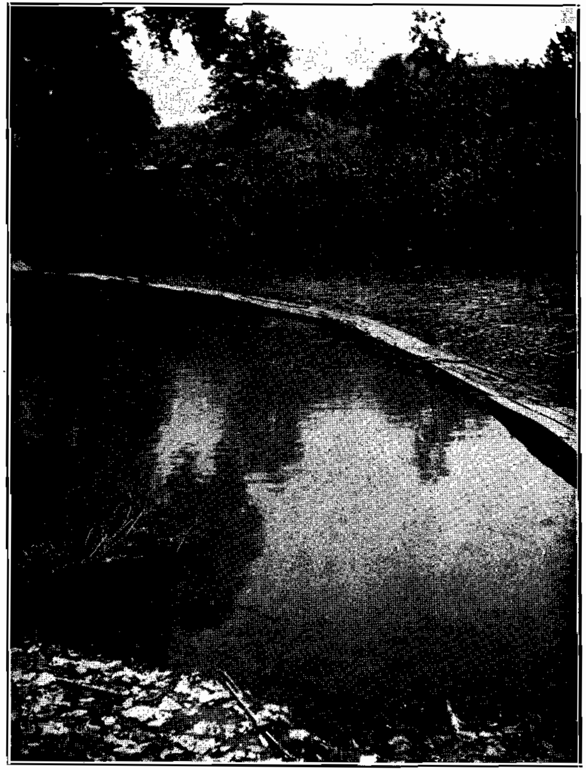
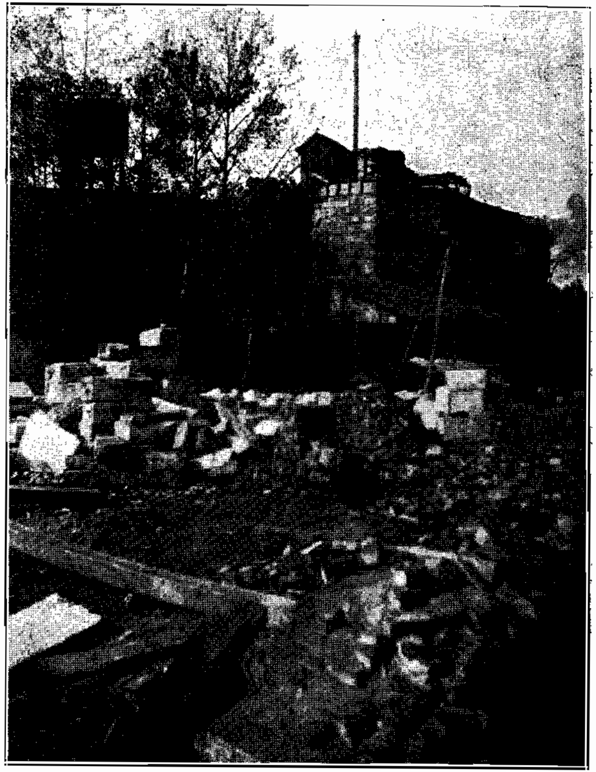
PLATE I.



FLOATING FOOT BRIDGE ACROSS BLUE RIVER AT MILLTOWN, IND.

(See page 242.)



LIME KILNS AT SALEM, IND.

(See page 249.)

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources.

TWENTY-EIGHTH ANNUAL REPORT.

W. S. BLATCHLEY,

STATE GEOLOGIST.

1903

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.
1904.

QE 1.. [handwritten library call number, partly illegible]

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
INDIANAPOLIS, March 4, 1904.

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

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, March 4, 1904.

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

D. E. SHERRICK,
Auditor of State.

March 8, 1904.

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

GEO. B. LOCKWOOD,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana, March 10, 1904.

DANIEL E. STORMS,
Secretary of State.

Received the within report and delivered to the printer this 10th day of March, 1904.

THOS. J. CARTER,
Clerk Printing Bureau.

State of Indiana, Department of Geology and Natural Resources.

INDIANAPOLIS, IND., February 20, 1904.

