....	....	....	×	....
Vanderburgh County.												
**Bellerophon nodocarinatus* Hall, 13	....	....	....	....	....	....	....	....	....	....	×	....
New Harmony and Sullivan County (C. A. White).												
**Bellerophon patulus* Hall, 11	....	....	....	×	....	....	....	....	....	....	....	....
Charlestown and Shelby County.												
**Bellerophon pelops* Hall	....	....	....	×	....	....	....	....	....	....	....	....
Charlestown.												
**Bellerophon percarinatus* Conrad, 13	....	....	....	....	....	....	....	....	....	....	×	....
Throughout the Coal Measures (White).												
Bellerophon subangularis Ulrich	×	....	....	....	....	....	....	....	....	....	....	....
Richmond (Ulrich).												
**Bellerophon sublaevis* Hall, 12	....	....	....	....	....	....	×	×	....	....	....	....
Spergen Hill and Bloomington (Hall), Washington, Owen and Harrison Counties, Greencastle.												
Bellerophon textilis Hall, 12	....	....	....	....	....	....	....	×	....	....	....	....
Spergen Hill, Bloomington and Lanesville (Hall).												
Bellerophon tuber Hall, 11	....	....	×	....	....	....	....	....	....	....	....	....
Waldron (James Hall).												
**Bucania chicagoensis* McChesney	....	....	×	....	....	....	....	....	....	....	....	....
Grant County.												
Bucania devonica H. & W.	....	....	....	×	....	....	....	....	....	....	....	....
Clark County (Nettleroth).												
Bucania crassa Ulrich	×	....	....	....	....	....	....	....	....	....	....	....
Richmond (Ulrich).												
Bucania expansa Hall	×	....	....	....	....	....	....	....	....	....	....	....
Richmond.												
Bucania simulatrix Ulrich	×	....	....	....	....	....	....	....	....	....	....	....
Richmond (Ulrich).												
Bulimella bulimiformis Hall	....	....	....	....	....	....	....	....	....	....	....	....
see Bulimorpha bulimiformis.												
Bulimella canaliculata Hall	....	....	....	....	....	....	....	....	....	....	....	....
see Bulimorpha canaliculata.												
Bulimella elongata Hall	....	....	....	....	....	....	....	....	....	....	....	....
see Bulimorpha elongata.												
Bulimorpha bulimiformis Hall, 12	....	....	....	....	....	....	....	×	....	....	....	....
Washington County												
Bulimorpha canaliculata Hall, 12	....	....	....	....	....	....	....	×	....	....	....	....
Washington County.												
Bulimorpha elongata Hall, 15	....	....	....	....	....	....	....	×	....	....	....	....
Washington County.												
Callonema bellatula Hall	....	....	....	×	....	....	....	....	....	....	....	....
Falls of the Ohio (Nettleroth).												
Callonema imitator H. & W.	....	....	....	×	....	....	....	....	....	....	....	....
Clark County (Nettleroth).												
Capulus acutirostris	....	....	....	....	....	....	....	....	....	....	....	....
see Platyceras acutirostrum.												
Capulus equilateralis Hall	....	....	....	....	....	....	×	....	....	....	....	....
Crawfordsville (Keyes).												
Capulus infundibulum Meek & W.	....	....	....	....	....	....	×	....	....	....	....	....
Crawfordsville (Keyes).												

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Capulus parvus Swallow Coal Measures (Keyes).											×	
Capulus sulcatinus Keyes Crawfordsville (Keyes).							×					
Chiton carbonarius Stevens, 8 Spergen Hill (R. P. Whitfield), Harrison County.								×				
Conradella dyeri cellulosa Ulrich Richmond and Versailles (Ulrich).	×											
**Cyclonema bilex* Conrad, 10 Franklin County (Moore), Madison (Meek), Richmond (White).	×											
**Cyclonema bilex* var. *conicum* Miller Madison.	×											
Cyclonema cancellatum 6 Madison (Cornett).		×										
Cyclonema fluctuata James (James).	×											
Cyclonema humerosum Ulrich Richmond and Versailles (Ulrich).	×											
Cyclonema leavenworthana Hall, 12 (Pleurotomaria leavenworthana) Spergen Hill and Bloomington (James Hall), Harrison and Washington Counties.								×				
Cyclonema mediale (Ulrich) (Ulrich)	×											
Cyclonema pulchellum Mill. & G. New Albany (Miller & Gurley).						×						
Capulus sulcatinus Keyes Crawfordsville (Keyes).							×					
Cyclonema subangulatum Hall (Pleurotomaria subangulatum), 12 Washington County and Spergen Hill (Hall).								×				
**Cyclora minuta* Hall Madison (Cornett).	×											
Cyclora parvula Hall Versailles (Miller).	×											
Cyclora pulcella Miller Versailles (Miller).	×											
Cyrtolites inornatus Hall Franklin County (Moore).	×											
Cyrtolites magnus Miller Richmond (Miller).	×											
Cyrtolites ornatus Conr. Versailles (Miller), Madison (W. S. T. Cornett).	×											
Cyrtolites sinuosus Hall, 11 Waldron (James Hall).			×									
Cyrtolites youngi Foerste Hanover (Foerste).		×										
Eotrochus concavus Hall (Pleurotomaria concavus), 12 Harrison County, Spergen Hill and Bloomington.								×				
**Euomphalus cyclostomus* Hall, 11 Shelby County.				×								
Euomphalus decewi Bill., 11 *see* Pleuronotus decewi.												
**Euomphalus disjunctus* Hall Rensselaer and Huntington.			×									
Euomphalus lens Hall *see* Straparollus lens.												

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	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Euomphalus planispira Hall, 12 Spergen Hill and Blooming on (Hall), Harrison County, Monroe County, Greencastle and Washington County.								×				
Euomphalus planorbiformis Hall, 8 Harrison County, Washington County and Orange County.								×	×			
Euomphalus quadrivolvus, 12 *see* St aparollus quadrivolvus.												
Euomphalus rugosus Hall, 13 *see* Euomphalus subrugosus.												
**Euomphalus sampsoni* Nettleroth Clark County (Nettleroth).				×								
Euomphalus spergensis, 12 *see* Straparollus spergensis.												
Euomphalus spergensis var. *planorbiformis*, 12 *see* Straparollus spergensis.												
Euomphalus spirorbis *see* Straparollus spirorbis.												
Euomphalus subrugosus M. & W. (E. rugosus) Throughout the Coal Measures (C. A. White).											×	
**Euomphagus tioga* Hall Charlestown.				×								
Helicotoma marginata Ulrich Richmond (Ulrich).	×											
Holopea grandis Miller & Gurley New Albany (Miller & urley).						×						
Holopea hubbardi Miller, 18 Madison.	×											
Holopea proutana Hall, 12 Spergen Hill (Hall), Washington County.								×				
**Isonema lichas* Hall Charlestown.				×								
Liospira vitruvia Bill (Ulrich).	×											
Lophospira acuminata n. sp. or var. *perangulata* Richmond (Ulrich).	×											
Lophospira ampla Ulrich Richmond (Ulrich).	×											
Lophospira bowdeni Safford (Ulrich).	×											
Lophospira multigruma Miller Madison and Richmond and Versailles.	×											
Loxonema hamiltonae Hall Clark County (Nettleroth).				×								
Loxonema hydraulicum H. & W. Charlestown (Nettleroth).				×								
Loxonema laeviusculum Hall Falls of the Ohio (Nettle oth).				×								
Loxonema nexile Phillips, 11 Shelby County.				×								
Loxonema rectistriatum Hall Falls of the Ohio (Nettleroth).				×								
Loxonema teres Hall Falls of the Ohio and Charlestown.				×								
Loxonema vincta Hall *see* Murchisonia vincta.												
Loxonema yandellanum Hall, 12 Spergen Hill (Hall), Washington County.								×				
Macrocheilus fusiformis *see* Soleniscus fusiformis.												
Macrocheilus (?) *littonanus* Hall, 12 Bloomington.								×				

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
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Macrocheilus primogenius Con. see Macrochilina primogenius.												
Macrocheilus primigenia Vigo County.											×	
**Macrocheilus ponderosa* Conrad Sullivan County and Vigo County.											×	
**Macrocheilus ventricosa* Hall Sullivan and Vigo Counties.											×	
Macrocheilina carinatus Nettleroth Falls of the Ohio (Nettleroth).				×								
**Macrocheilina klipparti* Meek Dubois County.											×	
Macrocheilina littonana Hall (Natica littonana). Bloomington (James Hall).								×				
**Macrocheilina primogenia* Conrad (Macrocheilus (?) littonanus), 12 Bloomington.								×				
Microceras inornatum Hall Versailles (Miller).	×											
Murchisonia attenuata, 12 Spergen Hill (Hall), Washington County.								×				
**Murchisonia bellicincta* Hall Madison and Richmond (Cornett), Ripley County.	×											
Murchisonia bicincta see M. milleri.												
Murchisonia desiderata Hall Falls of the Ohio (Nettleroth).				×								
Murchisonia elegantula see Pleurotomaria elegantula.												
**Murchisonia gracilis* Hall Madison.	×											
Murchisonia hammelli Miller, 18 Madison.	×											
Murchisonia indianensis Miller & G. New Albany (Miller & Gurley).						×						
Murchisonia insculpta Hall, 12 Spergen Hill and Bloomington (Hall), Washington and Harrison Counties.								×				
Murchisonia (Pleurotomaria) limitaris Hall Rockford (James Hall).						×						
**Murchisonia milleri* Hall (M. bicincta) Ripley County and Madison.	×											
Murchisonia multigruma Miller Richmond and Versailles (Miller).	×											
Murchisonia terebriformis Hall, 12. Bloomington (Hall), Washington County.								×				
Murchisonia turritella Hall, 12 Spergen Hill (Hall), Washington County.								×				
Murchisonia vermicula Hall. 12 Spergen Hill and Bloomington (Hall), Washington and Harrison Counties.								×				
**Murchisonia ventricosa* Hall Madison.	×											
Murchisonia vincta Hall, 12 (Loxonema vincta). Spergen Hill (Hall).								×				
Natica carleyana see Naticopsis carleyana.												
Natica littonana Bloomington (Hall).								×				
**Naticopsis carleyana* Hall, 12 (Natica carleyana) Spergen Hill and Bloomington (Hall).								×				
**Naticopsis gigantea* Hall Falls of the Ohio.				×								

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**Naticopsis laevis* Meek Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....
Naticopsis nana Meek & Worthen, 13 (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Naticopsis shumardiana Hall, 8 Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
Naticopsis wheeleri Swallow, 13 Vigo County (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Patella levettei White, 11 Spergen Hill.	....	....	....	....	....	....	....	×	....	....	....	....
**Platyceras acutirostre* Hall, 12 Owen County and Washington County, Bloomington.	....	....	....	....	....	....	....	×	....	....	....	....
**Platyceras ammon* Hall Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras (?) *arctiostoma* Ulrich Falls of the Ohio (Ulrich).	....	....	×	....	....	....	....	....	....	....	....	....
Platyceras attenuatum Hall, 6 Madison.	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras bucculentum H. Clark County (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras carinatum* Hall Charlestown and Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras compressum Nettleroth Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras conicum* Hall. Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras cymbium* Hall Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras cyrtolites* McChesney New Harmony.	....	....	....	....	....	....	....	....	....	....	×	....
**Platyceras dumosum* Conrad Clark County and Jennings County (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras dumosum var. *rarispinum* Hall Falls of the Ohio.	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras echinatum* Hall Clark County (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras equilaterales Hall, 8 and 10 Harrison County, Monroe County, Crawfordsville and Washington County.	....	....	....	....	....	....	×	....	....	....	....	....
**Platyceras erectum* Hall Charlestown (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras fissurellum* Hall, 8 Harrison County, Alters, Crawfordsville and Owen County.	....	....	....	....	....	....	×	....	....	....	....	....
Platyceras (*Orthonychia*) *fluctuosum* Ulrich Falls of the Ohio (Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras haliotoides* M. & W. Rockford.	....	....	....	....	....	×	....	....	....	....	....	....
Platyceras indianensis Miller & Gurley Charlestown (Miller & Gurley).	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras infundibulum M. & W., 8 Washington County, Harrison County, Monroe County and Crawfordsville.	....	....	....	....	....	×	×	....	....	....	....	....
Platyceras milleri Nettleroth Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
**Platyceras multispinosum* Meek Falls of the Ohio (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Platyceras nebrascense Meek, 13 Eugene, Edwardsport (C. A. White), Harrison County.	....	....	....	....	....	....	....	....	×	....	×	....
Platyceras quinquesinuatum Ulrich Falls of the Ohio (Ulrich).	....	....	....	×	....	....	....	....	....	....	....	....

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Platyceras rictum Hall Clark County (Nettleroth).				×								
Platyceras serratum Ulrich Falls of the Ohio (Ulrich).				×								
*_Platyceras subundatum_ Conrad Falls of the Ohio.				×								
Platyceras symmetricum Hall Clark County (Nettleroth).				×								
*_Platyceras thetis_ Hall Falls oı the Ohio, Charlestown (Nettleroth).				×								
Platyceras uncum Meek & Worthen, 8 Harrison County and Crawfordsville.						×	×	×				
*_Platyceras ventricosum_ Conrad Clark County (Nettleroth).				×								
*_Platystoma hemisphericum_ Hall Delphi.			×									
Platystoma lineata Hall Clark County (Nettleroth).				×								
Platystoma lineata var. _callosa_ Hall Clark County (Nettleroth).				×								
Platystoma niagarense Hall, 11 and 10 Waldron (Hall), Madison and Carroll County.			×									
Platystoma plebeium H., 11 Waldron (J. Hall).			×									
Platystoma turbinata Hall Falls of the Ohio (Nettleroth).				×								
Platystoma turbinata var. _cochleata_ H. Louisville, Ky. (Nettleroth).				×								
*_Pleuronotus decewi_ Billings, 11 (E. decewi) Falls of the Ohio (Nettleroth), Shelby County				×								
Pleurotomaria arabella Nettleroth Clark County (Nettleroth).				×								
Pleurotomaria bilex Conrad _see_ Cyclonema bilex.												
*_Pleurotomaria carbonarius_ N. & P. Vanderburgh County.											×	
Pleurotomaria concavus Hall, 8 _see_ Eotrochus concavus.												
Pleurotomaria conulus Hall, 12 Spergen Hill (Hall), Washington County.								×				
*_Pleurotomaria elegantula_ Hall, 12 (Murchisonia elegantula) Bloomington (Hall)								×				
*_Pleurotomaria ella_ Hall Delphi.			×									
*_Pleurotomaria grayvillensis_ N. & P. Vanderburgh County and Vigo County.											×	
Pleurotomaria humilis Hall, 12 Bloomington and Spergen Hill (Hall), Washington County.								×				
*_Pleurotomaria hoyi_ Hall Huntington.			×									
*_Pleurotomaria idia_ Hall Huntington (Hall).			×									
Pleurotomaria imitator Hall Charlestown. Falls of the Ohio (Hall).				×								
*_Pleurotomaria lucina_ Hall Charlestown and Bartholomew County.				×								
*_Pleurotomaria lucina_ var _perfasciata_ Hall Falls of the Ohio, Clark County (Nettleroth).				×								
Pleurotomaria leavenworthana _see_ Cyclonema leavenworthana.												

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Pleurotomaria meekana* Hall, 12 Spergen Hill and Bloomington (Hall), Washington County.								×				
Pleurotomaria mitigata Hall R. ckford (James Hall).						×						
**Pleurotomaria nodulostriata* Hall, 12 Spergen Hill and Bloomington (Hall), Washington County.								×				
**Pleurotomaria occidens* Hall Delphi.			×									
Pleurotomaria piasaensis Hall, 15 Washington County.								×				
Pleurotomaria procteri Nettleroth Clark County (Nettleroth).				×								
Pleurotomaria rotundata *see* Pleurotomaria subglobosa.												
**Pleurotomaria shumardi* M. & W., 8 Harrison County and Crawfordsville.							×					
**Pleurotomaria sphaerulata* Conrad, 13 Vanderburgh and Vigo (White).											×	
Pleurotomaria tabulata Conrad., Hall (Hall).											×	
Pleurotomaria subangulatum Hall *see* Cyclonema subangulatum Hall.												
Pleurotomaria subglobosa Hall, 12 (Pleurotomaria rotunda) Spergen Hill and Bloomington.								×				
**Pleurotomaria sulcomarginata* Conrad Watson's Station and Falls of the Ohio (Hall)				×								
Pleurotomaria subconica, Hall Richmond.	×											
Pleurotomaria swallovana Hall, 12 Spergen Hill and Bloomington (Hall), Washington County.								×				
**Pleurotomaria tabulata* Conrad, 10 and 13 Rush Creek, Vigo County, and Posey County (White).											×	
Pleurotomaria textiligera Meek Washington County.						×						
Pleurotomaria trilineata Hall, 12 Spergen Hill (Hall), Washington County.								×				
Pleurotomaria tropidophora Meek Versailles (Miller), Madison (W. S. T. Cornett).	×											
Pleurotomaria turbiniformis M. & W., 13 Vigo County (C. A. Wh te).											×	
Pleurotomaria vadosa H. Rockford (James Hall).						×						
**Pleurotomaria wortheni* Hall, 12 Spergen Hill and Bloomington (Hall), Washington County, Monroe and Harrison Counties.								×				
Polyphemopsis fusiformis Hall, 10 Newport (C. A. White).											×	
Polyphemopsis louisvillae H. & W. Falls of the Ohio (Nettleroth).				×								
Polyphemopsis nitidula M. & W. 11 Vermillion County (C. A. White).											×	
Protowarthia cancellata Hall (Ulrich).	×											
Protowarthia subcompressa Ulrich Versailles (Ulrich).	×											
Raphistoma richmondensis Ulrich Richmond (Ulrich).	×											

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Salpingostoma richmondensis Ulrich Richmond (Ulrich).	×											
Schizolopha moorei Ulrich Richmond (Ulrich).	×											
Soleniscus? (Macrocheilus) medialis M. & W., 13 Vermillion County (C. A. White).											×	
Soleniscus fusiformis Hall (Machrocheilus fusiformis), 7 Vanderburgh County.											×	
Soleniscus (Macrocheilus) paludinaeformis Hall, 13 Vermillion County (C. A. White).											×	
Soleniscus? (Macrocheilus) primigenus Conrad (C. A. White).											×	
Trochonema madisonensis Ulrich Madison (Ulrich).	×											
**Straparollus lens* Hall (E. lens) Rockford (Jas. Hall).						×						
**Straparollus planidorsalis* M. & W. Orange County.									×			
Straparollus quadrivolvis Hall Washington County.								×				
**Straparollus spergensis* Hall (Euomphalus spergensis) Spergen Hill, Greencastle and Monroe County (J. Hall).								×				
Straparollus spergensis var. *planorbiformis* Hall. (E. spergensis var. planorbiformis) Bloomington and Spergen Hill (J. Hall).								×				
Straparollus spirorbis Hall (Euomphalus spirorbis) Rockford (James Hall).						×						
Strophostylus cyclostomus var. *disjunctus* Hall, 11. Waldron (James Hall).			×									
Strophostylus cyclostomus Hall, 11 Waldron (J. Hall).			×									
Strophostylus varians Hall Falls of the Ohio (Nettleroth).				×								
Subulites benedicti Miller, 17 Franklin County.			×									
Temnocheilus coxanum M. & W., 8 Harrison County.								×				
Temnocheilus niotense M. & W., 8 Harrison County.								×				
Trochonema rectilatera Hall Falls of the Ohio (Nettleroth).				×								
Trochonema yandellana Hall & W. Falls of the Ohio (Nettleroth).				×								
Tryblidium indianense Miller, 17 Fayette County.	×											
Tryblidium madisonense Miller, 18 Madison.	×											
Turbo shumardi de Verneuil Clark County (Nettleroth).				×								
PTEROPODA.												
Coleolus spinulus Hall, 11 Waldron.			×									
**Coleolus tenuicinctus* Hall (Coleoprion tenuicinctus) Falls of the Ohio and Charlestown (Hall).				×								

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Conularia crawfordsvillensis R. Owen. Crawfordsville (R. Owen).							×					
Conularia formosa Miller & Dyer. Versailles (Miller & Dyer).	×											
Conularia gratiosa M. & G. Spergen Hill (Miller & Gurley).								×				
Conularia infrequens Hall, 11. Waldron.			×									
Conularia intertexta Miller, 18. West Point.							×					
**Conularia micronema* Meek, 8. Cla k County						×						
**Conularia missouriensis* Swallow, 8 and 10. Harrison County, Washington County and Ellettsville.								×	×			
**Conularia niagarensis* Hall. Grant County and Waldron.			×									
**Conularia newberryi* Winchell, 8. Harrison County and New Albany.						×						
**Conularia quadrisulcata* (?) Miller. Waldron.			×									
**Conularia subcarbonaria* Meek & Worthen, 8. Harrison County, Washington County and Crawfordsville.							×	×				
Conularia subulata Hall, 12. Alton (Hall).								×				
Conularia spergensis M. & G. Spergen Hill (Miller & Gurley).								×				
Hyolithes aculeatus Hall (Puginculus aculeatus) Rockford (James Hall).						×						
Hyolithes (?) *dubius* M. & F. Versailles (M. & F.).	×											
Hyolithes versaillesensis M. & F. Versailles (M & F.).	×											
Puginculus (?) (*Theca*) *aculeatus* H. *see* Hyolithes aculeatus.												
Styliola fissurella Hall (Tentaculites fissurella). New Albany and Scott Counties (Whitfield), Falls of the Ohio (Nettleroth).				×	×							
Tentaculites dexithea Hall. Pendleton (H ll).				×								
**Tentaculites fissurella* Hall *see* Styliola fissurella.												
Tentaculites flexuosa *see* Conchicolites flexuosus.												
**Tentaculites richmondensis* Miller Richmond (Miller) (Hall)	×											
Tentaculites scalariformis Hall Clark County (Nettleroth).				×								
**Tentaculites tenuistriatus* M. & W. Richmond.	×											
Tentaculites niagarensis Hall, 11 Delaware County.			×									
CEPHALOPODA.												
Ascoceras indianensis Newell Delphi (Newell).			×									
Ascoceras newberryi Bell Delphi (Newell)			×									
Cyrtoceras amoenum Miller Richmond (Miller).	×											

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Cyrtoceras howardi Miller, 18 St. Paul.	....	....	×	....	....	....	....	....	....	....	....	....
Cyrtoceras indianense Miller, 17 St. Paul and Hartsville.	....	....	×	....	....	....	....	....	....	....	....	....
Cyrtoceras lamellatum, 6. Madison (Cornett).	×	....	....	....	....	....	....	....	....	....	....	....
**Cyrtoceras ohioensis* Meek Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....
Cyrtoceras tenuiseptum Faber Versailles (Faber).	×	....	....	....	....	....	....	....	....	....	....	....
Cyrtoceras thompsoni Miller, 18. Fayette County.	×	....	....	....	....	....	....	....	....	....	....	....
Endoceras approximatum ? Hall Richmond (Miller).	×	....	....	....	....	....	....	....	....	....	....	....
**Endoceras magniventrum* Hall Madison.	×	....	....	....	....	....	....	....	....	....	....	....
**Endoceras proteiforme* Hall Franklin County.	×	....	....	....	....	....	....	....	....	....	....	....
Gomphoceras clarki Miller, 17. Corydon (Miller).	....	....	....	....	....	....	....	×	....	....	....	....
Gomphoceras indianensis Miller & Faber Versailles and Madison (Miller & Faber).	×	....	....	....	....	....	....	....	....	....	....	....
Gomphoceras linearis Newell Wabash City (Newell).	....	....	×	....	....	....	....	....	....	....	....	....
Gomphoceras minum Beecher Falls of the Ohio (J. Hall).	....	....	....	×	....	....	....	....	....	....	....	....
**Gomphoceras oviforme* Hall Charlestown (Nettleroth).	....	....	....	×	....	....	....	....	....	....	....	....
Gomphoceras projectum Newell Delphi (Newell).	....	....	×	....	....	....	....	....	....	....	....	....
**Gomphoceras raphanus* Hall Charlestown.	....	....	....	×	....	....	....	....	....	....	....	....
**Gomphoceras septore* Hall, 11 Delaware County, Delphi and Wabash.	....	....	×	....	....	....	....	....	....	....	....	....
**Gomphoceras subgracile* Hall Delphi. Wabash and Charlestown.	....	....	×	....	....	....	....	....	....	....	....	....
**Gomphoceras turbiniforme* M. & W. Charlestown (Meek & Worthen), (Nettleroth)	....	....	....	×	....	....	....	....	....	....	....	....
Gomphoceras wabashensis Newell, 17. Delphi (Newell) Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
Goniatites brownensis Miller, 17. Brown County (Miller).	....	....	....	....	....	×	....	....	....	....	....	....
Goniatites discoideus Hall Falls of the Ohio (Nettleroth).	....	....	×	....	....	....	....	....	....	....	....	....
Goniatites greeni Miller, 18, New Albany.	....	....	....	....	....	×	....	....	....	....	....	....
Goniatites greencastlensis Miller & Gurley Gre ncastle (Miller & Gurley).	....	....	....	....	....	....	....	×	....	....	....	....
Goniatites hyas Hall *see* G. lyoni.	....	....	....	....	....	....	....	....	....	....	....	....
Goniatites indianensis Miller, 17 Clark County (Miller).	....	....	....	....	....	×	....	....	....	....	....	....
**Goniatites ixion* Hall (G. rotatorius) Scott County and Rockford (J. Hall).	....	....	....	....	....	×	....	....	....	....	....	....
**Goniatites lyoni* M. & W. Rockford (Meek & Worthen).	....	....	....	....	....	×	....	....	....	....	....	....
**Goniatites oweni* Hall, 10. Scott County and Rockford.	....	....	....	....	....	×	....	....	....	....	....	....
**Goniatites oweni* var. *parallelus* Hall Rockford (J. Hall).	....	....	....	....	....	×	....	....	....	....	....	....
Goniatites rotatorius de Kon ? *see* G. ixion.	....	....	....	....	....	....	....	....	....	....	....	....

	Ordovician.	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Gyroceras abruptum Hall, 11 Waldron.			×									
Gyroceras baeri M. & W. (Trochoceras baeri), Richmond (Miller) & (Meek).	×											
**Gyroceras elrodi* White, 11 Hartsville, St. Paul and Delaware County.			×									
**Gyroceras gracile* Hall Rockford (J. Hall).						×						
**Gyroceras inelegans* Meek Falls of the Ohio.				×								
**Gyroceras spinosum* Conrad Logansport.				×								
Gyroceras? rockfordensis M. & W. Rockford (Meek & Worthen).						×						
Hexameroceras cacabiformis Newall, 17 Wabash County.			×									
Hexameroceras delphicolum Newell Delphi (Newell).			×									
Kionoceras columnare Hall (O. columnare) Wabash City (Newell).			×									
Kionoceras strix H. & W. (O. strix), 17 Wabash City (Newell), Delphi and Grant County.			×									
Lituites bickmoreanus Whitfield, 17 Wabash County.			×									
Lituites graftonensis M. & W., 17 Wabash County.			×									
**Lituites marshi* Hall, 11 and 17 Wabash County, Dela are County.			×									
Lituites multicostatus Whitfield, 17 Wabash County.			×									
**Nautilus clarkanus* Hall Spergen Hill (Hall), Washington and Tippecanoe Counties.								×				
Nautilus (*Solenochilus*) *collectus* M. & W. *see* Solenchilus collectum.												
**Nautilus coxanus*, 12 *see* T mnochilus coxanum.												
**Nautilus decoratus* Cox Vanderburgh, Clay and Vigo Counties and Greencastle.								×				
Nautilus digonus M. & W. *see* Trematodiscus digonus.												
Nautilus forbesianus McChesney, 13 Newport (C. A. White).											×	
Nautilus maximus Conrad Falls of the Ohio (Nettleroth).				×								
Nautilus missouriensis Swall?, 13 Fountain Connty (C. A. White).											×	
**Nautilus occidentalis* Swallow Dubois County.											×	
Nautilus oceanus Hall, 11 Waldron.			×									
**Nautilus planorbiformis* M. & W. Dubois County.											×	
**Nautilus* (*Cryptoceras*) *rockfordensis* M. & W. Rockford (Meek & Worthen).						×						
Nautilus trisulcatus M. & W. *see* Trematodiscus trisulcatus.												
Nautilus (*Discus*) *trisulcatus* M. & W. Rockford (Meek & Worthen).						×						
Nautilus winslowi M. & W., 13 *see* Temnochilus winslowi.												

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Ormoceras tenuifilum Hall, 6 Madison (W. S. T. Cornett).	×											
Orthoceras amycus Hall Waldron.			×									
* *Orthoceras annulatum* Sowerby, 11 Newton County, Grant County, St. Paul and Hartsville.			×									
Orthoceras bilineatum, 6 Madison (W. S. T. Cornett).	×											
Orthoceras caldwellensis Miller & Gurley Clark County (Mil er & Gurley).				×								
* *Orthoceras clavatum* Hall North Vernon.			×									
* *Orthoceras columnare* Hall, 17 *see* Kionoceras columnare.			×									
* *Orthoceras crebescens* Hall, 11 Wabash County, Grant County, Delaware County, Miami County and North Vernon.			×									
* *Orthoceras crebristriatum* M. & W. Waldron.			×									
Orthoceras epigrus Hall, 12 Spergen Hill (Hall), Lanesville.								×				
Orthoceras expansum Meek & Worthen, 8 Harrison County.							×	×				
Orthoceras franklinense Miller, 18 Franklin County.			×									
Orthoceras gorbyi Miller 18 Franklin County.	×											
Orthoceras (eu-orthoceras?) hanoverensis Foerste. Hanover (Foerste).		×										
* *Orthoceras heterocinctum* Winch. Rockford						×						
Orthoceras icarus Beecher Rockford (J. Hall).						×						
Orthoceras (eu-orthoceras?) ignotum Foerste Hanover (Foerste).		×										
* *Orthoceras imbricatum* Sowerby St. Paul.			×									
Orthoceras indianense Hall Rockford (J. Hall).						×						
Orthoceras junceum Hall Madison (W. S. T. Cornett)	×											
Orthoceras longicameratum Hall Waldron.			×									
Orthoceras marcellensis Vanuxem Rockford (J. Hall).						×						
Orthoceras medulare Hall, 11 Waldron.			×									
Orthoceras mohri Miller Versailles (Miller).	×											
Orthoceras obstructum Newell, 17 Wabash County (Newell).			×									
Orthoceras rigidium Hall, 17 Peru (Newell), Wabash County,			×									
* *Orthoceras rushense* McChesney, 13 Eugene, Newport, Lodi, Merom, Graysville, New Harmony, Newberg and Vanderburgh County.											×	
* *Orthoceras simulator* Hall, 11 Waldron (J. Hall), Newton County and Carroll County.			×									
Orthoceras spinale Madison (W. S. T. Cornett).	×											

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Orthoceras subcancellatum* Hall, 11 St. Paul and Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Orthoceras subulatum* Hall Waldron.	....	....	×	....	....	....	....	....	....	....	....	....
**Orthoceras strix* Hall, 17 *see* Kinoceras strix.	....	....	....	....	....	....	....	....	....	....	....	....
Orthoceras unionense Worthen, 17 Wabash County (Newell).	....	....	×	....	....	....	....	....	....	....	....	....
**Orthoceras whiti* Winch. Rockford.	....	....	....	....	....	×	....	....	....	....	....	....
Orthoceras winchelli M. & W. Greencastle.	....	....	....	....	....	....	....	×	....	....	....	....
Orthoceras (Actinoceras) youngi Foerste Hanover (Foerste).	....	×	....	....	....	....	....	....	....	....	....	....
Pentameroceras mirum Barrande Delphi (Newell).	....	....	×	....	....	....	....	....	....	....	....	....
Phragmoceras angustum Newell, 17 Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
**Phragmoceras ellipticum* H. & W. Clark County, Grant County and Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
**Phragmoceras linearis* New. Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
**Phragmoceras nestor* Hall, 17 Grant County, Marion and Monon.	....	....	×	....	....	....	....	....	....	....	....	....
**Phragmoceras parvum* H. & W. Grant County	....	....	×	....	....	....	....	....	....	....	....	....
Phragmoceras projectum Newell, 17 Wabash County	....	....	×	....	....	....	....	....	....	....	....	....
Phragmoceras walshi? M. & W. Jeffersonville.	....	....	....	×	....	....	....	....	....	....	....	....
Remeleceras clarkense Miller & Gurley Sampson Springs, Clark County (Miller & Gurley).	....	....	....	....	....	×	....	....	....	....	....	....
Soleniscus rockfordense Miller, 17 Rockford.	....	....	....	....	....	×	....	....	....	....	....	....
Solenochilus henryvillensis M. & G. Henryville (Miller & Gurley).	....	....	....	....	....	×	....	....	....	....	....	....
Solenochilus rockfordense Miller Rockford (Miller).	....	....	....	....	....	×	....	....	....	....	....	....
Streptodiscus indianensis Miller, 18 West Point.	....	....	....	....	....	....	×	....	....	....	....	....
**Temnocheilus coxanum* Meek & Worthen, 8 Orange County and Greencastle.	....	....	....	....	....	....	....	×	....	....	....	....
Temnocheilus niotense M. & W., 8 Harrison County.	....	....	....	....	....	....	....	×	....	....	....	....
**Temnocheilus winslowi* M. & W. (Nautilus winslowi) Danville and Dubois Counties (C. A. White).	....	....	....	....	....	....	....	....	....	....	×	....
Trematodiscus digonus M. & W. (Nautilus digonus) Jackson County.	....	....	....	....	....	×	....	....	....	....	....	....
Trematodiscus trisulcatus M. & W. (Nautilus trisulcatus) Rock ord (Meek & Worthen).	....	....	....	....	....	×	....	....	....	....	....	....
Trochoceras desplainense McChesney, 17 Wabash County.	....	....	×	....	....	....	....	....	....	....	....	....
Trochoceras (?) baeri M. & W. *see* Gyroceras baeri.	....	....	....	....	....	....	....	....	....	....	....	....
**Trochoceras waldronense*, 11 Waldron (Hall).	....	....	×	....	....	....	....	....	....	....	....	....

	Ordovician	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia	Mansfield.	Coal Measures.	Drift
ARTHROPODA.												
CLASS CRUSTACEA.												
PALEOSTRACA.												
Acidaspis fimbriata Hall, 11 Waldron.			×									
Asaphus gigas De Kay, 6. (Isotelus gigas) Madison (Cornett), Ripley County.	×											
Asaphus megistus Locke, 7 Ripley County.	×											
**Calymene blumenbachii* *see* Calymene niagarensis.												
Calymene nasuta Ulrich Osgood, Ripley County (Miller).			×									
**Calymene niagarensis* Hall, 11 (C. blumenbachii) Waldron (Hall), Wabash County, Jefferson County, Fayette County, Ripley County, Miami County and Madison.	×		×									
Calymene callicephala Green (C. senaria) Richmond (Meek), Franklin County.	×											
Calymene platys Green Falls of the Ohio (Hall & Clark).				×								
Calymene senaria Conrad, 10 *see* C. callicephala.												
Ceraurus icarus Billings Richmond (Meek).	×											
**Ceraurus* (Cheirurus) *niagarensis* Hall, 11 Waldron and Marion County (Hall).			×									
**Cyphaspis christyi* Hall, 11 Waldron.			×									
Carcinosoma ingens Claypole Kokomo (Claypole).			×									
Carcinosoma newlini Cl ypole Kokomo (Claypole).			×									
Dalmania calypso Hall *see* Dalmanites calypso.												
Dalmania pleione *see* Dalmanites pleione.												
Dalmania limuluris *see* Dalmanites limulurus.												
Dalmanites anchiops var. *sobrinus* H. & C. Falls of the Ohio (Hall & Clarke).				×								
Dalmanites (*Coronura*) *aspectans* Conrad Falls of the Ohio (Hall & Clarke).				×								
Dalmanites bicornis Hall, 11 Waldron (James Hall).			×									
Dalmanites carleyi Meek, 6 Madison (Cornett).			×									
Dalmanites (*Chasmops*) *calypso* Hall Falls f the Ohio (Hall & Clarke).				×								
**Dalmanites limulurus* Green (Dalmania limulurus) Madison and Jefferson Counties (Cornett).												
**Dalmanites micrurus* Green Louisville, Ky.			×									
**Dalmanites ohioensis* Meek & Worthen Madison and Falls of the Ohio.				×								
Dalmanites (*Cryphaeus*) *plieone* Hall (Dalmania pleione) Falls of the Ohio and Jennings County (Hall & Clarke).				×								

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
**Dalamites pleuropteryx* Green Louisville, Ky.			×									
**Dalmanites verrucosus* Hall, 11 Waldron (James Hall).			×									
**Dalmanites vigilans* Hall, 11 Waldron (James Hall).			×									
Encrinurus punctatus Wahlenberg Hanover (Foerste).		×										
Euproops colletti White, 13 Vigo County (White).											×	
Eurypterus kokomoensis Miller & Gurley Kokomo (Miller & Gurley).			×									
Eurypterus lacustris Claypole Kokomo (Claypole).			×									
**Homalonotus delphinocephalus* Green 11 Waldron (James Hall).			×									
Illaenus ambiguus Foerste Hanover (Foerste).		×										
**Illaenus armatus* Hall, 11 Waldron (James Hall).			×									
Illaenus daytonensis H. & W. Osgood (Foerste).		×										
Illaenus insignus Hall, 6 Madison.		×										
Illaenus madisonensis Foerste Osgood (Foerste).		×										
**Illaenus ioxus* Hall, 11 Renessalear & Waldron.			×									
**Isotelus gigas* *see* Asaphas gigas. Richmond.												
Lichas boltoni var. *occidentalis* Hall, 11 Waldron (James Hall).			×									
**Lichas breviceps* Hall, 11 Waldron & Charlestown (James Hall), Hanover (Foerste).		×	×									
Lychas byrnesanus M. & G. Madison (Miller & Gurley).			×									
Lichas emarginatus Hall Waldron (James Hall).			×									
Lichas hanoverensis M. & G. Hanover (Miller & Gurley).			×									
**Phacops bufo* Green Charlestown, N. Vernon and Falls of the Ohio (Miller & Gurley).				×								
Phacops cristata var. *pipa* H. & C. Falls of the Ohio (Hall & Clarke).				×								
Phacops gallicephalus, 6 Madison (Cornett).	×											
**Phillipsia bufo* M. & W., 10 Spergen Hill (Whitfield), Crawfordsville, Jacksonville and Harrison County.							×	×				
Phillipsia doris (Hall), Winch. (Proteus doris) Rockford (Herrick), (Hall).						×						
**Phillipsia meramecensis* Shumard Lanesville and Bloomington.								×				
**Phillipsia portlocki* M. & W. Harrison County and Washington.							×	×				
Phillipsia rockfordensis Winch. Rockford (Herrick).						×						
Phillipsia (*Griffithides?*) *sangamonensis* M. & W. Perrysville, Eugene, Lodi, Silverwood, Newport and Dubois County (C. A. White)											×	

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Phillipsia (*Griffithides*) *scitula* M. & W., 13											×	
Perryville, Eugene, Lodi, Silverwood and Newport (C. A. White).												
Phillipsia seminifera Morrison, 8								×				
Harrison County.												
**Phillipsia stevensoni* Meek									×			
Orange County.												
Piliolites ohioensis Cozzens				×								
Falls of the Ohio (Cozzens).												
Proëtus canaliculatus Hall & Clark				×								
Falls of the Ohio (Hall & Clarke).												
Proëtus clarus Hall				×								
Falls of the Ohio (Jas. Hall & J. M. Clarke).												
**Proëtus crassimarginatus* Hall				×								
Falls of the Ohio (Hall).												
‡*Proëtus curvimarginatus* H. & C.												
Pendleton (Hall & Clark).												
‡Schoharie grit (Hall & Clark).												
Proëtus determinatus Foerste		×										
Ripley County (Foerste).												
Proëtus doris Hall												
see Phillipsia doris.												
‡*Proëtus latimarginatus* H. & C.												
Pendleton (Hall & Clark).												
**Proëtus longicaudus* Hall				×								
Falls of the Ohio.												
Proëtus microgemma H. & C.				×								
Falls of the Ohio (Hall & Clark).												
**Proëtus planimarginatus* Meek				×								
Madison, Falls of the Ohio.												
EUOSTRACA.												
Macrocaris gorbyi Miller, 18							×					
West Point.												
ENTOMOSTRACA.												
Aparchites inornatus Ulrich				×								
Falls of the Ohio (E. O. Ulrich).												
Barychilina puncto-striata Ulrich				×								
Barychilina puncto-striata var. *custa* Ulrich				×								
Falls of the Ohio (Ulrich).												
Barychilina pulchella Ulrich				×								
Falls of the Ohio (Ulrich).												
Beyrichia chambersi Miller	×											
Richmond (Miller).												
Beyrichia granulosa Hall, 11			×									
Waldron (Hall).												
Beyrichia hammelli M. & F.	×											
Versailles (M. & F.).												
Beyrichia (? *Depranella*) *kalmodina* Jones				×								
Falls of the Ohio (Ulrich).												
Beyrichia lyoni Ulrich				×								
Falls of the Ohio (Ulrich).												
Beyrichia striato-marginatus Miller	×											
Osgood (Miller).												
Bollia obesa Ulrich				×								
Falls of the Ohio (Ulrich).												
Bollia pumila Ulrich				? ×								
Weisburg.												