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

DEAR SIR—I transmit to you herewith the manuscript of the Twenty-eighth Annual Report of the Department of Geology and Natural Resources, the same being for the calendar year 1903.

Respectfully yours,

W. S. BLATCHLEY,

State Geologist.

ASSISTANTS.

T. C. HOPKINS, Syracuse, N. Y.	Field Assistant.
E. M. KINDLE, Franklin	Paleontologist.
L C. WARD, Huntington	Field Assistant.
AUGUST F. FOERSTE, Dayton, Ohio	Field Assistant.
L. E. DANIELS, Laporte	Clerk and Field Assistant.
JAMES EPPERSON, Linton	Inspector of Mines.
ANDREW DODDS, Oakland City	Assistant Inspector of Mines.
JONATHAN THOMAS, Carbon	Assistant Inspector of Mines.
B. A. KINNEY, Marion	Supervisor of Natural Gas.
ALBERT STEVENS, Muncie	Assistant Supervisor of Natural Gas.
ISADORE KESSLER, Indianapolis	Stenographer.

TABLE OF CONTENTS.

DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND.

W. S. BLATCHLEY, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

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

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

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

INTRODUCTORY.

The most valuable feature of the present report of the Department of Geology is an accurate, sectional, geological map of the State. The data for this map have been gathered during the past nine years, or since the present Director assumed charge of the Department. Every boundary line between the different formations shown on the map has been traced in the field since then. Dr. T. C. Hopkins has had direct charge of the making of the original copy of the map. In its compilation he has used the field notes and maps made by Drs. Ashley, Siebenthal, Kindle, Foerste and other assistants on the survey. Besides these, he has incorporated the results of his own work in the oölitic limestone and sandstone districts, and also the results of much special field work done by him with a view of making the map as complete and accurate as possible. The map is on a scale of four miles to the inch, and shows every section comprised within the limits of the State, while the boundary lines are traced as accurately as possible through the sections they cross. In the deep drift-covered area of the northern part of the State it is impossible to trace the boundary between the formations, hence that portion of the map is left uncolored.

In order that the map may be as intelligible as possible to persons who have but little knowledge of geology, Drs. Hopkins and Foerste have prepared a special paper to accompany it, describing briefly the rocks of the different periods represented in the State. By using this paper in connection with the map, much of interest can be learned concerning the topography and general structure of the surface of the State.

The production of petroleum in Indiana has rapidly grown until that industry has become one of the greatest in the State. The price of the crude product during the past year reached the highest in its history, and averaged higher than during any previous year. This stimulated the sinking of many new bores which added quite an area to that hitherto productive. The output of Indiana oil for the year 1903 reached the enormous total of 9,177,722 barrels, which, at the average market price of $1.14 3-20 per barrel, brought to the producers $10,476,369. More inquiries come to the office of the Department concerning oil than any other resource. In order to meet these inquiries a paper has been prepared giving in detail the developments and statistics of the industry in the State during the year. Accompanying this paper is an accurate map of the main Indiana oil field as it was on January 1, 1904.

The fourth paper in the volume deals with "The Lime Industry in Indiana." The burning of lime in the State has gradually grown from the days of the pioneers, when it was carried on in rude temporary kilns in each neighborhood where lime rock occurs, until it has become an important industry with hundreds of thousands of dollars invested. The paper describes and gives the general location of each kind of rock suitable for lime burning in the State; and also contains descriptions of all the lime burning plants now in operation. It is the first time that the Lime Industry has been given more than brief mention in any of the reports issued by the Department.

In the report for 1900, the writer predicted that the yearly output of Indiana coal would reach 10,000,000 tons before 1910. From present indications, it will more likely double that amount by the time mentioned, as the report of the State Mine Inspector shows that 9,992,553 tons were mined in the State in 1903. This was an increase of 1,229,356 tons over the output of 1902, which was the largest in the history of the State. The output in 1898 was 5,177,044 tons; the increase in five years was, therefore, 4,815,509 tons, or 93 per cent.