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Bythrocypris indianense Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Bythocypris punctulata Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Ceratopsis chambersi Miller Richmond and Versailles (A. E. Ulrich.)	×											
Ctenobolbina (? Bollia) antespinosa Ulrich Falls of the Ohio (Ulrich).				×								
Ctenobolbina informis Ulrich Falls of the Ohio.				×								
Ctenobolbina papillosa Ulrich Falls of the Ohio (Ulrich).				×								
Cythere carbonaria Hall *see* Leperditia carbonaria.												
Cytherellina glandella Whitfield *see* Cytheropsis glandella.												
Cytheropsis glandella Whitfield Spergen Hill (R. P. Whitfield).								×				
Entomis madisonensis Ulrich Madison (Ulrich).	×											
Entomis waldronensis Ulrich Waldron (Ulrich).		×										
Eurychilina striatomarginata Miller Osgood (S. A. Miller).	×											
Halliella retifera Ulrich Falls of the Ohio (Ulrich).				×								
Isochilina rectangularis Ulrich Falls of the Ohio (Ulrich).				×								
Kirkbya subquadrata Ulrich Falls of the Ohio (Ulrich).				×								
Labichia montifera Ulrich Madison (Ulrich).	×											
Leaia tricarinata Meek & Worthen Vermillion County (C. A. White), Vigo County.											×	
Leperditia caecigena Miller Madison (E. O. Ulrich), Versailles and Osgood (Miller).	×											
Leperditia carbonaria Hall, 12 (Cythere carbonaria) Bloomington and Lanesville, and Washington County.								×				
Leperditia faba Hall Waldron (J. Hall).			×									
Leperditia (?) *subrotunda* Ulrich Falls of the Ohio (E. O. Ulrich).				×								
Octonaria clavigera Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Octonaria devonica Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Octonaria ovata Ulrich Falls of the Ohio (E. O. Ulrich).				×								
Octonaria stigmata Ulrich Falls of the Ohio (E. O. Ulrich).				×								
Octonaria stigmata var. *loculosa* Ulrich Falls of the Ohio (E. O. Ulrich).				×								
Octonaria stigmata var. *oblonga* Ulrich Falls of the Ohio (E. O Ulrich).				×								
Pachydomella tumida Ulrich Falls of the Ohio (A. E. Ulrich).				×								
Strepula quadrilirata var. *simplex* Weisburg (Ulrich).	×											
Tetradella quadrilirata H. & W. Richmond and Versailles (Ulrich).	×											

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INSECTA.												
Paoli vetusta S. I. Smith, 20 French Lick.										×		
PISCES.												
Antilodus arcuatus N. & W. Greencastle (Newberry).								×				
Antliodus minutis N. W. Harrison County (Newberry).								×				
Antliodus similis Newberry & Worthen Harrison County (Newberry).							×					
Archaeobatis gigas New. Greencastle (Newberry).								×				
Aspidotus crenulatus Newberry & Worthen *see* Psephodus crenulatus.												
Chomatodus angustus Newberry Harrison County (Newberry).								×				
Chomatodus obliquus Newberry Harrison County (Newberry).								×				
Chomatodus pusillus N. & W., 8 Harrison County (Collett).								×				
Chomatodus selliformis Newberry Harrison County (Newberry).								×				
Cladodus graciles N. & W. Posey County (Newberry & Worthen).											×	
Ctenoptychius semicircularis N. & W. *see* Peripristis semicircularis.												
Deltodus cinctus St. John & Worthen Harrison County (Newberry).								×				
Deltodus grandis? N. & W. Harrison County (Newberry).								×				
Deltodus spatulatus N. & W. Harrison County (Newberry).							×					
Diplodus compressus Newberry Posey County (Newberry & Worthen).											×	
Diplodus latus Newberry Posey County (Newberry & Worthen).											×	
Edestus heinrichsi N. & W. Vermillion County, Parke County (Hitchcock) (Newberry).											×	
Edestus minor Newberry Posey County (Newberry & Worthen).											×	
Helodus coniculus Newberry & Worthen Harrison County (Newberry).								×				
Helodus laevis Newberry Harrison County (Newberry).								×				
Labodus marginatus Greencastle (Newberry).								×				
Lisgodus affinis Newberry Harrison County (Newberry).								×				
Macropetalichthys rapheidolabis Norwood & Owen (Norwood & Owen) Falls of the Ohio.				×								
Orodus colletti Newberry Harrison County (Newberry).								×				
Orodus elegantulus N. & W. Harrison County (Newberry).							×					
Orodus multicarinatus N. & W. Rockford (Norwood & Worthen).						×						
Orodus ornatus N. & W. Harrison County (Newberry).							×					

	Ordovician	Silurian.		Devonian.		Carboniferous.						Quaternary.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures	Drift.
Orthopleurodus carbonarius New. & W. Posey County (St. John & Worthen).											×	
Petalodus knappi Newberry Harrison County (Newberry).							×					
Peripristis semicircularis N. & W. (Ctenoptychius semicircularis) Posey County (Newberry & Worthen).											×	
Petrodus occidentalis (Newberry & Worthen), 7 Vigo County, Clay County, Vanderburgh County, Owen County.											×	
Sandalodus minor New. & Worthen (Trigonodus minor) Harrison County (Newberry).								×				
Taeniodus regularis St. John & Worthen Bedford (St. John & Worthen).								×				
Thrinacodus bicornis Newberry Harrison County (Newberry).								×				
Trigonodus minor N. & W. *see* Sandalodus minor.												
Polyrhizodus littoni N. & W. Greencastle (Newberry).								×				
Psammodus glyptus St. J. & W. Greencastle (Newberry).								×				
MAMMALIA.												
Cariacus dolichopsis Cope, 15 Harrison County.												×
Castoroides ohioensis Foster, 15 Richmond, Hancock County, near Greenfield, Randolph County (J. Moore), Vanderburgh, Carroll and Kosciusko Counties.												×
Cervus virginianus Wabash County.												×
Dicotyles nasutus Leidy, 15 Gibson County.												×
Dicotyles torquatus?, 15												×
Elephas americanus Blum, 15 Vigo, Parke, Vermillion, Wayne, Putnam, Vanderburgh and Montgomery Counties.												×
Elephas primigenius, 15 Clinton and Wabash Counties.												×
Equus fraternus Leidy, 15												×
Equus major DeKay, 15												×
Mastodon americanus Blum., 15 Covington, Fountain County, and Wabash County.												×
Megalonyx jeffersoni Cuv., 15 Henderson, Ky.												×
Platygonus compressus Le Conte, 15 Laketon, Wabash County.												×
Tapirus terrestris? 15 Evansville.												×
PLANTAE.												
Alethopteris grandiflora Newberry, 7 Vigo County.											×	
Alethopteris niagarensis, 7 Vigo County.											×	

	ORDOVICIAN	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Annularia longifolia Brongniart, 10 Vigo County, Shelburn.											×	
Annularia sphenophylloides Zuker, 7 Vigo County.											×	
Asterophycus coxii Lesquereux, 13 New Harmony.											×	
Asterophyllites equisetiformis Scholt Clay County.											×	
Buthrotrephis graciles var. *crassa* Hall, 11 Waldron (J. Hall).			×									
Calamites canniformis Schlotheim, 8 Harrison County.										×	×	
Callipteridium sullivanti Lesq. (Callipteris sullivanti), 10 Spring Creek and Perrysville.											×	
Callipteris sullivanti *see* Callipteridium sullivanti.												
Carpolithes fasciculatus Lesqx., 8 Harrison County.										×		
Caulerpites marginatus Lesquereux ? 8 Harrison County.						×			×	×		
Chondrites colletti Lesquereux, 8 *see* Taonurus colletti.												
Cordaites angustifolius Lesquereux, 8 *see* Cordaites diversifolius.												
Cordaites borassifolia Sternb., 8 Harrison County, Montgomery County, Vigo County and Clay County.										×	×	
Coradites diversifolius Lesq. (C. angustifolius) Clay County, Vigo County and Harrison County.										×	×	
Cyclopteris elegans Lesq., 7 Vigo County.											×	
Hymenophyllites alata *see* Sphenopteris alata.												
Hymenophyllites primatifidus Lesq., 7 Vigo County.											×	
Lepidodendren aculeatum Sternberg									×			
Lepidodendron dichotomum Sternberg Orange County (Lesquereux).										×		
Lepidodendron diplostegiodes Lesq									×			
Lepidodendron elegans Sternberg, 7 Vigo County.											×	
Lepidodendron forulatum Lesq									×			
Lepidodendron obovatum Sternberg Orange County.										×?		
Lepidodendron rushvillense Orange County (Lesquereux).										×		
Lepidodendron veltheimianum Sternberg Orange County (David White).										×?		
Lepidophloios macrolepidotus Goldf., 13 Orange County (Lesquereux) Grape Creek.										×		
Lepidophyllum brevifolium Lesqx., 8 Harrison County.										×		
Lepidophyllum imbricata Sternberg? 8 Harrison County.										×		
Lycopodites strictus Lesqx New Harmony (Lesquereux).											×	
Neuropteris biformis Lesqx French Lick (David White).										×		

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Neuropteris collinsi Lesqx. Vigo County.											×	
Neuropteris elrodi Lesqx. Orange County (Lesquereux).										×	×	
Neuropteris hirsuta Lesqx. Shelburn, Sullivan County, Spring Creek, Vermillion County (C. A. White), Vigo County and Clay County.											×	
Neuropteris loshi Brong., 7 Vigo County.											×	
Neuropteris rarinervis Bunbury, 10 Clay County and Vigo County (C. A. White.)											×	
Neuropteris smithsii Lesqx. ? Orange County (David White).										×		
Odontopteris subcuneata Bunbury, 10 Vermillion County (C. A. White), Spring Creek.											×	
Paleophycus divaricatum Lesq., 13 Salt Creek, Vigo County (Lesquereux).											×	
Paleophycus gracile Lesq., 13 Salt Creek, Vigo County (Lesquereux).											×	
Palaeophycus lineare Duden New Albany.					×							
Paleophycus milleri Lesq., 13 Salt Creek, Vigo County (Lesquereux).											×	
Palaeophycus new-albense Duden New Albany (Duden).					×							
Paleoxyris corrugatum *see* Spirangium corrugatum.												
Paleoxyris prendelli *see* Spirangium prendelli.												
Parenchymophycus asphalticum Duden New Albany (Duden).					×							
Pecopteris callosa *see* Pseudopecopteris callosa.												
Pecopteris arborescens Scholtheim Vigo County.											×	
Pseudopecopteris callosa Lesq. (Pecopteris callosa) Vigo County.											×	
Pseudopecopteris latifolia Brongn. (Sphenopteris latifolia) Orange County (Lesquereux).										×		
Pseudopecopteris muricata Brongn., 13 and 20 Orange County (Lesquereux) and (David White).										×		
Rhacophyllum flabellatum Sternb., 13 (Lesquereaux.)									×			
Sigillaria menardi Brongniart, 7 Vigo County.											×	
Sigillaria obovata Lesq., 7 Vigo County.											×	
Sigillaria oculata Scholtheim, 7 Vigo County.											×	
Sigillaria reniformis? Brongn., 8 Harrison County.									×			
Sphenophyllum emarginatum Brongn., 11 Warren County.											×	
Sphenophyllum schlotheimii Brongn., 11 Vigo and Clay Counties.											×	
Sphenopteris alata Brongniart (Hymenophylites alata) Vigo County.											×	

	ORDOVICIAN.	SILURIAN.		DEVONIAN.		CARBONIFEROUS.						QUATERNARY.
	Cincinnati.	Clinton.	Niagara and Water Lime.	Corniferous and Hamilton.	New Albany Shale.	Knobstone and Rockford Limestone.	Burlington and Keokuk.	Warsaw and St. Louis.	Kaskaskia.	Mansfield.	Coal Measures.	Drift.
Sphenopteris hoeninghausii (Brongn.), 20 Orange County (David White).	....	....	....	....	....	....	....	....	....	×	....	....
Sphenopteris latifolia Brongniart... *see* Pseudopecopteris latifolia.	....	....	....	....	....	....	....	....	....	....	....	....
Sphenopterus tridactylites Brongn. Orange County (Lesquereux).	....	....	....	....	....	....	....	....	....	×	....	....
Spirangium prendeli Lesq. (Paleoxyris prendelli) Vigo County.	....	....	....	....	....	....	....	....	....	....	×	....
Sporangites radiatus Duden, 21 New Albany (Duden).	....	....	....	....	×	....	....	....	....	....	....	....
Stigmaria ficoides Brongn., 8 Monroe and Harrison Counties.	....	....	....	....	....	....	....	....	×	×	....	....
Stigmaria hightoweri Kront. Crawfordsville.	....	....	....	....	....	....	×	....	....	....	....	....
Stigmaria stellata Goeppert, 8 Harrison County.	....	....	....	....	....	....	....	....	....	×	....	....
Stigmaria undulata Goeppert?, 8 Harrison County.	....	....	....	....	....	....	....	....	....	×	....	....

PART II. BIBLIOGRAPHY OF INDIANA PALEONTOLOGY.

1889. BEECHER, E. C., AND CLARK, JOHN M. The development of some Silurian Brachiopoda. Mem. N. Y. State Mus , Vol. 1, No. 1, pp. 1–95, pls. I–VIII, Oct., 1889. The material described is from the Niagara group at Waldron.

1888. BEECHLER, CHAS. Corrected list of fossils found at Crawfordsville, Indiana. 16th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., 1888, pp. 65–76. This list indicates where each of the species noted was figured and described.

1888. BEECHLER, CHAS. Keokuk group at Crawfordsville, Indiana. Am. Geol., Vol. 2, pp. 407–412. Gives a list of fossils occurring there.

1891. BEECHLER, CHAS. The rocks at St. Paul, Indiana, and vicinity. Am. Geol., Vol. 7, 1891, p. 179. Divides the beds at St. Paul into five horizons.

1873. BORDEN, W. W. Clark and Floyd Counties. Geol. Surv. of Ind., 1873, pp. 134–189.

1874. BORDEN, W. W. Jefferson County. Geol. Surv. of Ind., 1874, pp. 135–186. Gives sections through Devonian and Niagara rocks, with a few of the characteristic fossils of the different horizons; also Whitfield's determinations of Black Shale fossils.

1874. BORDEN, W. W. Scott County. 6th Ann. Rep't Geol. Surv. of Ind., 1874, pp. 112–134. Gives list of the New Albany Shale fossils found in Scott County, also list of fossils from the limestone at Falls of the Ohio and Silver Creek, Clark County.

1875. BORDEN, W. W. Jennings County. Geol. Surv. of Ind., 1875, pp. 146–180. The more common New Albany Shale fossils found in the county are mentioned.

1875. BORDEN, W. W. Geol. Surv. of Ind., 1875, Ripley County, pp. 181–202. The author gives a number of Lower Silurian fossils, with their relative positions in sections of these rocks.

1883. BROWN, R. T. List of fossils in Morgan County. 13th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., p. 85. Includes species from Knobstone, Keokuk and St. Louis groups

1854. CASSEDAY, SAMUEL A. Abdruck, a. d. Zeitschr. d. deutscher geologischen Gesellschaft, Jahrg., 1854, p. 237. Describes the new genus *Batocrinus* and two new species of the same from Spergen Hill. For translation of same see 18th Rep't Ind. Dept. of Geol. and Nat. Hist., 1893.

1860. CASSEDAY, S. A. AND LYON, S. S. Description of two new genera and eight new species of fossil Crinoidae from the rocks of Indiana and Kentucky. Proc. Am. Acad. of Arts and Sci., Vol. V, 1860, pp. 16–31. Describes two new species without figures from the Subcarboniferous of Montgomery County: *Dichocrinus polydactylus* and *Dichocrinus ficus*.

1851. CHRISTY, D. On the Goniatite limestone of Rockford, Jackson County, Indiana. Proc. Am. Assoc. Adv. Sci., Vol. 5, 1851, pp. 76–80. The Goniatites are stated to occur in a limestone in the middle of the Black Shale.

1843. CLAPP, A. The geological equivalents of the vicinity of New Albany, Indiana, as compared with those described in the Silurian system of Murchison. Phila. Acad. of Sci. Proc., Vol. I, pp. 18–19, 171–178, 1843.

1890. CLAYPOLE, E. W. Paleontological notes from Indianapolis. Am. Geol., Vol. 5, pp. 255–260, 2 figs. *Eurysoma newlini*, a new genus and species from the Waterlime beds at Kokomo, is described. *Eurypterus lacustris* is reported from the same locality.

1894. CLAYPOLE, E. W. A new species of Carcinosoma. Am. Geol., Vol. 13, 1894, pp. 77–79, pl. 4. Describes a new species, *C. ingens*, from the Waterlime beds at Kokomo. *Carcinosoma* is proposed in place of *Eurysoma*, which was preoccupied.

1873. COLLETT, JOHN. Geology of Lawrence, Knox and Gibson Counties. Ind. Geol. Surv., 1873, pp. 260–430. Mention is made of fossils noted in local sections.