During the past three years there has been an absence of the customary strikes on the part of the miners, due to the biennial agreement between miners and operators. The prolonged strike in the Pennsylvania hard coal fields in 1902, causing thousands of tons of soft coal to be used instead of anthracite; the almost complete failure of natural gas in this State, and the unprecedented activity in manufacturing of every kind, were the principal factors causing the enormous output of Indiana coal in 1903. At one time in January of that year, mine-run bituminous coal was sold at $3.60 per ton at the mines in Vermillion County, and the average yearly price was far in excess of what it had ever been.

According to the report of Mr. Epperson, the relative rank of the 14 coal producing counties for the year 1903, together with the output of each in tons and the amount of wages paid to miners was as follows:

TONS OF COAL PRODUCED AND WAGES PAID TO MINERS IN INDIANA IN 1903, BY COUNTIES.

	No. of Tons Produced.	*Wages Paid.*
Greene County	2,226,791	$1,888,045 39
Vigo County	1,716,726	1,493,761 80
Sullivan County	1,553,338	1,264,436 99
Clay County	1,222,474	1,415,508 06
Vermillion County	942,165	748,447 77
Parke County	929,994	1,088,504 26
Pike County	484,228	449,931 99
Warrick County	315,641	214,481 75
Vanderburgh County	204,648	192,735 78
Daviess County	191,159	195,442 12
Knox County	137,949	122,591 61
Gibson County	46,700	51,233 06
Fountain County	16,620	13,336 19
Perry County	11,120	11,115 35
Total	9,992,553	$9,149,572 12

Of the coal produced, 1,025,940 tons were block coal and the remainder bituminous. Clay and Parke counties alone yielded block coal; Clay County producing 586,381 tons and Parke County the remainder, or 439,559 tons. The output of block coal has fallen off nearly one-third since 1900, when 1,512,098 tons were mined. This decrease is in Clay County, where many of the old mines have been worked out. It is estimated that, at the present rate of output, the block coal of the State will be wholly exhausted in 20 years. The report of Mr. Epperson gives many other facts of interest relative to the coal industry of the State, being very full and complete in detail.

The report of the State Gas Supervisor, Mr. B. A. Kinney, of Marion, Indiana, follows that of the Mine Inspector. On account of the numerous bores put down in gas territory in search of oil, Mr. Kinney and his assistant were kept very busy in enforcing the law against the waste of gas, a large number of affidavits having been filed against offenders during the year. Being well acquainted with all parts of the territory and conscientious in the performance of his duty, the State Supervisor has reduced to a gas remaining. His report shows that the average gas well drilled during the year would have been considered a failure ten years ago, the great majority of them yielding less than 500,000 cubic feet a day when finished. A small area of comparatively virgin gas territory was opened up in northern Grant and southern Wabash and Huntington counties, the output of which was piped to the cities of Wabash, Marion and Huntington. In the old field the supply of gas is practically exhausted, except for domestic consumption in the residences of the smaller towns and country. A few factories still use it in the summer season, but almost all have to supplement its use with coal or other fuel.

A short paper by W. M. Mills on the physiography of the region immediately surrounding Winona Lake, the famous resort in Kosciusko County, follows that of Mr. Kinney. In it interesting facts are given concerning the basin and water supply of the lake, together with others relating to the plant life found about its margins and in its waters.

Following the custom adopted in recent years of publishing in the reports a paper on the Natural History or Paleontology of the State, the next paper is devoted to the fossil faunas of the Niagara rocks of northern Indiana. This paper is by Dr. E. M. Kindle, and is a companion to his excellent paper on the Devonian fossils which formed a portion of the 1900 (25th) Report. Most of the species described in the paper are figured on accompanying plates, the drawings being made especially for the paper by Dr. J. C. McConnell, of Washington, D. C., the well known draughtsman of the Paleontological Division of the U. S. Geological Survey, and by G. S. Barkentin, who fills a similar position on the New York Survey. A number of the species described and figured are new to science; thus making the paper the more interesting to paleontologists and to all persons who desire some knowledge of the animals existing in the seas of Upper Silurian time.