1875. COLLETT, JOHN. List of fossils found in the Keokuk group at Crawfordsville, Indiana. 7th Ann. Rep't Geol. Surv. of Ind., 1875, pp. 376–381.

1880. COLLETT, JOHN. Geology of Putnam County. Rep't Geol. Surv. Ind., pp. 397–422, 1880. Gives lists of the more common fossils found in the Chester, St. Louis, Keokuk and Knobstone groups.

1882. COLLETT, JOHN. Geological Survey of Jasper County. 12th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., 1882, pp. 65–76. Gives lists of fossils found in the county.

1883. COLLETT, JOHN. Geology of Posey County. 13th Ann. Rep't Ind Dept. Geol. and Nat. Hist., 1883, pp. 45–68. A number of Coal Measure fossils are noted.

1879. COPE, E. D. The relations of the horizons of extinct vertebrata of Europe and North America. U. S. Geol. and Geog. Surv. of the Territories, Bull. Vol. V, pp. 33–54, 1879.

1884. COPE, E. D., AND WORTMAN, J. L. Postpliocene vertebrates of Indiana. 14th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., 1884, pp. 3–41.

1842. CONRAD, T. A. Observations on the Silurian and Devonian systems of the United States, with descriptions of new organic remains. Jour. Acad. Nat. Sci. Phila., Vol. 8, pp. 228–280, pl. 12–17. Three new species from Silurian rocks are described: *Delthyris acutilirata*, *Atrapa capax*, and *Pleurotomaria bilex*.

1855. CONRAD, T. A. Description of a new species of Pentamerus. Proc. Phila. Acad. Nat. Sci., 1855, p. 441. Describes *P. laqueatus* from Delphi, Indiana.

1858. NORWOOD AND PRATTEN. Notice of *Producti* found in the Western States and Territories, with description of twelve new species. Proc. Phila. Acad. Nat. Sci., Vol. 3, 2d ser., pp. 5–20, pls. 1–2.

1874. CORNETT, W. T. S. List of fossils found in Jefferson County, Indiana. Geol. Surv. of Ind., 1874, pp. 182–186.

1874. CORNETT, W. T. S. Indianapolis Journal, July 10, 1874. Geology of the Madison hills. The author announces the discovery of a stratum of Lower Silurian fossils in rocks called Upper Silurian in Borden's report.

1875. CORNETT, W. T. S. Geol. Survey of Ind., 1875, p. 183. Letter to W. W. Borden concerning the discovery of Lower Silurian fossils in strata previously considered Upper Silurian.

1870. COX, E. T. Dubois and Pike Counties. 2d Ann. Rep't Geol. Surv. Ind., pp. 192–287. Gives lists of fossils from different sections.

1875. COX, E. T. Vanderburg, Owen, and Montgomery Counties. Geol. Surv. Ind., 1875, pp. 240–422. Gives list of fossils from Crawfordsville.

1875. COX, E. T. Huntington County. Geol. Survey of Ind., 1875, p. 124. He names seven species of Brachiopoda and corals from the Niagara of Huntington County, Indiana.

1875. COX, E. T. Vigo County. Geol. Survey of Ind., 1875, pp. 78–115. Several species of Coal Measure fossils are noted in connection with geological sections.

1848. COZZENS, ISAACHAR. Description of three fossils from the Falls of the Ohio. Ann. N. Y. Lyceum, Nat. Hist., Vol. 4, pp. 157–159, pl. X, 1846. Describes *Piliolites ohioensis*, *Pentagonia peersii*, and *Conulites elevata*.

1885. DAVIS, WILLIAM J. A monograph of the fossil corals of the Silurian and Devonian rocks of Kentucky, Part II. Geol. Surv. of Ky., 1885, pp. I–XIII, pls. 1–139. The volume illustrates about 300 species of corals, 170 of which are new but not described. Nearly all of the specimens figured are from Louisville or the Falls of the Ohio.

1889. DENNIS, D. W. Analytical key to the fossils of Richmond, Indiana, pp. 1–48.

1888. DRYER, CHAS. R. Geology of Allen County. 16th Ann. Rep't Ind. Dept. of Nat. Hist. and Geol., 1888, p. 126. Mentions two species: *Strophodonta profunda* and *Spirifera radiata*.

1896. DUDEN, HANS. Some notes on the Black Slate or Genesee Shale of New Albany, Indiana. 21st Ann. Rep't Ind. Dept. Geol. and Nat. Res., pp. 108–119, pls. 2–3. Describes the following species of fossil plants from the black shale: *Parenchymophycus asphalticum*, *Palaeophycus new-albanense*, *Palaeophycus lineare*, *Sporangites radiatus*.

1881. ELROD, M. N. Geology of Bartholomew County. Ind. Dep't Geol. and Nat. Res., 1881, pp. 150–213. Gives list of Hartsville fossils.

1882. ELROD, M. N. Geology of Decatur County. Ind. Dep't Geol. and Nat. Res., 1882, pp. 100–152. Gives lists of Silurian and Devonian fossils.

1883. ELROD, M. N. List of fossils found in Rush County. 13th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., 1883, pp. 97–98. Includes Niagara and Devonian fossils.

1883. ELROD, M. N. Geology of Fayette County. 13th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., 1883, pp. 41–60. Gives list of Paleozoic fossils.

1884. ELROD, M. N. Geology of Marion County. Ind. Dept. Geol. Nat. Res., 1884, pp. 61–72. Gives list of Hudson River fossils.

1876. ELROD, M. N., AND MCINTIRE, E. S. Report of a geological survey of Orange County. Rep't Geol. Surv. Ind., pp. 203–239, 1876. Lists of more common fossils and the geological position of *Paolia vetusta* are shown on pp. 206, 207, 221.

1891. ELROD, M. N., AND BENEDICT, A. C. List of fossils found in Wabash County. 17th Rep't Ind. Dept. of Geol. and Nat. Hist., 1891, pp. 198–199. The list includes forty species, almost half of which are Cephalopoda, from Niagara strata.

1878. ETHERIDGE, R. Paleontology of the coasts of the Arctic lands visited by the British expedition under Captain Sir Geo. Nares, R. N., K. C. B., F. R. S. Quart. Jour. Geol., Vol. 34, pp. 568–639, pl. 25–29, 1878. Mentions *Archimedes arctica* as common to Carb. of Indiana and Spitzbergen.

1886. FABER, C. L. Remarks on some fossils of the Cincinnati group. Jour. Cin. Soc. Nat. Hist., Vol. IX, No. 1, 1886, pp. 14–20, pl. 1. Describes *Cyrtoceras tenuiseptum* n. sp. from the Hudson River group at Versailles.

1888. FOERSTE, A. F. A study of the head of typical forms of *Lichas breviceps* from the Niagara of Waldron, Ind. Bull. Denison Univ., Vol. III, pl. XIII, fig. 21.

1890. FOERSTE, A. F. Notes on Clinton group fossils, with special reference to collections from Indiana, Tennessee and Georgia. Proc. Bost. Soc. Nat. Hist., Vol. 24, 1889–90, pp. 263–352, pls. 5–9. Several species from the Clinton group at Hanover, Indiana, are described or mentioned.

1891. FOERSTE, A. F. Fossils of the Clinton group in Ohio and Indiana. Geol. Surv. Ohio, Vol, VII, pp. 516–601. Describes some new species, gives figures of all the Ohio and Indiana fossils mentioned, together with notes on the same. The Indiana localities of seventeen fossils are given. He considers the beds just below the Waldron Shales in Indiana to represent the Clinton group.

1893. FOERSTE, A. F. Remarks on specific characters in Orthoceras. Am. Geol., Vol. 12, 1893, pp. 232–236, fig. 1–6. Discusses the characters of the siphuncle in *O. ignotum* Foerste, which is found at Hanover, Ind.

1895. FOERSTE, A. F. An account of the Middle Silurian rocks of Ohio and Indiana. Jour. Cin. Soc. Nat. Hist., Vol. 18, 1895, pp. 161–191, pl. 7. Sections in Southeastern Indiana are correlated with others in Ohio. Lists of fossils are given from several localities in Southeastern Indiana.

1896. FOERSTE, A. F. A report on the geology of the Middle and Upper Silurian rocks of Clark, Jefferson, Ripley, Jennings, and southern Decatur Counties, Ind. 21st Ann. Rep't Ind. Dept. Geol. Nat. Res., pp. 212–288. Lists of fossils from a number of localities in the region are given.

1874. GARDNER, JAS. Tripoli. Geol. Surv. of Ind., 1873, pp. 423–425, fig. 1–5. The material reported upon is from above coal, K., Dubois County; it is composed mainly of sponge spicules.

1885. GORBY, S. S A new Crinoid. Hoosier Mineralogist and Archeologist, Vol. 1, No. 10, 1885. Describes without figure *Eucalyptocrinus elrodi* from Hartsville, Indiana.

1886. GORBY, S. S. Geology of Washington County. 15th Ann. Rep't Ind. Dept. of Geol. and Nat. Hist., 1885–'86, pp. 117–153. Gives a list of about one hundred and twenty species of Warsaw fossils; also a number of fossils from the other formations of the county.

1886. GORBY, S. S. Geology of Tippecanoe County. 15th Ann. Rep't Ind. Dept. of Geol. and Nat. Hist., 1885–'86, p. 83. Mentions half a dozen species of St. Louis fossils.

1886. GORBY, S. S. The Wabash Arch. 15th Ann. Rep't Ind. Dept. of Geol. and Nat. Hist., p. 236. Notes a few Niagara fossils at Kentland, and some Hudson River fossils from the same locality which he supposes to have been forced up from the underlying Lower Silurian.

1888. GORBY, S. S. Geology of Miami County. 16th Ann. Rep't Ind. Dept. of Geol. and Nat. Hist., 1888, p. 181. Gives six species of Niagara fossils.

1886. GORBY, S. S., AND LEE, S. E. Geology of Boone County. 15th Ann. Rep't Ind. Dept. of Geol. and Nat. Hist., 1885–86, p. 167. Notes the finding of *Rhynchonella capax* in the Drift.

1880. GREEN, G. K. Geology of Monroe County. Rep't Geol. Surv. Ind., 1880, pp. 427–449. Gives lists of Subcarboniferous fossils from several localities in the county.

1883. GURLEY, W. F. E. New Carboniferous fossils. Bulletin No. 1, pp. 1–9, 1883. Danville, Ill. Three species from Indiana are described in this paper without figures. They are *Lingula crawfordsvillensis* from the Keokuk, *Dentalium acutisulcatum* and *Cypricardia undulatum* from the Coal Measures.

1879. HAINES, MARY P. List of fossils found in the Lower Silurian rocks in the vicinity of Richmond, Indiana. 8th, 9th and 10th Ann. Rep'ts Ind. Geol. Surv., pp. 201–204. This list is based upon Mrs. Haines' private collection of fossils.

1843. HALL, JAS. Notes explanatory of a section from Cleveland, Ohio, to the Mississippi River, in a southwest direction, with remarks upon the identity of the Western formations with those of New York. Assoc. Am. Geol. Trans., 1843, pp. 267–293, plate.

1843. HALL, JAS. On the geographieal distribution of fossils in the older rocks of the United States. Am. Jour. of Sci., Vol. 45, 1843, pp. 157–160, 162–163.

1844. HALL, JAS. Geographical distribution of fossils. Am. Jour. Sci., Vol. 47, 1844, pp. 117–118.

1851. HALL, JAS. Parallelism of the Paleozoic deposits of the United States and Europe. Foster and Whitney's Rep't on Lake Superior. Pt. II, 1851, pp. 285–318. Compares the Paleozoic rocks of the West with those of New York.

1856. HALL, JAS. Description of new species of fossils from the Carboniferous Limestones of Indiana and Illinois. Trans. Alb. Inst., Vol. 4, pp. 1–36. A large number of new species, all from the St. Louis group of Indiana and Illinois, with one exception, are deseribed but not figured.

1857. HALL, JAS. Descriptions of Paleozoic fossils. 10th Reg. Rep't N. Y., 1857, pp. 41–186. Describes some new brachiopods from the Devonian and *Spirifer texta* from the Knobstone.

1858. HALL, JAS. Paleontology of Iowa. Geol. Surv. of Iowa, Vol. 1, Pt. 2, pp. 473–724, pls. 1–29. A number of the fossils which were described from the St. Louis L. S. at Spergen Hill, Indiana, in the Trans. of the Albany Institute, Vol. IV, are illustrated in this volume.

1860. HALL, JAS. Descriptions of new species of Crinoidea from the Carboniferous rocks of the Mississippi Valley. Bost. Jour. Nat. Hist., Vol. 7, pp. 261–328. The author describes six new species of Crinoids from the Keokuk at Crawfordsville. These are *Scaphiocrinus unicus*, *S. nodobranchiatus*, *S. robustus*, *S. aequalis*, *Cyathocrinus hoveyi* and *C. lyoni.*

1860. HALL, JAS. Upon the fossils of the Goniatite limestone in the Marcellus Shale of the Hamilton group in the eastern and central parts of the State of New York and those of the Goniatite beds of Rockford, Indiana; with some analogous forms from the Hamilton group. 13th Ann. Rep't Regents Univ. N. Y., 1860, pp. 95–112, figs. 1–22. A large list of new species from Rockford is described, most of which are not figured.

1861. HALL, JAS. Supplementary note. 14th Ann. Rep't Regents Univ. N. Y., 1861, p. 81. The age of the Rockford Goniatite beds and of the Black Shale is discussed. It is suggested that the former is the equivalent of the Chemung.

1861. HALL, JAS. Preliminary notice of the Trilobites and other Crustacea of the Upper Helderberg, Hamilton and Chemung groups. 14th Ann. Rep't Regents Univ. of N. Y., 1861, pp. 82–114. Three Trilobites from the Falls of the Ohio are described. *Dalmania calypso*, *D. pleione* and *Proteus crassemarginatus*.

1862. HALL, JAS. Notice of some new species of fossils from a locality of the Niagara group in Indiana, with a list of identified species from the same place. Trans. Albany Inst., Vol. 4, 1862, pp. 195–228. The new species described in this paper are figured in the 16th Ann. Rep't Regents Univ. of N. Y.

1867. HALL, JAS. Descriptions and figures of the fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups. Pal. of N. Y., Vol. 4, Pt. 1, 1867, pp. I–XIII, 1–422, pls. 1–63. A number of the species described occur at the Falls of the Ohio and elsewhere in Indiana rocks.

1878. HALL, JAS. Note upon the history and value of the term Hudson River in American geological nomenclature. Am. Assoc. Adv. Sci. Proc., Vol. 26, pp. 259–265, 1878. Abstract Am. Jour. Sci., 3d ser., Vol. 16, p. 482.

1879. HALL, JAS. The fauna of the Niagara group in Central Indiana. 28th Ann. Rep't N. Y. State Mus. Nat. Hist., 1879, pp. 99–199, pls. 1–34. The species occurring at Waldron, Indiana, are described and figured in this report.

1882. HALL, JAS. Descriptions of fossil corals from the Niagara and Upper Helderberg groups of Indiana. 12th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., pp. 271–375.

1882. HALL, JAS. Vancleve's fossil corals, identified and compiled by Dr. Jas. Hall. 12th Ann. Rep't Ind. Dept. Geol. Nat. Hist., 1882, pp. 239–318, pls. 1–28.

1884. HALL, JAS. Lamellibranchiata of the Upper Helderberg, Hamilton, Portage and Chemung groups (Monomyaria). Pal. N. Y., Vol. 5, Pt. 1, 1884, pp. I–X, 1–268, pls. 1–33, 81–92. The following species are figured and described from the Falls of the Ohio: *Aviculopecten princeps, Pterinopecten reflexus, P. nodosus, Pterinea grandis, Glyptodesma occidentale, Limoptera cancellata. Pterinea grandis,* a new species from Scott County, is described.

1884. HALL, JAS. Descriptions of fossil corals from the Niagara and Upper Helderberg groups. 35th Ann. Rep't N. Y. State Mus. Nat. Hist., pp. 407–464, pls. 16, 23–30. Describes and figures a large number of new species from the Falls of the Ohio.

1884. HALL, JAS. Descriptions of the species of fossil Reticulate Sponges constituting the family Dictyospongia. 35th Ann. Rep't N. Y. State Mus. Nat. Hist., pp. 465–481, pls. 18–21. Species from the Keokuk at Crawfordsville are described.

1885. HALL, JAS. Lamellibranchiata (Dimyaria), Pal. N. Y., Vol. 5, Pt. I, pp. 269–561, pls. 34–96. Eighteen species from Indiana are described and figured in this volume, some of which are new.

1887. HALL, JAS. Corals and Bryozoa. Pal. of N. Y., Vol. 6, 1887, pp. I–XXVI, 1–298, pls. 1–66. In this volume Prof. Hall describes and figures about seventy species, many of which are new, from the "Corniferous Limestone" at the Falls of the Ohio.

1888. HALL, JAS. Pteropoda of the Niagara, Lower and Upper Helderburg, Hamilton and Waverly Groups. Pal. N. Y., Supplement Vol. 5, Pt. 2, pp. 5–7, pl. 104, 1888. Describes and figures *Tentaculites dexithea* from Pendleton.

1888. HALL, JAS. Tubicolor Annelida, Pal. N. Y., Supplement Vol. 5, Pt. 2, pp. 8–24, pl. 116, 1888. Describes and figures *Cornulites proprius* from Waldron, and figures *Tentaculites richmondensis* Miller from Richmond.

1888. HALL, JAS. Supplement containing descriptions and illustrations of Pteropoda, Cephalopoda and Annelida. Pal. N. Y., Vol. 5, Pt. 2, 1888, pls. 114–129. Three Cephalopods from Indiana are figured in this supplement. These are *Gomphoceras minum* from the Falls of the Ohio, *Orthoceras indianense* and *O. icarus* from Rockford, Indiana.

1888. HALL JAS., AND CLARK, J. M. Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. Pal. of N.Y., Vol. 7, 1888, pp. I–LXIV, 1–236, pls. 1–36. Two new species from what Hall considers a

Schoharie grit horizon at Pendleton, Indiana, are described. These are *Poetus curvimarginatus* and *P. latimarginatus*. Other new species from the Falls of the Ohio are figured.

1892. HALL, JAS., AND CLARK, J. M. An introduction to the study of the genera of Paleozoic Brachaeopoda. Pal. of N. Y., Vol. 8, Pt. 1, 1892, pp. 182, 346. Two new Brachiopods from Indiana are described and figured in this volume. *Derbya ruginosa* from the Keokuk and *Pholidops calceola* from the Corniferous Ls.

1872. HALL, JAS., AND WHITFIELD, R. P. Descriptions of new species of fossils from the vicinity of Louisville, Kentucky, and the Falls of the Ohio. 24th Ann. Rep't Regents of the Univ. of N. Y., 1872, pp. 223–239. The plates were published in the 27th Ann. Rep't Reg Univ. N. Y., 1875, Nos. 9–13.

1844. HAYMOND, RUFUS. Notices of remains of Megatherium, Mastodon and Silurian fossils. Am. Jour. Sci., Vol. 46, pp. 294–296, 1844.

1887. HERRICK, C. L. A sketch of the geological history of Licking County, accompanying an illustrated catalogue of Carboniferous fossils from Flint Ridge, Ohio. Denison Univ. Bull., Vol. 2, pp. 62, 63. Gives descriptive notes on three Trilobites from Rockford, Indiana. They are *Phillipsia scitula* M. & W., *P. doris* (Hall) Winch. and *P. rockfordensis* Winch.

1891. HUBBARD, GEO. C. The Upper limits of the Lower Silurian at Madison, Indiana. Proc. Ind. Acad. Sci., 1891, pp. 68–70. Places the limit 50 feet above the Favistella reef.

1891. HUBBARD, GEO. C. The Cystideans of Jefferson County, Indiana. Proc. Ind. Acad. Sci., 1891, p. 68. Gives no list of species. Mentions Big Creek as a good locality for collecting.

1891. HUBBARD, GEO. C. Hudson River fossils of Jefferson County, Indiana. Proc. Ind. Acad. Sci., 1891, p. 68. Gives a summary by families of number of species. No specific names given.

1874. JAMES, U. P. Descriptions of new species of fossils from the Lower Silurian formation, Cincinnati group. Cin. Quart. Sci., Vol. 1, 1874, pp. 239–242. Describes a new species from Wayne County—*Avicula corrugata*—and mentions Indiana localities for some other species.

1886. JAMES, J. F. Cephalopoda of the Cincinnati group. Jour. Cin. Soc. Nat. Hist., Vol. 8, 1886, pp. 235–253. The paper contains a convenient key to the species of Cephalopoda and gives Indiana localities for a number of species.

1886. JAMES, J. F. Protozoa of the Cincinnati group Jour. Cin. Soc. Nat. Hist., Vol. IX, No. 3, pp. 244–252, 1886. Gives a synopsis of genera and species of the Protozoa of the Hudson River group. Notes *Labechia montifera* from Madison and *Stromatocerium richmondense* Miller, Hudson River group, Richmond.

1892. JAMES, J. F. Manual of the Paleontology of the Cincinnati group. Jour. Cin. Soc. Nat. Hist., Pt. 3, in Vol. 15, No. 2, 1892, pp. 88–100; Pt. 4, Vol. 15, Nos. 3 and 4, pp. 144–160; Pt. 5, Vol. 16, 1894, pp. 178–208; Pt. 6, Vol. 18, 1895; Pt. 7, Vol. 18, pp. 115–140.

1897. JAMES, J. F. Article XII—Manual of the Paleontology of the Cincinnati group. Jour. Cin. Soc. Nat. Hist., Vol. XIX, No. 3, pp. 99–118. The following species from Indiana localities are included: *Xenocrinus baeri* M., Richmond, *Glyptocrinus decadactylus* H., Madison.

1889. KEYES, C. R. The Carboniferous Echinodermata of the Mississippi basin. Am. Jour. Sci., 3d Ser., Vol. 3, p. 186. Gives table showing range of principal carboniferous genera.

1890. KEYES, C. R. Synopsis of American Carbonic Calyptræidæ. Proc. Phila. Acad. Nat. Sci., 1890, pp. 150–181, Pl. 2. Three species from Crawfordsville are figured—*Capulus sulcatinus*, *C. equilateralis*, *C. infundibulum*—and one from the Coal Measures, *C. parvus*.

1896. KINDLE, E. M. The Whetstone and Grindstone rocks of Indiana. 20th Ann. Rep't Ind. Dept. Geol. and Nat. Res., 1895, p. 349. Describes occurrence of *Lepidodendrons* standing upright in the Whetstone quarries near French Lick, and republishes the original figure of *Paola vetusta*.

1889. KNOWLTON, F. K. Description of a problematic organism from the Devonian at the Falls of the Ohio. Am. Jour. Sci., 3d Ser., Vol. 37, 1889, pp. 202–209, fig. 1–3. The organisms are referred provisionally to the genus Calcisphaera.

1870. LESQUEREAUX, LEO. Description of new species, and an enumeration, with remarks on species already known. Geol. Surv. of Ill., Vol. 4, 1870, pp. 379–477, pls. 5–31. One new coal plant is described from Indiana, without figure—*Chondrites colletti*—and mention is made of another.

1875. LESQUEREAUX, LEO. Species of fossil marine plants from the Carboniferous Measures. Geol. Survey of Ind., 1875, pp. 135–145. Five new species are described and figured. Four of these are from Indiana and one from Illinois.

1875. LESQUEREAUX, LEO. Geol. Survey of Ind., 1875, p. 7. Eight species of fossil plants from the Millstone grit are given by Cox, which were determined by Lesquereaux.

1883. LESQUEREAUX, LEO. Principles of Paleozoic Botany and the fauna of the Coal Measures. 13th Ann. Rep't Ind. Geol. Surv., 1883, pp. 1–185, pls. 1–22. Gives descriptions of the fossil plants which have been and are likely to be found in Indiana.

1884. LESQUEREAUX, LEO. A list of the species of fossil plants found at each locality. 2d Geol. Surv. Pa., Vol. 3, p. 852. Gives list of species known from the Whetstone beds.

1849. LYELL, CHAS. A second visit to the U. S. Vol. II, pp. 269–278, London, 1849. Describes fossil *Sigilaria* at New Harmony and the Coral reef at Louisville.

1857. LYON, SYDNEY S. Description of new species of organic remains. Ky. Geol. Surv., Vol. 3, 1857, pp. 467–498, pls. 1–5. The following new crinoids from the Falls of the Ohio are figured and described: *Actinocrinus abnormis*, *Dalatocrinus lacus*, *Vasocrinus sculptus*, *Olavanites verneuilii*, *O. angularis*, *Codaster alternatus*.

1859. LYON, SYDNEY S. AND CASSEDAY S. A. Description of nine new species from the Subcarboniferous rocks of Indiana and Kentucky. Am. Jour. of Sci. and Arts, Vol. XXIX, pp. 68–79, 1859. Describes five species without figures from the Indiana Subcarboniferous, *Cayathocrinus decadactylus*, *C. hexadactylus*, *Actinocrinus indianensis* and *Onychocrinus exculptus*, from Montgomery County, and *Actinocrinus coreyi*, from Washington County.

1859. LYON, S. S., AND CASSEDAY. Description of nine new species of Crinoidea from the Subcarboniferous rocks of Indiana. Am. Jour. Sci., Vol. 28, 2d ser., pp. 233–246, 1859. The species which are described here without figures are figured in the Geol. Surv. of Ill., Vol. 7.

1861. LYON, SIDNEY S. Descriptions of new Paleozoic fossils from Kentucky and Indiana. Proc. Acad. Nat. Sci. Phila., pp. 409–414, 1 plate, 1861. Describes two new species from strata just below the Hydraulic limestone at the Falls of the Ohio, *Onochocrinus exculptus* and *Megistocrinus spinulosus*.

1882. McCASLIN, DAVID S. Geology of Jay County. 12th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., 1882, p. 166. Gives a list of fifteen species from Niagara at Jay City.

1869. MCCHESNEY, J. H. Descriptions of Paleozoic rocks of the Western States, with illustrations. Trans. Chic. Acad. of Sci., Vol. 1, 1867–1869, pp. 1–57, pls. 1–9. Several species from the Coal Measures of Indiana are described, and also one from the Hudson River group, *Trematospira mathewsoni*.

1865. MEEK, F. B. Descriptions of nine species of Crinoidea, etc., from the Paleozoic rocks of Illinois and some of the adjoining States. Proc. Phila. Acad. Sci., 1865, pp. 143–166. Describes some new Crinoids from Crawfordsville.

1869. MEEK, B. F. Description of new Crinoidea and Echinoidea from the Carboniferous rocks of the Western States, with a note on the Genus Onychaster. Proc. Phila. Acad. Nat. Sci., 1869–70, pp. 67–83. Describes *Calceocrinus bradleyi* from Crawfordsville.

1871. MEEK, F. B. Descriptions of new Western Paleozoic fossils, mainly from the Cincinnati group of the Lower Silurian series of Ohio. Proc. Phila. Acad. Sci., 1871, pp. 308–336. Refers *Homocrinus polydactylus* Shum. from Richmond, Indiana, to *Poteriocrinus* (*Dendrocrinus*) *polydactylus*.

1871. MEEK, F. B. On some new Silurian Crinoids and Shells. Am. Jour. Sci. and Arts, Vol. II, 3d ser., 1871, pp. 295–302. Describes two new Crinoids *Dendrocrinus casei* and *Lepocrinites moorei*, from Richmond, Indiana.

1872. MEEK, F. B. Descriptions of two new star-fishes and a Crinoid from the Cincinnati group of Ohio and Indiana. Am. Jour. of Sci. and Arts, Vol. III, 3d ser., p. 260. Describes *Glyptocrinus baeri* and *Stenaster grandis* from Richmond, Indiana.

1872. MEEK, F. B. Descriptions of two new star-fishes and a Crinoid from the Cincinnati group of Ohio and Indiana. Am. Jour. of Sci., 3d ser., Vol. 3, 1872, pp. 257–262. These descriptions, with illustrations, are republished in the Pal. of Ohio.

1873. MEEK, F. B. Spergen Hill fossils identified among specimens from Idaho. Am. Jour. Sci., 3d ser., Vol. 5, 1873, pp. 383–384.

1873. MEEK, F. B. Descriptions of invertebrate fossils of the Silurian and Devonian systems. Geol. Surv. of Ohio, Vol. I, Pt. II, pp. 1–243. Gives Indiana localities of many Lower Silurian fossils.

1860. MEEK, F. B., AND WORTHEN, A. H. Descriptions of new Carboniferous fossils from Illinois and other Western States. Proc.

Phila. Acad. Nat. Sci., 1860, pp. 447. Several fossils from Rockford are described, some of which are figured in Vol. 2, Geol. Surv. of Ill.

1861. MEEK, F. B., AND WORTHEN, A. H. 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. Am. Jour. Sci., 2d ser., Vol. 32, pp. 167–177. Gives list of species from Rockford known to be identical with Chateau Ls. species in Missouri and Illinois.

1865. MEEK, F. B., AND WORTHEN, A. H. Descriptions of new Crinoidea, etc., from the Carboniferous rocks of Illinois and some of the adjoining States. Proc. Phila. Acad. Nat. Sci., 1865, pp. 155–166. Describes several Crinoids from Crawfordsville.

1865. MEEK, F. B., AND WORTHEN, A. H. Contributions to the Paleontology of Illinois and other Western States. Proc. Phila. Acad. of Sci., 1865, pp. 251–275. *Gyroceras? rockfordensis* and *Nautilus (Cryptoceras) rockfordensis* are described from Rockford, Indiana.

1866. MEEK, F. B., AND WORTHEN, A. H. Invertebrate fossils of the Kinderhook group. Geol. Surv. of Ill., Vol. 2, 1866, pp. 145–166, pl. 14. Several species from Rockford originally described in Proc. Phila. Acad. Sci., 1860, are figured in this volume.

1868. MEEK, F. B, AND WORTHEN, A. H. Paleontology. Geol. Surv. of Ill., 1868, Vol. 3, Pt. 2, pp. 291–565, pls. 1–20. A number of fossils from Indiana, previously described in the Proc. Phila. Acad. of Sci. without illustrations, are figured in this volume.

1868. MEEK, F. B., AND WORTHEN, A. H. Fossils of the Hamilton group. Geol. Surv. of Ill., Vol. 3, 1868, pp. 419–449, pls. 10–12. A few Indiana species previously described in Proc. Chic. Acad., Vol. 1, and Proc. Acad. Nat. Sci. Phila., 1866, are figured in this volume.

1870. MEEK, F. B., AND WORTHEN, A. H. Descriptions of new species and genera of fossils from the Paleozoic Rocks of the Western States. Proc. Phil. Acad. Nat. Sci., 1870, pp. 22–64. A number of species from Indiana are described but not figured in this paper. Some of them have since been figured in Vol. 7, Geol. Surv. of Ill.

1873. MEEK, F. B., AND WORTHEN, A. H. Descriptions of invertebrates from the Carboniferous System. Geol. Surv. of Ill., Vol. 7, 1873, pp. 323–529, pls. 1–17. This paper figures a number of Crawfordsville Crinoids which were described by the authors without figures in the Proc. Phila. Acad. Nat. Sci., 1870, p. 22, and by Lyon and Cassiday in Am. Jour. Sci., Vol. 28, 2d ser., p. 233.

1874. MILLER, S. A. Monograph of the Gasteropoda of the Cincinnati group. Cin. Quart. Jour. Sci., Vol. 1, 1874, pp. 302–321, fig. 30–34. One new species from Richmond, Indiana (*Bellerophon mohri*) is described, and Indiana localities of several other species are given.

1874. MILLER, S. A. Monograph of the Lamellibranchiata of the Cincinnati group. Cin. Quart. Jour. Sci , Vol. 1, 1874, pp. 211–236, fig. 20–29. Several new species of *Tentaculites* and *Beyricia*, and some new *Lamellibranches* are described and figured from Richmond, Osgood and Versailles, Indiana.

1874. MILLER, S. A. Notice of *Modiolopsis pholadiformis* (Foster & Whitney). Cin. Quart. Jour. Sci., Vol. 1, 1874, p. 262. A Lamellibranch from Richmond is identified with this species.

1875. MILLER, S. A. *Crania reticularis.* Cin. Quart. Jour. Sci , Vol. 2, 1875, p. 280, fig. 22. This species is described from a specimen obtained from Brookville, Indiana.

1875. MILLER, S. A. Class Cephalopoda (Cuvier), as represented in the Cincinnati group. Cin. Quart. Jour. Sci., Vol. 2, 1875, pp. 121–134. Indiana localities are given for several species.

1875. MILLER, S. A. Monograph of the Class Brachiopoda of the Cincinnati group. Cin. Quart. Jour. Sci., Vol. 2, 1875, pp. 6–62. Indiana localities are given for a large number of the species considered.

1878. MILLER, S. A. Descriptions of a new genus and eleven new species of fossils. Jour. Cin. Soc. Nat. Hist., Vol 1, 1878, pp. 100–108, pl. 3 and 4. Four new species from the Hudson River group of Indiana are described; these are *Cyrtolites magnus, Murchisonia multigruma, Cyrtoceras amoenum and Angellum cuneatum.*

1878. MILLER, S. A. Description of eight new species of Holocystites from the Niagara group. Jour. Cin. Soc. Nat. Hist., Vol. 1, No. 3, pp. 129–136, pls. V. and VI., 1878. Describes and illustrates with good figures the following new species: *H. brauni, H. ornatus, H. globosus, H. elegans, H. pleonus,* from the Niagara, Jefferson County, Indiana; *H. wetherbyi* Niagara, Ripley County, Indiana; *H. perlongus* Niagara, Waldron, Indiana.

1879. MILLER, S. A. Description of twelve new fossil species and remarks upon others. Cin. Soc. Nat. Hist., Vol. II, No. 2. 1879, pp. 104–118, pls. 9–10. Describes the following species from Niagara strata, Ripley County: *Holocystites tumidus*, *H. baculus*, *H. rotundus*, *H. subrotundus*, *H. dyeri*, *H. ventricosus*, *Pisocrinus gemmiformis*. From Osgood, *Stephanocrinus osgoodensis*.

1879. MILLER, S. A. Catalogue of fossils found in the Hudson River, Utica Slate and Trenton groups, as exposed in southeastern Indiana, the southwestern part of Ohio and northern part of Kentucky. Ind. Geol. Rep't, 1876–77–78

1879. MILLER, S. A. Remarks upon the Kaskaskia group, and descriptions of new species of fossils from Pulaski County, Kentucky. Jour. Cin. Soc. Nat. Hist., Vol. II, No. 1, pp. 31–42, 1879. The paper gives the views of Hall, Shumard and Worthen on the stratigraphic relations of the Kaskaskia group, and concludes that the name Kaskaskia must displace Chester in nomenclature by reason of ten years priority in publication.

1879. MILLER, S. A. Description of two new species from the Niagara group and five from the Keokuk group. Jour. Cin. Soc. Nat. Hist., Vol. II, No. 2, 1879, pp. 254–259, pl. XV. Describes *Cyathocrinus harrisi* and *Palaeaster crawfordsvillensis* from the Keokuk at Crawfordsville, and *Holocystites turbinatus* from the Niagara, Ripley County.

1881. MILLER, S. A. Observations on the unification of geological nomenclature, with special reference to the Silurian formation of North America. Jour. Cin. Soc. of Nat. Hist., Vol. IV, No. 3, pp. 267–293, 1881. Describes the Silurian rocks as they occur in Indiana and elsewhere in the United States, and discusses their paleontological features in detail.

1881. MILLER, S. A. Description of new species of fossils. Jour. Cin. Soc. Nat. Hist., Vol. IV, No. 3, pp. 259–262, pl. 6, 1881. Describes and figures one new species from the Hudson River group at Versailles and Osgood, Indiana, *Leperditia calcigena*.

1882. MILLER, S. A. Description of two new genera and eight new species of fossils from the Hudson River group, with remarks upon others. Jour. Cin. Soc. of Nat. Hist., Vol. V, pp. 34–44, pl. 1–2, 1882. One new sponge is described from Richmond, *Stromatocerium richmondense*. This was described as "pisolitic balls" by J. T. Plummer in the A. J. S., Vol. 44, p. 281.

1882. MILLER, S. A. Description of three new orders and four new families in the class Echinodermata and eight new species from the Silurian and Devonian formations. Jour. Cin. Soc. Nat.

Hist., Vol. V, 1882, pp. 221–231, pl. IX. Describes *Lichenocrinus tuberculatus*, from the Hudson River group three miles south of Osgood; *Cyclora pulcella*, from the Hudson River at Versailles, and *Poteriocrinus davisanus* and *P. nettlerothanus*, from the Upper Helderberg at Deputy, Indiana.

1882. MILLER, S. A. Descriptions of ten new species of fossils. Jour. Cin. Soc. Nat. Hist., Vol. V, 1882, pp. 79–88, pls. 3 and 4. Describes *Cyathocrinus crawfordsvillensis* from Crawfordsville.

1888. MILLER, S. A. The structure, classification and arrangement of American Paleozoic Crinoids into families. 16th Rep't Ind. Dept. of Geol. and Nat. Hist., 1888, pp. 302–326. The author indicates the systematic relations as understood by him of the Paleozoic genera, including those from Indiana.

1891. MILLER, S. A. Paleontology. 17th Rep't Ind. Dept. of Geol. and Nat. Hist., 1891, pp. 611–705, pls. I–XX. This paper describes and figures sixty-eight new species of Indiana fossils from the Carboniferous, Devonian and Silurian rocks; also several from Kentucky and Missouri.

1893. MILLER, S. A. Paleontology. 18th Rep't Ind. Dept. of Geol. and Nat. Hist., 1893, pp. 257–356, pls. I–XII. The author describes forty new species from the Carboniferous, Devonian and Silurian rocks of Indiana. Several new species from Ohio, Kentucky, Missouri and Kansas are described.

1894. MILLER, S. A., AND FABER, CHAS. Jour. Cin. Soc. Nat. Hist., Vol. 17, pp. 22–33, pl. 1. New species of fossils from the Hudson River group and remarks upon others. The authors describe a new Lamellibranch—*Bodmania insuetum*—which is the type of a new genus from Richmond, Indiana.

1888. MILLER, S. A., AND GURLEY, F. E. Description of some new genera and species of Echinodermata from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri and Iowa. 16th Rep't Ind. Dept. of Geol. and Nat. Hist., 1888, pp. 326–373, 10 pls. Describes and figures thirty-one new species of Crinoidea from the Keokuk group of Indiana.

1890. MILLER, S. A., AND GURLEY, W. F. E. Description of some new genera and species of Echinodermata, from the Coal Measures and Subcardoniferous rocks of Indiana, Missouri and Iowa. Jour. Cin. Soc. Nat. Hist., 1890, pp. 3–25, pl. 1–4. The following new species of crinoids are described from Crawfordsville: *Agaricocrinus splendeus*, *Onychocrinus ulrichi*, *Batocrinus ulrichi*, *Batocrinus marinus*, *B. jucundus*, *Poteriocrinus granilineus*, *P. crawfordsvillensis*, *Scaphiocrinus manus*.