The present volume is the 28th in the series of annual reports issued by the Department of Geology of the State of Indiana, and the ninth issued under the auspices of the writer. Believing that a general table of contents and index to the past volumes would be of permanent value to all persons who use these reports for reference, the writer has had one compiled by Dr. Hopkins, and

THE GEOLOGICAL MAP OF INDIANA.

By T. C. Hopkins.

EXPLANATORY.

The large geological map that accompanies this report is a compilation of the stratigraphic work of the assistants of the Indiana Geological Survey since 1895, or since the present State Geologist, W. S. Blatchley, has been in office. Much of the area is shown in greater detail on larger scale maps accompanying the different annual reports, but portions of the State were surveyed especially for this map, and the results are here shown for the first time.

The drafting of the geographical base was done by the writer with some assistance from Mr. Chas. J. Clark, Civil Engineer. It is a compilation from many different sources. The primary base was the record of the government land survey as delineated on the township sheets in the land office in Indianapolis. These were corrected in the field for a large part of the State, but for the portion of the State not covered by some of the assistants on the survey, the data is mainly that from the old government survey with such additions as could be obtained from other sources, and will be lacking in the accuracy of detail found in the portions covered by the field work of the assistants on the survey.

The geologic work was done by the different assistants on the survey. Geo. H. Ashley supervised all the work on the Coal Measures, and did a considerable portion of it himself. He also, with Mr. Kindle, traced the partings for the Lower Carboniferous groups in southern Indiana south of and including part of Orange County. The Coal Measure maps are published in seven map sheets in the Twenty-third Annual Report, and the maps of the Lower Carboniferous limestone of southern Indiana are published in two sheets in the Twenty-seventh Annual Report.

C. E. Siebenthal traced the boundaries of the oölitic limestone in Lawrence, Monroe and southern Owen counties, as delineated on the sheets published in the Twenty-first Annual Report. He also assisted Mr. Ashley in mapping the Coal Measures as indicated in the Twenty-third Annual Report. He also mapped part of the Devonian area of southern Indiana as shown on the map sheet in the Twenty-fourth Annual Report.

E. M. Kindle mapped the whetstone area in Orange County, and assisted Mr. Ashley in mapping the Coal Measures and the Lower Carboniferous of southern Indiana, and did part of the areal work on the Silurian and Devonian in north-central Indiana.

August F. Foerste mapped the Silurian and Ordovician areas in the southeast part of the State and also placed the work on the State map. Part of this work is shown on sketch maps accompanying his papers in the Twenty-first and Twenty-second Annual Reports, but a considerable portion of it is shown on the State map for the first time.

J. F. Newsom, aided by his students from Indiana University, mapped a section across southern Indiana and traced a considerable portion of the partings on each side of the Knobstone group.

J. A. Price mapped the Waldron shale in eastern Indiana, as shown on the map sheets accompanying his paper on that subject in the Twenty-fourth Annual Report, and assisted Mr. Ashley in mapping the coal field.

The writer, T. C. Hopkins, mapped the base of the Coal Measures from township 12 N. to its northern limit, as shown on the map sheets in the Twentieth Annual Report. He also traced the partings between the different groups of the Lower Carboniferous through Lawrence, Monroe, Owen, Morgan, Putnam, Montgomery, Fountain and Tippecanoe counties as delineated on this map for the first time. He also traced part of the Knobstone parting, and did some work on the Devonian shales in Tippecanoe County.

All of the work was done under the direction and supervision of the present State Geologist, W. S. Blatchley.

The geological partings in the central and north-central portions of the State are deeply buried beneath a heavy mantle of glacial drift, so that very few outcrops of the rocks can be seen; hence the partings between the different groups could not be traced with the same degree of accuracy as could those in the western, southern and southeastern parts of the State, where the glacial drift is absent or much thinner, and where the streams have eroded deep valleys, thus causing many outcrops of the rocks so that their position can be determined. The greater detail in these areas is indicated by the greater sinuosities of the lines of parting.