1895. MILLER, S. A., AND GURLEY, WM. F. E. Description of some new species of invertebrates from the Paleozoic rocks of Illinois and adjacent States. Bull. No. 3, Ill. State Mus. Nat. Hist., 1893, pp. 1–81, pls. 1–8. The paper describes from Indiana two new Trilobites—*Lichas hanoverensis*, *Lichas byrnesanus*, *Lingula indianensis*, *Conularia gratiosa*, *C. spergensis* and a number of new Crinoids.

——. MILLER, S. A., AND GURLEY, WM. F. E. New and interesting species of Paleozoic fossils. Bull. 7, Ill. State Mus. Nat. Hist. pp. 1–89, pls. 1–5. Several Indiana species are described.

1896. MILLER, S. A., AND GURLEY, WM. F. E. New species of Echinodermata and a new Crustacean from the Paleozoic rocks. Bull. 10 Ill. State Mus. Nat. Hist., p. 90, pl. 5. Describes *Eurypterus kokomoensis* from Kokomo.

1896. MILLER, S. A., AND GURLEY, WM. F. E. New species of paleozoic invertebrates from Illinois and other States. Bull. 11 Ill. State Mus. Nat. Hist., pp. 1–50, pls. 1–5. Describes three *Gastropods*, a *Goniatite*, an *Orthoceras* and a *Conularia*.

1897. MILLER, S. A., AND GURLEY, WM. F. E. New species of Crinoids, Cephalopods and other Paleozoic fossils. Bull. 12 Ill. State Mus. Nat. Hist., pp 1–69, pls. 1–5. Describes several species from Indiana.

1878. MILLER, S. A., AND DYER, C. B. Contributions to Paleontology. Jour. Cin. Soc. Nat. Hist., Vol. 1, 1878, pp. 24–39, pls. 1–2. Three new species from Waldron are described—*Codaster pulchellus*, *Eucalyptocrinus tuberculatus*, and *Spirifera* (?) *waldronensis*. A new species from Versailles, Indiana—*Conularia formosa*—is described and figured.

1892. MILLER, S. A., AND FABER, C. Some new species and new structural parts of fossils. Jour. Cin. Soc. Nat. Hist., Vol. 15, 1892, pl. 1. A new species from the Niagara at Madison, Indiana—*Holocystites affinis*—is described and figured.

1894. MILLER, S. A., AND FABER, C. L. Description of some Cincinnati fossils. Jour. Cin. Soc. Nat. Hist., Vol. 17, 1894, pp. 137–158, pl. 7 and 8. The authors describe the following new species from Indiana: *Gomphoceras indianensis*, *Hyolithes versaillensis*, *Hyolithes* (?) *dubius* and *Berychia hammelli*.

1886. MOORE, D. R. Fossil corals of Franklin County, Indiana. Bull. Brookville Society of Nat. Hist., No. 2, 1886, pp. 50–51. This paper gives a list of twenty-three species from the Upper and Lower Silurian, and four from the Drift.

1886. MOORE, D. R. Two hours among the fossils of Franklin County, Indiana. Bulletin of the Brookville Society of Natural History, No. 1, pp. 44–45. The paper gives a list of seventeen Lower Silurian fossils.

1893. MOORE, JOS. The recently found Castoroides in Randolph County, Indiana. Am. Geol., Vol. 12, 1893, pp. 69–74, pl. 3. *Castoroides ohioensis* Foster.

1890. MOORE, JOS. Concerning a skeleton of the great fossil beaver, *Castoroides ohioensis*. Jour. Cin. Soc. of Nat. Hist., Oct. 1890, pp. 138–169. Gives detailed description and twenty-five figures of a specimen from Randolph County, Indiana.

1890. MOORE, JOS. Concerning some portions of *Castoroides ohioensis* not heretofore known. Proc. Am. Assoc. Adv. Sci., Vol. 39, 1890, pp. 265–267. Specimen from Randolph County.

1873. NEWBERRY, J. S. Descriptions of fossil fishes. Geo. Surv. of Ohio, Vol. I, Pt. II, pp. 247–355. The author refers to the species referred incorrectly by Owen and Norwood to the Upper Silurian at Madison (p. 262), and calls attention to a bone bed at North Vernon, Indiana. Reports *Gyrocanthus compressus* from Dearborn County.

1879. NEWBERRY, J. S. List of fossils of Harrison County. 8th, 9th and 10th Ann. Rep'ts Geol. Surv. Ind., 1879, pp. 341–349. The list of fossils by Collett has appended a list of species of fishes determined by Newberry. The new species described are *Chomatodus selliformis*, *C. angustus*, *C. obliquus*, *Lisgodus affinis*, *Orodus colletti*, *Helodus laevis*, *Deltodus cinctus*, *Petalodus knappi*, and *Archaeobatis gigas*. The last genus is also new.

1890. NEWBERRY, JOHN S. The Paleozoic fishes of North America. Monog. U. S. Geol. Surv., Vol. 16, 340 pages, 53 pls., Washington, 1890. A few species from Indiana are figured.

1866. NEWBERRY, J. S., AND WORTHEN, A. H. Descriptions of new species of Vertebrates, mainly from the Subcarboniferous Limestone and Coal Measures of Illinois. Geol. Surv. of Ill., Vol. 2, 1866, pp. 11–141, pls. 1–13. Five species of fishes from Posey County are described—*Cladodus gracilis*, *Diplodus latus*, *D. compressus*, *Ctenoptychius semicircularis*, *Edestus minor*—and one from Rockford, *Orodus multicarinatus*.

1889. NETTLEROTH, HENRY. Kentucky fossil shells. A monograph of the fossil shells of the Silurian and Devonian rocks of Kentucky. Ky. Geol. Surv., pp. 1–245, pls. I–XXXVI, Frankfort, Ky. A large number of Devonian fossils from Clark County, Indiana, and the Falls of the Ohio are figured and described.

1888. NEWELL, FREDERICK H., Niagara Cephalopods from Northern Indiana. Pr. Bost. Soc. Nat. Hist., Vol. 23, pp. 466–486.

1875. NICHOLSON, H. ALLEYNE. Description of the corals of the Silurian and Devonian systems. Geol. Surv. of Ohio, Vol. II, 1875, pp. 183–242. The author reports *Eridophyllum strictum* from the Corniferous at Louisville.

1875. NICHOLSON, H. ALLEYNE. Descriptions of Amorphozoa from the Silurian and Devonian formations. Geol. Surv. of Ohio, Vol. II, 1875, pp. 245–255. Reports *Dictyostroma undulata* from the Niagara of Louisville, Ky.

1848. NORWOOD, J. G. Proc. Bost. Soc. Nat. Hist., Vol. 2, 1848, p. 102. In a letter to the society, Norwood announces the discovery of fossil fishes at a locality sixteen miles north of Madison.

1846. NORWOOD, JOS. G., AND OWEN, D. D. Description of a new fossil fish from the Paleozoic rocks of Indiana. Am. Jour. Sci., 2d Ser., Vol. 1, pp. 367–371, figs. 1 and 2. The fish described is *Macropetalichthys rapheidolabis*, from the Corniferous.

1858. NORWOOD, J. G., AND PRATTON, HENRY. Notice of the genus *Chonetes*, as found in the Western States and Territories with descriptions of eleven new species. Proc. Phila. Acad. Nat. Sci., 1855–1858, Vol. 3, 2d ser., pp. 23–31, pl. 1. Figures *C. nana* from Falls of the Ohio.

1858. NORWOOD, J. C., AND PRATTON, HENRY. Notice of Producti found in the Western States and Territories, with descriptions of twelve new species. Proc. Phila. Acad. Sci. 1855–58, Vol. 3, 2d ser., pp. 522, pls. 1–2. Describes and figures *P. flemingii* de Kon. from the "Mountain Limestone," and from the Coal Measures in Posey County *P. buchianus* de Kon., *P. fimbriatus* Sow., *P. wabashensis* nov. sp., *P. flemingii* de Kon., *P. undiferous* de Kon.

1843. OWEN, D. D. On fossil palm trees in Indiana. Am. J. S. and A., Vol. 45, 1843., pp. 336–337 (abstract). Describes specimens from the Coal Measures at Big Creek, twelve miles from New Harmony and Bug Creek.

1859–60. OWEN, RICHARD. Report of a geological reconnoissance of Indiana, 1859–60, pp. 1–368. Gives lists of the characteristic Lower Silurian, Upper Silurian and Devonian fossils found in the State. The following fossils are figured: *Siphonia digitata*, *Halysites sexto-attenuatus*, *Bucania euomphaloides*, *Gyroceras rhombolinearis*, *Columnaria inequalis*, *Ceriopora lyra*, *Lithostrotion canadense*, *Pileopis pabulocrinus*, *Conularia crawfordsvillensis*. Figures very poor.

1881. PHINNEY, A. J. Delaware County. 11th Ann. Rep't Ind. Dept. Geol. and Nat. Hist., pp. 126–149. Gives list of fossils found in the county.

1843. PLUMMER, JOHN T. Suburban geology about Richmond, Indiana. Am. Jour. Sci., Vol. 44, 1843, p. 281. Describes "pisolitic balls" which have since been described by S. A. Miller as a sponge, *Stromatocerium richmondense.*

1858. PROUT, H. A. Descriptions of Bryozoa from the Paleozoic rocks of the Western States and Territories. Trans. St. Louis Acad. Sci., Vol. 1, pp. 443–452, 571–581, pls. 15–18. Two new species from the Falls of the Ohio are described—*Semicoscinium rhomboideum*, *Limaria falcata* and *Semicoscinum tuberculatum.*

1843. ROGERS, H. D. On Marcellus and Hamilton of the West and South. Am. Jour. Sci., Vol. 41, pp. 161–162, 1843.

1866. ROMINGER, C. Observations on Chaetetes and some related genera in regard to their systematic position, with an appended description of some new species. Proc. Phila. Acad. of Sci., 1866, pp. 113–123. Three new species from Indiana are described—*Fistulipora neglecta*, *F. halli* and *F. spergensis.*

1876. ROMINGER, C. Fossil corals. Geol. Surv. of Mich., Vol. 3, Pt. 2, 1876, pp. 1–155, pls. 1–55. The paper describes or mentions about fifty species of corals from Indiana, many of which are figured.

1892. ROMINGER, C. On the occurrence of typical Chaetetes in the Devonian strata at the Falls of the Ohio, and likewise in the analogous beds in Germany. Am. Geol., Vol. 10, pp. 56–62, pl. 3. Describes one new species, *Chaetetes ponderosus.*

1890. ROWLEY, R. K. Some observations on the natural casts of Crinoids and Blastoids from Subcarboniferous Limestones of Indiana, Iowa, Illinois, Kentucky and Alabama. Am. Geol., Vol. 6, pp. 66–67.

1886. SEELEY, H. M. The genus Strephochetus: Distribution and species. Am. Jour. Sci., ser. 3, Vol. 32, p. 31. Sponge found at Madison. Describes *S. richmondensis* Miller from Richmond and Madison.

——. SHALER, N. S. On the fossil Brachiopods of the Ohio Valley. Ky. Geol. Surv., pp. 1–44, pls. 1–8. This paper gives very full descriptions, with tables of measurement of several Lower Silurian species of the family Strophomenidae, together with notes on their geological and geographical range. It bears no date.

1858. SHUMARD, B. F. Description of new fossil Crinoidea from the Paleozoic rocks of the western and southern portions of the United States. From St. Louis Acad. Sci., Vol. I, pp. 71–80, pl. 1. Describes and figures *Homocrinus polydactylus* from the Lower Silurian at Richmond.

1858. SHUMARD, B. F. Descriptions of new species of Blastoidea from the Paleozoic rocks of the Western States, with some observations on the structure of the summit of the genus Pentremites. Trans. St. Louis Acad. Sci., Vol. 1, pp. 238–248, pl. 9. Describes three species from Indiana—*Codaster pyramidatus*, *C. americanus*, *Pentrimites grosvenore*.

1871. SMITH, S. I. Notice of a fossil insect from the Carboniferous formation of Indiana. Am. Jour. Sci., Ser. 3, Vol. 1, pp. 44–46. The paper describes a new insect, *Paolia vetusta*, from the Hindostan Whetstone beds at French Lick. The original figure is republished in the 20th Ann. Rept. Geol. Surv. of Ind., p. 356.

1858. STEVENS, R. P. Description of new Carboniferous fossils from the Appalachian, Illinois and Michigan coal fields. Am. Jour. Sci., 2d ser., Vol. 25, pp. 258–265. Describes *Chiton parvulus* from Bergen Hill (Spergen Hill?).

1883. ST. JOHN, ORESTES, AND WORTHEN, A. H. Descriptions of fossil fishes. Geol. Survey of Ill., Vol. VII, 1883, pp. 57–264. Records *Taeniodus regularis* nov. sp. from Bedford, and *Orthopleurodus carbonarius* (N. and W.) from Posey County.

1886. THOMPSON, MAURICE. Fossil mammals of the Post-Pliocene in Indiana. 15th Ann. Rep't of Ind. Dept. of Geol. and Nat. Hist., 1885 and '86, pp. 283–285. Gives brief descriptions and localities of all species certainly identified.

1891. THOMPSON, MAURICE. Geology of Carroll County. 17th Rep't Ind. Dept. of Geol. and Nat. Hist., 1891, pp. 171–191. Mentions a few fossils found at Delphi, by which he identified Niagara and Devonian strata at this point.

1886. THOMPSON, W. H. A Geological Survey, Clinton County. 15th Ann. Rep't Ind. Dept. of Geol. and Nat. Hist., 1885–86, p. 155. Notes the discovery of *Elephas primigenius*.

1879. ULRICH, E. O. Description of a Trilobite from the Niagara group of Indiana. Jour. Cin. Soc. Nat. Hist., Vol. II, No. 2, pp. 131–134, 1879. Describes and figures *Calymene nasuta* from the Niagara group at Osgood, Ripley County.

1879. ULRICH, E. O. Descriptions of new genera and species of fossils from the Lower Silurian about Cincinnati. Jour. Cin. Soc. Nat. Hist., Vol. II, No. 1, pp. 8–30, 1879. Describes and figures *Tellinomya cingulata* n. sp., found at Marble Hill, near Madison, and at Louisville, Kentucky.

1880. ULRICH, E. O. Catalogue of fossils occurring in the Cincinnati group of Ohio, Indiana and Kentucky. 31 pages, Cincinnati, 1880.

1882. ULRICH, E. O. American Paleozoic Bryozoa. Jour. Cin. Soc. Nat. Hist., Vol. V, 1882, pp. 232–257, pls. 10–11. Notes the following species from Osgood, Indiana: *Diplotrypa milleri* n. sp., *Monotrypella subquadrata* n. sp., *Callopora elegantula.*

1883. ULRICH, E O. American Paleozoic Bryozoa. Jour. Cin. Soc. Nat. Hist., Vol. VI, pls. 10–14, pp. 245–279, 1883. Describes and figures the following new species from the Niagara group of Indiana: *Trematopora halli* n. sp. from Waldron, *T. whitfieldi* n. sp. from Waldron, and *Idiotrypa parasitica* n. sp. from Osgood.

1886. ULRICH, E. O. Descriptions of new Silurian and Devonian fossils. Contributions to American Pal., Vol. I, No. 1, 1886, pp. 3–35, pls. 1–3, Cincinnati. A number of new species of Bryozoa and Gastropods are described from Indiana rocks, also a new Brachiopod from the Knobstone—*Rhynchonella greeniana*—and a new species of foraminifera—*Moelerina greenei.*

1888. ULRICH, E O. A correlation of the Lower Silurian horizons of Tennessee and of the Ohio and Mississippi valleys with those of Canada. Am. Geol., Vol. I, pp. 100–110, 179–190, 305–315; Vol. II, pp. 39–44, 1888. Gives description of paleontology, stratigraphy and structure of the Lower Silurian of the Ohio Valley.

1888. ULRICH, E. O. A correlation of the Lower Silurian horizons of Tennessee and the Ohio and Mississippi valleys with those of New York and Canada. Am. Geol. 1, 1888, pp. 39–44, 100–110, 305–315.

1890. ULRICH, E. O. New and little known American Paleozoic Ostracoda. Jour. Cin. Soc. Nat. Hist., Vol. 13, 1890, pp. 104–137, 173–211, pls. 7–18. Nearly thirty new species from Indiana are described in this paper.

1890. ULRICH, E. O. New Lamellibranchiata. Am. Geol., Vol. 6, Sept., 1890.

1893. ULRICH, E. O. New and little known Lamellibranchiata from the Lower Silurian rocks of Ohio and adjacent States. Geol. Surv. of Ohio, Vol. VII, pp. 627–693, pls. 45–56. Describes the following new species from Indiana: *Ichyrodonta miseneri*, *Ichyrodonta modioliformis*, *Modiolodon subrectus*, *M. declivis*, *M. subovalis*, *Clionychia excavata*.

1894. ULRICH, E. O. The Lower Silurian Ostracoda of Minnesota. Geol. and Nat. Hist. Surv. Minn., Vol. III, pp. 633–693, pls. 43–46, 1894. The author mentions two species of Ostracoda occurring at Richmond and Versailles which he figures; they are *Ceratopsis chambersi* Miller and *Tetradella quadrilirata* H. & W.

1897. ULRICH, E. O. The Lower Silurian Gastropoda of Minnesota. Geol. of Minn., Vol. 3, Pt. 2, pp. 815–1081, pls. 61–82. A large number of Gastropods from Indiana rocks are figured, some of which are new species.

1897. ULRICH, E. O. The Lower Silurian Ostracoda of Minnesota. Geol. of Minn., Vol. 3, Pt 2, pp. 629–693, pls. 43–46. Two species are mentioned from the Cincinnati group of Indiana —*Ceratopsis chambersi* var. *robusta* and *Tetradella quadrilirata* Hall and White.

1897. ULRICH, E. O. The Lower Silurian Lamellibranchiata of Minnesota. Geol. of Minn., Vol. 3, Pt. 2, pp. 475–628, pls. 35–42. Four species are reported from the rocks of the Cincinnati group in Indiana. They are *Byssonychia tenuistriata*, *Modiolopsis concentrica* Hall. & Whit., *Orthodesma canaliculatum* Ulrich, *Whitella obliquata* Ulrich.

1847. VERNEUIL, ED. DE. Note sur le parallesme des roches des depots paleozoiques de l'Amerique Septrionale avec ceux de l'Europe, suive d'un tableau des especes fossiles commones aux deux continents, avec l'indication des etages on elles as recountreut, et terminee par un examen critique de chacune de ces especes. Bull. Soc. Geol. de France, (2) t IV, pp. 640–710, 1847. Translated and condensed by Jas. Hall. Am. Jour. Sci., 2d ser., Vol. 5, 1848, pp. 176-183, 359–370; also Vol. 6, pp. 45–51, 218–231. de Verneuil considers the Black shale of Indiana and Kentucky equivalent to the Genesee of New York.

1889. VOGDES, ANTHONY W. The genera and species of North American Carboniferous Trilobites. Ann. N. Y. Acad. Sci., Vol. 4, pp. 69–105, pls. 2 and 3. Republishes the original descriptions of *Phillipsia doris* (Hall) Winch. and *P. rockfordensis* Winchell.