It may be of interest to the general reader to know how a geological map is made. It will not be possible in a few lines to give all the details of such work, but in general the plan is somewhat as follows: The geologist first traverses the region to be mapped, visiting the outcrops wherever he can find them, studying them in their different characters and noting their relations to each other, so that he can make out a section of the geological column showing the kinds of strata, that is the different limestones, sandstones, shales, etc., their relation to one another and the thickness of each as they occur in the area to be mapped. He then decides upon how many of these subdivisions he will show on the map he is to make. Thus sometimes each single stratum is shown by a separate color or pattern and again a series of strata are grouped together and delineated by a single color for the whole group.

After determining how many and what groups are to be represented, and knowing the general characteristics and distinctions of each, he proceeds to find where these different groups outcrop and to trace the lines of parting where the outcrops of the different groups meet. If the rocks were perfectly bare this would be a very simple process and would only necessitate the worker's ability to properly locate on the map the line as he follows it out in the field. But the outcrops are, in many places, in fact in Indiana in most places, covered with a thick mantle of loose material and only in places here and there on the bluffs of the watercourses and the steep places on the hillsides can the rock be seen. To trace out the line of parting where the outcrops can be seen only here and there requires the application of considerable general knowledge and close observation. It is necessary to study the character of the soil produced by the different strata which is sometimes so characteristic as to enable one to follow out the parting in this way. It is necessary to observe the topographic peculiarities of each stratum, which is an assistance sometimes. If one is a bed of clay or shale underlying a limestone or sandstone, it is frequently a horizon for springs. Frequently the only data available is that obtained from well records. In many regions some of the wells, in some places all of them, are sunk through the soil mantle into the solid rock underneath and if the geologist can obtain a piece of the rock or obtain definite information about it, he will be greatly aided in his work.

If every person who sinks a well or has one made would keep a careful record it would be a great service to geology. The most desirable data are the thickness of the soil mantle to the solid rock, the kind of rock first struck and thickness of this and of any other underlying strata that are penetrated by the well digger or the drill. If a careful record had been kept of all the wells that have been sunk in Indiana and these records were accessible to the geologist, they would be of great service.

When, by the aid of these different methods and others, the geologist has determined the position of the lines separating the outcrops of the different strata, he draws them on his map and designates the different areas by different colors or different shading or marking, and the engraver and the printer make a reproduction of it by engraving it on copper or stone and then printing from it as from ordinary type.

The time, the expense and the skill required in the construction of a geological map are increased as the scale of the map increases, and as greater accuracy of detail is required. If an area is underlain by valuable mineral deposits it may be studied and mapped on a scale and nicety of detail that would not be justified on another area.

No attempt has been made on the accompanying map to show the different kinds of soil and glacial deposits of the State, as sufficient data for that part of the work has not been gathered.

Many of the minor subdivisions are too small to be readily represented on a map of ordinary size. Hence the Geological map of Indiana presents the distribution chiefly of the major subdivisions of the Paleozoic formations of the State, while many of the smaller subdivisions are recorded only in the text.

A brief discussion of the chief characteristics of the various divisions and subdivisions of the Paleozoic rocks of Indiana is presented in the following pages.

THE PETROLEUM INDUSTRY IN INDIANA IN 1903.

By W. S. Blatchley.

Definition of Petroleum.—Crude petroleum, or "rock oil," is a natural bitumen, composed mainly of the combustible elements, carbon and hydrogen. In its most common form it is a brownish-black, ill-smelling liquid, with a specific gravity of about .86. When kindled, it burns readily with a bright flame and without leaving a residue. When exposed to the atmosphere it gives up slowly its volatile gases, and is, in time, reduced to a thick, semi-solid, asphaltum-like mass. The name petroleum comes from two Latin words, *"petra,"* a rock, and *"oleum,"* oil, and in many localities it is known as "rock oil," or simply "oil."

Distribution of Petroleum.—Petroleum is widely distributed throughout the countries of the world, and is found in the rocks of almost every geological formation, from those of the old Archæan time up to the later members of the Tertiary Age. In some of the older countries, as India and Japan, it has been known to and used by man as a remedial agent for more than 2,500 years. For many centuries, however, its uses were few, its possibilities of furnishing valuable products by distillation not being known. With the advancement in the knowledge of chemistry came a better understanding of its component elements, and within the past quarter of a century it has come to be one of the great and necessary resources of the earth. Its value has fluctuated from time to time, but since 1900 the tendency has been upward, for the demand has come to exceed the supply. For a year or two the refiners have been using the crude oil faster than it is being pumped into the pipe lines, and the reserve stocks of millions of barrels in the great iron tanks have been called upon to supply the deficiency.