1881. WACHSMUTH, CHAS., AND SPRINGER, FRANK. Revision of the Paleo-Crinoidea, Part II. Proc. Phila. Acad. Nat. Sci., 1881, pp. 177–414, pls. 17–19. Describes the following new species from the Keokuk group in Indiana: *Eretmocrinus originarius*, *E. intermedius*, *E. adultus* and *Batocrinus whitei.*

1892. WACHSMUTH, CHAS., AND SPRINGER, FRANK. Description of two new genera and eight species of Camerate Crinoids from the Niagara group. Am. Geol., Vol. 10, 1892, pp. 135–144.

1878. WETHERBY, A. G. Description of a new family and genus of Lower Silurian Crustacea. Jour. Cin. Soc. Nat. Hist., Vol. I, 1878, No. 4, pp. 162–166. Describes the new Crustacean genus *Enoploura* from specimens found at Richmond and Osgood, Indiana, and Ohio localities, to which he transfers Meek's species, *balanoides*, from the Cystidae. See Meek's description in A. J. S., Vol. III (3d ser.), p. 423, 1872; also see review and sharp criticism of Wetherby's genus in Geological Magazine, May, 1880, by Dr. Henry Woodward.

1878. WHITE, C. A. Descriptions of new species of invertebrate fossils from the Carboniferous and Upper Silurian rocks of Illinois and Indiana. Proc. Phila. Acad. of Sci., 1878, pp. 29–37. The following species from Indiana are described without figures: *Baryphyllum fungulus*, *Platycrinus bonensis*, *Scapiocrinus gibsoni*, *Lepidesthes colletti* and *Scaphiocrinus gurleyi.*

1880. WHITE, C. A. Fossils of the Indiana rocks. 2d Ann. Rep't Dept. Stat. and Geol. of Ind., 1880, pp. 471–522, pls. 1–11. A few of the more common fossils of each of the formations in Indiana are described and figured.

1883. WHITE, C. A. Fossils of the Indiana rocks, No. 3. 13th Ann. Rep't Geol. Surv. Ind., 1883, pp. 107–180, pls. 23–39. The principal species of the Coal Measures are described.

1896. WHITE, DAVID. Report on the Fossil Plants from the Hindostan whetstone beds in Orange County, Indiana. 20th Ann. Rep't Ind. Dept. Geol. and Nat Res., 1896, pp. 354–355. Gives list of species identified from a collection of plant fossils transmitted by E. M. Kindle.

1874. WHITFIELD, R. P. 6th Ann. Rep't Geol. Surv. Ind., pp. 179–182. Gives a list of fossils from the black shale, with notes.

1881. WHITFIELD, R. P. Remarks on Dictyophyton, and descriptions of new species of allied forms from the Keokuk beds at Crawfordsville, Indiana. Bull. Am. Mus. Nat. Hist., Vol. I, 1881, pp. 10–20, pls. 3, 4. Three new species are described—*Uphantaenia dawsoni*, *Dictyophyton cattiliforme* and *D. cylindricum.*

1882. WHITFIELD, R. P. On the fauna of the limestones of Spergen Hill, Indiana, with a revision of the descriptions of its fossils hitherto published and illustrations of the species from the original type series. Bull. Am. Mus. Nat. Hist., Vol. I, 1882, pp. 39–97, pls. 6–9. Two new species are described from the St. Louis L's, at Spergen Hill—*Pteronites spergensis* and *Cytherellina glandella.* A list of species identified from this locality in addition to the species described by Hall is given.

1885. WHITFIELD, R. P. Notice of a new Cephalopod from the Niagara rocks of Indiana. Bull. Am. Mus. Nat. Hist., 1885, Vol. I, No. 6, p. 192, pl. 21.

1884. COPE, E. D., AND WORTMAN, J. L. Postpliocene vertebrates of Indiana. 14th Ann. Rep't Dept. Geol. and Nat. Hist. Surv.

1876. WINCHELL, N. H. Vegetable remains in the drift deposits of the Northwest. Am. Assoc. Adv. Sci. Proc., Vol. 24, Part 2, pp. 43–56, 1876.

1865. WINCHELL, ALEXANDER. Descriptions of new species of fossils from the Marshall group of Michigan and its supposed equivalents in other States: with notes on some fossils of the same age previously described. Proc. Phila. Acad. Nat. Sci., 1865, pp. 109–133. Describes and gives notes on six species of fossils from Rockford, Indiana.

1869. WINCHELL, ALEXANDER. On the geological age and equivalents of the Marshall group. Proc. Am. Phil. Soc., Vol. XI, pp. 57–83; Vol. XII, pp. 385–478. Gives a catalogue of the fossils of the Marshall group and its equivalents in the States where it has been recognized, including Indiana.

1895. WINCHELL, N. H., AND SCHUCHERT, C. Sponges Graptolites and Corals from the Lower Silurian of Minnesota. Geol. of Minn., Vol. 3, Pt. 1, pp. 55–95, pls. F. and G. Describes and figures some corals from Indiana—*Streptelasma rusticum* and *Protarea vetusta.*

1884. WORTHEN, A. H. Descriptions of two new species of Crustacea, fifty-one species of Mollusca, and three species of Crinoids from the Carboniferous formation of Illinois and adjacent States. Bull No. 2, Ill. State Mus. Nat Hist., 1884, pp. 1–27. The following new species from Crawfordsville are described without figures: *Sanguinolites? multistriatus, Aviculopecten spinuliferous, A. colleti* and *Batocrinus montgomeryensis.*

1889. WORTHEN, A. H. Catalogue of American Paleozoic fossils: the collection of Prof. A. H Worthen, deceased. pp. 1–75, Warsaw, Ill., 1889. This collection, which is now the property of the State of Illinois, includes about 752 types, 240 of which are Crinoids. Many of the specimens are from Indiana.

THE

BIRDS OF INDIANA.

A DESCRIPTIVE CATALOGUE OF THE BIRDS THAT HAVE BEEN OBSERVED WITHIN THE STATE, WITH AN ACCOUNT OF THEIR HABITS.

By AMOS W. BUTLER.

INTRODUCTION.

At the request of Prof. W. S. Blatchley, the chief of the Department of Geology and Natural Resources, I have undertaken the preparation of a report upon the birds of Indiana. This is made necessary by the fact that Dr. A. W. Brayton's "Catalogue of the Birds of Indiana," published in 1879, has long been out of print and the supply of my own catalogue of 1890 is practically exhausted. Both of these papers were published by the Indiana Horticultural Society.

With the increasing interest in the relations of birds to the farm, orchard, garden and lawn; with the attention that has of late been directed to birds as subjects for nature study in all our schools and with the awakening desire to prevent the slaughter of native beneficial birds, for purposes of decoration and adornment, has come a demand for information relating to the birds about us that is unsupplied.

It is desired that I give at this time an account of the occurrence, distribution, breeding range, nesting habits and foods of the birds of the State, to which shall be added descriptions of all the species that occur within our limits and an artificial key to aid in their determination. With the material available, the result of over twenty-one years' observations on the migrations of birds within the State of Indiana, it was to have been hoped that the way might have opened for some extended consideration of the data at hand. I have been enabled to illustrate slightly the movements of birds generally, giving the earliest and latest dates as indicating the two extremes of the migratory periods as they are known to us. It is to be hoped that at an early date at least one volume will appear, giving some of the more important results of the observations that have been made.

While this report is based largely upon my notes, made principally in southeastern Indiana within the past twenty-one years, I have also had the benefit of the material that has come into my hands as the curator of the Department of Ornithology of the Indiana Academy of Science. Dr. C. Hart Merriam, chief of the Biological Survey of the U. S. Department of Agriculture, has very kindly afforded me facilities for examining the migration reports in his office from Indiana for a series of years. He has also arranged to supply such cuts as are in the possession of that department for the purpose of illustrating this report.

I have been favored with the assistance of Mr. Robert Ridgway, curator of the Department of Birds of the United States National Museum; Dr. J. A. Allen, American Museum of Natural History, New York; Dr. F. W. Langdon, Mr. Charles Dury, Mr. H. W. McBride, Cincinnati, O.; Mr. Ruthven Deane, Mr. H. K. Coale, Mr. J. G. Parker, Jr., Mr. F. M. Woodruff, Chicago, Ill.; Mr. E. R. Quick, Brookville, Ind.; Mr. C. E. Aiken, Salt Lake City, Utah; Mr. Jerome Trombley, Petersburg, Mich.; Mr. L. Whitney Watkins, Manchester, Mich.; Prof. B. W. Evermann, Icthyologist, U. S. Fish Commission, Washington, D. C.; Prof. W. S. Blatchley, Dr. A. W. Brayton and Hon. R. Wes. McBride, Indianapolis, Ind., and also of Mrs. Jane L. Hine, Sedan; Mr. E. J. Chansler, Bicknell; Messrs. L. A. and C. D. Test, Lafayette; Prof. H. S. Voorhees, Brookville, and Miss Lulu Ward, Milton, and of a great number of patient investigators who, for the love of nature and the desire to advance knowledge, have made careful observations and submitted valuable reports. Towards the end of this paper I have attempted to mention them by name, and I sincerely hope I have omitted none. To each one I extend my thanks for the assistance rendered.

In addition the J. B. Lippincott Company have kindly given me permission to make use of the keys in Ridgway's Manual of North American Birds. A. C. McClung & Company have granted the same permission regarding Dr. Jordan's Manual of Vertebrates, and Dr. Elliott Coues has authorized me to make use of his Key to North American Birds. I am indeed thankful for the courtesy extended by the persons interested in these valuable works. I have availed myself of the opportunity, and from them have gathered much of the material for the keys and descriptions found herein. In addition I have consulted Dr. Wheaton's Birds of Ohio, Mr. McIlwraith's Birds of Ontario, Prof. Cook's Birds of Michigan, Mr. Ridgway's Birds of Illinois, Dr. Hatch's Birds of Minnesota, Dr. Warren's Birds of Pennsylvania, Mr. Chapman's Birds of Eastern North America, Maj. Bendire's Life Histories of North American Birds, Mr. Nehrling's North American Birds, the reports of Professors King and Forbes on the food of birds, and numerous other publications, from all of which I have used more or less material. For this I desire to acknowledge my indebtedness to those authors and to others to whose works reference is made herein.

It has been my purpose not to include within this list any bird which has not been ascertained to occur within the State and not to note any species as having bred unless I have been satisfied upon good authority that it has done so. I have added a supplemental list of species which, from their having been taken near our limits, may, with greater or less probability, be expected to be found within the State.

THE INDIANA BIRD LAW.

In 1891 the Legislature, at the request of the Indiana Academy of Science and the Indiana Horticultural Society, enacted the following law for the protection of our native beneficial birds:

"AN ACT for the protection of birds, their nests and eggs.

(Approved March 5, 1891.)

"Section 1. Be it enacted by the General Assembly of the State of Indiana, That it shall be unlawful for any person to kill any wild bird other than a game bird or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird.

"Sec. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mud hens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock, and sandpipers, tattlers, and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act.

"Sec. 3. Any person violating the provisions of section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days.

"Sec. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in secton 5 of this act.

"Sec. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly acrcedited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege, and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed any bird or taken the nests or eggs of any bird for any other purpose than that named in this section, and shall further be subject for each offense to the penalties provided in this act.

"Sec. 6. The permits authorized by this act shall be in force for two years only from the date of their issue and shall not be transferable.

"Sec. 7. The English or European house sparrow (*Passer domesticus*), crows, hawks, and other birds of prey are not included among the birds protected by this act.

"Sec. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

"Sec. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage."

In some localities this law has been enforced, but presumably in others it is not well known. It is to be hoped that our citizens will familiarize themselves with it to the end that it may be made efficient throughout the Commonwealth.

POSITION AND BOUNDARY.

The following is an account of the location and physical features of Indiana. The quotations are from Dr. Charles R. Dryer's "Studies in Indiana Geography:"

"Indiana is one of the North Central States, situated in what is sometimes called the Middle West, between the upper Great Lakes and the Ohio, and mostly in the Mississippi basin. The central parallel of the United States, the 39th, crosses its southern third and it is included between 37 degrees 41 minutes and 41 degrees 46 minutes north latitude, and between 84 degrees 44 minutes and 88 degrees 6 minutes west longitude. It is bounded on the north by the parallel which is ten miles north of the southern extremity of Lake Michigan; on the east by the meridian of the mouth of the Great Miami River; on the south by the Ohio, and on the west by the Wabash river and the meridian of Vincennes. Its extreme length is 250 miles, its average width 145 miles, its area 36,350 square miles.

ELEVATION.

"According to Powell's division of the United States into physiographic regions, Indiana lies mostly on the Ice Plains, but includes a small portion of the Lake Plains on the north and of the Alleghany Plateau on the southeast. The highest land in the State, in southern Randolph county, is 1,285 feet above tide; the lowest, at the southwest corner is 313 feet. The area above 1,000 feet comprises 2,850 square miles, in three tracts: (1) An irregular area around the headwaters of the Whitewater river, in Union, Wayne, Randolph, Delaware, Henry, Rush, Decatur, Franklin and Ripley counties;* (2) a narrow crescentic ridge in Brown county; (3) a considerable area in Steuben, DeKalb, Noble and Lagrange counties. Isolated peaks rise in Brown county to 1,172 feet and in Steuben to 1,200 feet. The area between 500 and 1,000 feet in elevation is 28,800 square miles and that below 500 feet is 4,700 square miles. The average elevation of the state is 700 feet.

* * * * *

PHYSIOGRAPHIC REGIONS.

"The most striking physical contrast in Indiana is that between the glaciated and unglaciated areas. A comparison of the topographic map with that showing the revised glacial boundary brings out this contrast sharply. North of the limit of drift the contour lines run in large curves and are far apart, showing the general smoothness and monotony of the surface. South of the glacial boundary the lines are crowded and extremely tortuous, showing a surface much cut up. The limit of drift incloses and fits this area of broken surface as a man's coat fits his shoulders.

"*The Ohio Slope.*—That portion of the State which slopes directly to the Ohio, including the driftless area and the southeastern part of the drift plain, is a region of deep, narrow valleys, bounded by precipitous bluffs and separated by sharp, irregular divides. Isolated knobs and buttes are numerous; the crests and summits are from 300 to 500 feet above the valley bottoms. The streams are rapid and broken by frequent cataracts. All open out into the Ohio Valley, a trench from one to six miles wide, 400 feet deep and bounded by steep bluffs.

"*The Central Plain.*—North of an irregular line extending in a general direction from Richmond to Terre Haute, and south of the westward flowing portion of the Wabash from Fort Wayne to Attica,

* Also Fayette and a part of Dearborn.

the topography is that of an almost featureless drift plain. It is traversed by numerous morainic ridges, but they are low and inconspicuous. The traveler may ride upon the railway train for hours without seeing a greater elevation than a hay stack or a pile of sawdust. The divides are flat and sometimes swampy, the streams muddy and sluggish. The valleys begin on the uplands as scarcely perceptible grooves in the compact boulder clay, widen much more rapidly than they deepen and seldom reach down to the rock floor.

"*The Northern Plain.*—The portion of the drift plain north of the Wabash river is more varied than the central plain, and comprises several regions which differ materially in character. A small area around the head of Lake Michigan is occupied by sand ridges and dunes, partly due to a former extension of the lake and partly to present wind action. Some of the drifting dunes are more than 100 feet high. This region is separated by a belt of morainic hills from the *basin of the Kankakee*, which contains the most extensive marshes and prairies in the State. This region also is traversed by numerous low ridges of sand, the origin and character of which are not yet well understood. Many of its features are probably due to the fact that during the retreat of the ice-sheet it was temporarily occupied by a glacial lake, which received the wash from the high moraines to the eastward. Northeastern Indiana is the *region of high moraines*, and has a strongly marked character of its own. A massive ridge of drift, 25 miles wide, 100 miles long and from 200 to 500 feet thick, extends from Steuben County to Cass County and is joined by several smaller branches from the northwest. This is the joint moraine of the Erie and Saginaw lobes of the Laurentide glacier. Much of its surface is extremely irregular, presenting a succession of rounded domes, conical peaks, and winding ridges, with hollows of corresponding shape between, which are occupied by innumerable lakes and marshes; the highest points are 100 to 300 feet above the level intermorainic intervals. A large proportion of the material is sand and gravel. A small area in eastern Allen County is a part of the bed of the glacial Lake Maumee.

DRAINAGE.

"The general slope of Indiana is to the southwest, as indicated by the course of the Wabash River and its tributaries, which drain two-thirds of the State. Of the remaining third one-half is drained directly to the Ohio and one-half to Lakes Erie and Michigan and to the Mississippi through the Illinois.

"*The Wabash River* is the great artery of Indiana, which it traverses for more than 400 miles. The fall is quite uniformly about eighteen inches per mile. Its current is gentle and unbroken by notable rapids or falls. Its valley is quite varied in character. Above Huntington it is a young valley, without bluffs, terraces or flood plain. Below Huntington it once carried the drainage of the upper Maumee Basin, and is nowhere less than a mile wide as far down as Attica. Below that point its width varies from two to six miles. The original valley has been largely filled with drift, which the present river has been unable to clear out. It winds between extensive terraces of gravel, which border it at various elevations, and flows at a level from 50 to 100 feet above the original rock floor. Below Terre Haute, the wide flood plain, ox-bow bends and bayous give it a character similar to that of the lower Mississippi. The upper tributaries as far down as Lafayette are post-glacial streams in drift valleys, whose courses are largely determined by the trend of the moraines. Below that point the smaller tributaries enter the river through picturesque sandstone gorges.

"*White River*, the largest tributary of the Wabash, and rivaling it in volume of discharge, is a much more varied and complex stream. The larger West Fork rises at the summit level of the state in Randolph county. In its upper course it is moraine-guided, like the upper tributaries of the Wabash, and presents the same characters as the other streams of the central plain. In Morgan county it assumes a different aspect, and thence to its mouth flows through a valley from one to three miles wide, 100 to 300 feet deep, bordered by wide bottoms. The East Fork rises on the same elevation as the West, but reaches its destination by a more tortuous course. Although its length is increased and its slope decreased by its numerous meanders, it is still a swift stream. Both forks of White river suffered many disturbances during the glacial period, which have not yet been studied in detail, but are obvious from the varying character of their valleys and from the terraces which border them at all heights up to 300 feet.

"*The Whitewater River* takes the shortest course of all from the summit level to the Ohio, and its average fall is about seven feet to the mile. At Richmond it has cut a narrow gorge into the soft shales 100 feet deep. In strongest contrast with this and the other rivers of the Ohio Slope is the *Kankakee*, which winds through wide marshes with a scarcely perceptible current and without definite banks. Its basin, however, is sufficiently elevated to render good drainage possible by the construction of the requisite ditches, and much has already been done to that end.

PHYSIOGRAPHIC FEATURES.

"Many important land forms are wanting in Indiana. There are no mountains, no valleys formed by upheaval or subsidence, no volcanoes or volcanic rocks except foreign fragments brought by the ice sheet, no features due to disturbance of the earth crust except the rock foundations of the State itself.

"*Plains.*—As already indicated, the greater part of Indiana is a *plain of accumulation;* the surface of a sheet of glacial drift which varies in thickness from a few feet to 500 feet or more. The average thickness is more than 100 feet. It consists chiefly of a mass of clay containing more or less gravel and boulders—the *till* or boulder clay of the geologists. This is locally varied by heaps, ridges, sheets and pockets of sand and gravel, and in the southern part of the State is overlain by a peculiar fine silt called *loess.* The boulder clay is the grist of the glacial mill, and is composed of a very intimate and heterogeneous mixture of native and foreign materials, containing fragments of almost every known mineral and rock. The large fragments, or boulders, are widely distributed, and of every size up to 30 feet in diameter. They are nearly all igneous or metamorphic in character and can be traced back to their origin in the Canadian highlands north of the Great Lakes.

"The driftless area is a *plain of degradation,* formed by the removal of the original rock surface to an unknown depth, and now represented by the summits of the flat and even-topped divides, ridges and hills.

"*Hills.*—On the northern plain occur numerous *hills of accumulation* forming the great morainic belts, the result of excessive dumping and heaping up of drift along the margins and between the lobes of the melting ice-sheet. The most impressive examples are found in Steuben, Lagrange, Noble and Kosciusko counties, where they attain a height of 200 feet or more, and are as steep and sharp as the materials will lie. Their peculiar forms and tumultuous arrangement give a striking and picturesque character to the landscape.

"The Ohio Slope is studded all over with *hills of degradation*—blocks and fragments of the original plain left by the cutting out of the valleys between them. Some are broad and flat-topped, some narrow, crooked and level-crested, some sharp or rounded, isolated knobs or buttes. These are very conspicuous in the counties of Greene, Daviess, Martin, Crawford, Orange, Washington and Jackson, but attain their greatest development in Floyd, Clark and Scott, where the Silver Hills and Guinea Hills rise to 400 and 500 feet above the valley bottoms. In Brown County the knob topography attains the highest absolute elevation in Weed Patch Hill, and the surrounding region is so rugged as to have gained the title of the 'Switzerland of Indiana.'

"In Benton county Mounts Nebo and Gilboa are isolated masses of rock projecting above the general level of the plain, and are probably entitled to the name of *monadnocks*.

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"*Lakes.*—The surface of the northern plain is peppered with small lakes which occupy irregular depressions in the surface of the drift, and are especially characteristic of the massive moraines. The whole number cannot be less than 1,000. The largest, Turkey Lake in Kosciusko county, has an area of five and a half square miles.

"*Marshes and Swamps.*—These exceed the lakes in number and extent. The smaller ones are the basins of former lakes which have been filled up with sediment and vegetation. The largest are in the Kankakee Basin, and are the remaining vestiges of a glacial lake. Everywhere over the central plain the divides are too flat and the slopes too gentle for good drainage, and marshes abound. These, however, have been largely drained by ditches."

The surface of the State presents considerable differences in its vegetation. The heaviest timber which was found in central and southern Indiana has for the greater part disappeared. Throughout the northern part of the State the number of large trees is much less and the general size of forest trees decreases noticeably as one proceeds northward.

"Contrary to the statements made in many books, Indiana is not a prairie state. An area estimated to comprise one-eighth of the whole, situated, except a few isolated patches in the northwestern part, is marsh and upland prairie. The remainder of the State was originally covered by a heavy growth of oak, walnut, beech, maple and other hardwood timber, with sycamore and poplar near the streams and a little pine along the Ohio slope. No region in the United States could show finer specimens or a greater number of individuals and species of forest trees than the lower Wabash Valley. The same region is said to be the original habitat of the bluegrass which has made Indiana and Kentucky pastures so famous." (Dryer, p. 25.)

PECULIARITIES AFFECTING BIRD DISTRIBUTION.

The region about the southern end of Lake Michigan presents an unusually fertile field for the ornithologist. Situated as it is, midway between the wooded region of the East and the treeless plains of the West, with the warm river bottoms of the South, rich in southern species, extending to within a comparatively short distance, and the great lake upon the north, northwestern Indiana forms a kind of "four corners" where the avian faunæ of four regions intergrade. To the proximity of Lake Michigan we are indebted for a number of more or less strictly maritime species. As would be expected the southern species occur only in summer, with the exception of *Lophophanes bicolor*, which is found only in winter. Not only is the influence of the lake upon the faunæ shown by the occurrence of numerous species of birds, attracted by the presence of a large body of water, with its congenial surroundings, but the influence of the lake upon the climate and the vegetation in its immediate vicinity has a marked influence upon the list of summer residents. The northwestern portion of the State is divided into alternating tracts of prairie, marsh and woodland, each possessing a bird life of its own. In Lake County, along the Lake Shore, is a stretch of pine woods known as "the pinery," which is quite peculiar. (Condensed from E. W. Nelson's notes of "Birds of Northeastern Illinois.") Coming south one crosses the Kankakee River and marshes, well-known regions for water fowl and marsh-inhabiting birds, and enters the Wabash Valley. Back from this valley proper we find occasional prairies and extensive meadows, where such prairie-inhabiting forms as Henslow's Sparrows, Yellow-winged Sparrows, Black-throated Buntings and Prairie Larks are expected to be found. The lower Wabash Valley is noted for its extended "bottom lands" and "cypress swamps," which, for their flora no less than their birds, are of much interest. The amount of bird life here in summer is very much in excess of that in the northwestern corner of the State at that season. The difference in the number of birds noted would be readily observed. In the southeastern part of the State the land rises in some places almost 400 feet above the Ohio River within a mile or very little more. On leaving the fertile river bottoms, with their successive terraces, one ascends the steep river hills and soon reaches the wet flats where the drainage is so poor that the water stands upon the surface beneath the oak and beech timber the greater part of the year. There is an intimate relation between the topography and the character of the soil here. There is a comparatively level plateau extending from the Ohio River "bluffs" to the northward, west of the valley of the Whitewater, and forming the water shed of a number of streams, some running into the Whitewater and some into the White River. This surface soil is usually a white or gray clay, characteristic of the country within 30 miles of the Ohio River in the southeastern corner of the State. From this one descends until the "broken uplands" are found lying just below the level land. Still lower down the "hillsides" are reached. These rise more or less abruptly from the bottom lands. The prevailing timber of this region is oak, maple, beech, sweet gum, black gum, etc., and with them are found, each in its season, some birds which prefer these surroundings—Summer Redbird, Cape May Warbler, Black-throated Blue Warbler, etc. East of the Whitewater River to beyond the Ohio line the country is more level and the soil darker and more fertile, the land ranking with the best in the State. The central portion of the State is comparatively level and very fertile. It was more recently settled than the southeastern portion, and hence to-day there may still be seen among the finest farms specimens of the largest trees to be found upon Indiana soil. The northeastern part of the State has been but little explored by the zoologist. Doubtless it will prove a valuable field for the one who will occupy it. This is the "lake region" of Indiana. Within this quarter is the meeting of two drainage systems—the Wabash to the southwest and the St. Joseph and St. Mary's to the northeast. The Wabash River is the line of principal migration in Indiana. As it turns to the eastward many routes leave it for the north, particularly just south of Lake Michigan, but many birds follow its course along its length. To this fact seems to be due the peculiar distribution of such forms as the Prothonotary and Cerulean Warblers, and in less degree the Kentucky, Worm-eating and Sycamore Warblers.

CHANGES IN BIRD-LIFE.

When our race first viewed this region it was a vast forest, a wilderness, unbroken save by the water courses, the trail of the Indian, the runways of the deer, the roadways of the buffalo. Our birds were only such as frequented the densest woodland or the bars in the river channels, together with forms of wide range and birds of passage. With the cutting away of the larger trees sprang up thickets, and therewith came thicket-inhabiting forms. As the clearings were extended meadow lands and pasture lands were reserved. To the meadows came such forms as the Bay-winged Bunting, Field Sparrow, Black-throated Bunting and Grasshopper Sparrow, species peculiar to such surroundings. Some parts of this land were wet and, where the drainage was not good, became swamps and sloughs. There birds peculiar to such localities settled, among them Marsh Wrens, Rails, Gallinules, Swamp Sparrows and Red-winged Blackbirds. As the orchard and garden developed, other birds, well known to us and greatly beloved for their cheery, social ways, there made their home; such are the Orchard Oriole, Warbling Vireo and Yellow Warbler. The changes in conditions and continual increase in number of settlers caused a continual diminution in numbers of many birds; especially is this true of geese, ducks and other water-loving species, while some birds famous in history and literature have passed from us and are fast becoming extinct. Such are the Ivory-billed Woodpecker, Pileated Woodpecker, Wild Turkey and Carolina Parakeet. About our homes the Bluebirds, House Wrens and Carolina Wrens came and lived with us, even nearer and dearer than other birds.

As time went on drainage became a feature introduced into the new country. With the drainage of our sloughs and swamps a second change was noted. The forms of avian life, which lived among its reeds and flags, mingling their voices with those of the frogs, disappeared, and the land reclaimed tells, in its luxuriant growth of corn, no story to the casual passer-by of the former population which occupied it. Time went on, change followed change, little by little, but still each cleared field, each rotation of crops, each one of a thousand variations in cause had its effect upon the numbers or the life history of our birds.

DESTRUCTION OF BIRDS.

By man's agency the English Sparrow was introduced, and as its numbers increased, began to assert itself in the struggle for existence. The Bluebird, which has come from the hole in the snag, was driven from her box. The Martin and Chimney Swift, which formerly nested in hollow trees, left their nesting sites about the house, and even the Eave Swallow, which in olden times fastened its nests to the cliffs, was in some cases driven away. The warfare still continues with this aggressive little foreigner, worse some places than others, but with such surprising powers of reproduction and unheard-of audacity, it seems they must soon cover our entire continent.

Another epoch in this category is marked by the abnormal craze which has for some years been noted of using the skins and parts of birds for purposes of decoration and adornment. This barbarous custom has been frowned down in some places by society leaders, but is still quite common.

It is marvelous, the destruction of innocent, beneficial lives that have been sacrified upon the altar of fashion. Our State has now a very good law for the protection of our native birds, and it behooves us all to see that in our communities, our separate neighborhoods, that law is fully enforced. Unless this is done we may awake too late to the importance of protecting these feathered friends who gather their substance from the insect enemies of the farm, the orchard, the garden and the woodland.

Birds are also destroyed in great numbers by natural causes. The sudden severe storms which occur at times in the migrating season often cause the death of a great number of tiny wanderers. It is no unusual thing to find along the shores of Lake Michigan, and numbers of other great lakes, following some severe, cold storm, the bodies of great numbers of migrating birds. How great this loss of life is cannot be estimated, but they are often found lying close together on the beach where they have been tossed by the waves. Again, it is no unusual thing to find, following a spell of cold weather in April or May, the bodies of many birds which have just arrived from the South and have been unable to withstand the effects of the sudden cold which came upon them. Other birds which irregularly winter with us, at times when they attempt to remain, are destroyed in great numbers in unusually severe and unfavorable winter weather. A striking illustration of this was the severe weather of the late winter and early spring of 1895, when, over almost the entire Southern States east of the Mississippi, a cold wave prevailed coincident with the winter range of the Buebirds, Hermit Thrushes, Robins and other birds occupying that region. These wintering birds were destroyed in great numbers—so great, in fact, as almost to exterminate the entire race of Bluebirds and to greatly lessen the numbers of some other forms. In addition to this, many birds are destroyed at the time of migration on dark nights by flying against the lighthouses, light towers and other lights in high places. Unfavorable weather during the breeding season is also the cause of large loss of life among the young birds and of the destruction of many eggs.

In addition, birds are subject to disease, fall a prey to their enemies, are killed by accident, and, as these conditions combine in a favorable or in an unfavorable way, we may note among many species, taking one year with another, an increase or a decrease in their normal numbers.

ZOOLOGICAL AREAS.

Geographers have attempted to divide the world into zoological regions in accordance with the harmonic distribution of certain typical forms. These zoological areas have not been very accurately defined. They may be termed the different divisions of the sea of animal life, with its tides, currents, varying temperature and depth, two areas meeting as land and sea, each with irregular shore lines and deeply indented coasts, the boundaries continually changing as barriers in one direction are overcome, and in another a different coast configuration appears.

Indiana is included entirely within the Eastern (Atlantic) faunal province, and while it is within the limits of the Carolina fauna of Mr. Allen, the southern portion contains so many birds that are distinctive of the Louisiana fauna (Austroriparian Province of Professor Cope) that it has been thought it should be referred to that district. According to Dr. Merriam's provincial classification, almost all of Indiana is included within the upper Sonoran Zone. The Transition Zone appears in the northern part, while the extreme southwestern portion is included in an arm of the lower Sonoran Zone.

BIRD MIGRATION.

The migratory instinct is one of the wonders of nature. The origin of migration seems to reach far back into the unwritten history of the past. According to geological testimony, in the earlier ages of the earth's history a warm climate existed almost to the North Pole. Then neither lack of food nor the consequences of rigorous winter compelled the birds to leave that favored region. With the changing of conditions by which the circumpolar area became colder, then ice-locked and finally the limit of ice extended far to the southward, the birds were forced to more congenial lands. With the winter they sought warmer climes, and as the summer approached they sought to return to the ancestral home. Finally the southern limit of the ice sheet was reached, and it began to recede. With its recession the birds were enabled to reach higher latitudes, and in time, when the frigid area reached its present limitation, there was left for our solution the problem of the migration of birds. This habit is not the acquirement of any one bird, but is the influence of the experience of many generations of birds extending through long ages of time, an inherited desire to seek nesting sites near the old home of their race.

With what regularity do certain forms leave their summer homes in the temperate and frigid realms and traverse the great expanse of plain and wood and ocean to far within the tropics, there spending the colder parts of the year, returning to the same breeding ground when summer approaches! Unerringly they pursue long lines of migration, as though following beaten paths, for thousands of miles. O'er river and lake and sea, o'er marsh and mountain and meadow they fly. So accurate is the chart, so true the compass of instinct, that each returning annual pilgrimage brings the little wanderers to their former homes. When the frosts touch the maple leaves and tinge the woods with bright autumn colors we miss some of our little friends. Day after day as the daylight grows shorter others follow where they led, until, when the snows come, many of the summer songsters have left us. These have sought the regions best suited to their condition in winter, where the food supply is more abundant or more easily obtained. Others from farther north have taken their places. These, to us, are winter residents. To our friends farther northward they are summer residents; between us there is a region where they are known as migrants. Among these latter bids which spend a part or the whole winter in our States are the Junco or Black Snow-bird, one form of Shore-lark, Tree Sparrows, the Sapsucker or Yellow-bellied Woodpecker, rarely the White Snow-bird or Snowflake, the Snowy Owl and the Bohemian Waxwing. Their summer homes are north of us.

Some of the forms, perhaps most of them, which are with us the whole year round are not represented winter, spring, summer and autumn by the same individuals. In winter the Song Sparrow among the garden shrubbery or in the willow thickets are not particularly numerous, but late in March and early in April a host of Song Sparrows have appeared from the milder climate of Tennessee and neighboring States. Their numbers are very noticeable, but they, with many, perhaps all, of those who wintered with us, have passed on farther north. The usual number remains to keep house, rear a family and cheer humanity with their songs. With October those who spent their summers farther north return, and, as the frosts succeed dews and snows succeed frosts, they gradually pass by to favorite winter homes, leaving the individuals we knew the past winter with their children, our companions through the colder part of the year. The American Goldfinch that appears with the apple leaves in April in lemon-yellow dress with black cap and wings, comes from the southland to replace other more hardy relatives of his by the same name, who were hardly recognized by many of us for the plain winter dress they wore. Well, they passed on northward just a day or two before these brighter-appearing ones arrived from the pine groves and cotton fields of the Southern States. Next fall they will return with their bright colors deadened by the touch of the north wind, but we will know them by their voices.

The impression which may prevail that the winter residents are smaller than the summer forms is erroneous. The Shore-larks, which winter with us, represent the same species which is resident in summer and the northern form which is larger. The idea that many birds migrate at night is correct.

Some winters the Robins, Meadow Larks, Kingfishers, Killdeers, Red-headed Woodpeckers and Chewinks remain with us. Other years they pass to the southward. Even when they are here, some years they seem to the casual observer to have left; yet the inquisitive lover of birds knows his little friends are to be found, even in inclement weather, though they do not appear to the uninitiated. To such an one a protected thicket, a deep ravine, an unexposed hillside, a dense woodland, as his tramp leads through such out-of-the-way places, is found to be inhabited by forms which have disappeared to many eyes. The instinct which calls upon some to seek the better feeding grounds, the warmer places of earth, has impelled these to well-protected spots and localities where food may be most easily obtained.

The Catbird, Blackbird, Chipping Sparrow and Phœbe go but a little farther south, some years lingering along the Ohio River.

The Marsh Wrens, Red-winged Blackbird, Hermit Thrush and sometimes the beautiful little Ruby-crowned Kinglet and eccentric little Blue-gray Gnat-catcher linger along the gulf coast, while all the north is snow-bound.

Other birds go farther on their winter journey. The Baltimore Orioles go as far as Panama. Our cheery Bobolink with "his Quaker wife," both plain clad when cold comes nigh, visit the West Indies and South America. The King Bird reaches the West Indes and Bolivia. The Night Hawk covers the same islands and Eastern South America. The Cerulean Warbler, on the contrary, visits Cuba and Central America. Kirtland's rare warbler winters only in the Bahamas. The little Spotted Sandpiper visits Brazil. The Blue-winged Teal extends its journey to Ecuador, and Swainson's Thrush to Peru.

Some make more extended tours even than these. The American Golden Plover, a well-known game bird, which breeds in the northern part of our continent, when winter holds the northern hemisphere in his cold grasp, is found as far away as Patagonia, while the Knot, a coast bird which breeds in very high northern latitudes, the eggs of which were taken by the members of the Greely Arctic expedition at Ft. Conger, about north latitude 82 degrees, ranges to Cape Horn during our winter. Thus it will be observed migration may mean the trip to the protected thicket in the vicinity of wild grapes, blackberries and weed patches laden with seed at the southern edge of the farm, or the almost endless voyage of some shore birds across every one of the earth's zones. It may mean a change of individuals; a moving of those which summer with us a little farther south and a filling of their places by others of the same kind from a little farther north. It may mean a restlessness which some years impels the Bob White to move southward a few miles, or again to leave the hills and congregate in the valleys, or the reverse. Many times they fly into towns, and becoming confused, enter houses and stores, and are readily caught in the hand. It may mean the slow movement of the short-winged warblers and wrens, or the rapid flight of the swallow and Wild Pigeon. Its cause is the instinct which tells them to prepare for winter or return for spring. A call that must be answered, an inherent demand that comes to each individual through the accumulated experiences of the past which it cannot disobey.

Birds do not move promiscuously over the country, but are observed to have migratory routes. The Mississippi River is a great artery along which in spring courses a mighty stream of avian life destined to its breeding ground. At the mouth of the Ohio a large stream turns off to ascend that river, sending out branches of considerable size up the Wabash, Whitewater and Miami rivers. The Whitewater Valley forms one channel by which these wandering birds reach the Maumee and the lakes, whence many pass on still farther northward to their summer homes. As the rivers become the channels of migration for certain species, other forms of different habits follow the higher lands or the mountain bases, along characteristic topographical features. As the warm air of spring comes, as from the throbbing of a great tropical heart, so the birds come, in pulsating movements, each succeeding one stronger and driving its tide of life farther along its course. Each bird-wave seems to move as though the rear of the migrating forms was continually passing over the more advanced and taking the lead. Among the smaller streams, the main ridges, the connecting woodland, at the height of the migration may readily be observed the smaller currents of bird life given off by the larger streams, each following its own course, all instinctively going in a definite direction—north. The whole movement may be compared to the circulation of sap in a tree. From trunk to limb, from limb to branch, from branch to bough, from bough to twig, from twig to leaf. The entire movement over either hemisphere may be likened to numberless trees with their roots at the equator, their topmost branches approaching the poles. In autumn the courses of the bird currents are not so plainly marked, but yet along the borders of our streams may be seen, at favorable times, hordes of little wanderers moving past in almost endless streams at early morn and eventide.

GENERAL INDEX.