During the year 1902 the United States produced 80,894,590 barrels of petroleum, which brought, delivered into the pipe lines,

$69,610,348. In the same year Russia produced 80,493,381 barrels. The United States thus stood first in the rank of petroleum producing countries, and, aside from Russia, produced more oil than all the rest of the world combined.

The oil from the different parts of the United States varies much in character and grade. That from Pennsylvania, New York, West Virginia and southeastern Ohio, known as "Pennsylvania Oil," is considered best for making illuminating products, and brings the highest price on the market. The "Lima Oil" from the Trenton rocks of northwestern Ohio and northeastern Indiana ranks second in grade. Like the Pennsylvania oil, it possesses a paraffine base, but contains a certain percentage of sulphur, not found in the former, and for that reason is more expensive to refine. The oils of Kansas, Colorado and Corsicana, Texas, have also a paraffine base, and rank about equal with the Lima oil in value. Most of the petroleum produced in Louisiana, Texas and California has an asphaltum base, and consequently yields an illuminating oil of low value. It is used largely for fuel and brings a much lower price per barrel than the oils with a paraffine base.

While the increase in petroleum production in the United States in 1902 was 11,505,396 barrels, the great percentage of gain was in the low grade oils of California and Texas. The high grade Pennsylvania product decreased 1,646,651 barrels, while the medium grade Lima output increased 1,425,247 barrels, all of which came from new developments in Indiana. During that year the accumulated stocks of Pennsylvania and Lima oils were decreased 4,175,173 barrels. In other words, the supply of high and medium grade oils throughout the year averaged 11,000 barrels a day less than the demand. For that reason the price rose gradually in 1902, and again in 1903, when the shipments of Lima oil exceeded the output of the wells by 3,780,288 barrels. At the present writing it is the opinions of experienced oil operators that the price of the better grades of crude petroleum will not soon, if ever, fall below the dollar mark. The prospects for any increased output of the paraffine oil production of the United States are being gradually narrowed down each succeeding year. At the same time there has been a constant increase in the demand for all classes of products that are manufactured from the higher grades of petroleum, with no indications of any immediate change.

Uses of Petroleum.—The average person has but little knowledge of the many uses to which crude petroleum is put or of the variety of products made from it in the great refineries. The most important and best known of these products is, of course, the illuminating oil known as kerosene, or "coal oil." This oil has become one of the greatest adjuncts of modern civilization; in fact, such a necessity of daily life that millions of inhabitants of this and other lands would find it difficult to do without. Besides kerosene, all the gasoline, benzine and naphtha of commerce come over as distillates from the crude petroleum. Among the solid products are vaseline, used so extensively as an external application, and paraffine, the candles of which have almost wholly superseded the old tallow "dip." Much paraffine is also used in making matches; as a preservative for eggs and various food stuffs; in laundry work as an auxiliary to soap, and for many other purposes. Rhigolene, a volatile product of crude petroleum, is a valuable anæsthetic, particularly for local application to produce cold.

Both petroleum products and crude petroleum are much used in the manufacture of artificial gas. In the making of "air gas," or carburetted air, gasoline is needed, while for "oil gas" and carburetted water gas crude petroleum is used, the liquid hydrocarbons of the oils being converted into permanent gas of high illuminating power. The crude petroleum is also often used for the enriching of coal gas., i. e., for making it of higher illuminating power.

Mineral oils from petroleum and the crude product itself are now almost wholly used for lubricating machinery, especially railway engines. As noted above, the poorer grades of crude petroleum, especially those with an asphaltum base, are extensively used as fuel.

In the words of the superintendent of one of the leading refineries of the country: "Practically nothing is now allowed to go to waste. Our by-products are really more valuable than the refined oil itself. Benzine and gasoline, which were formerly not considered by us, are now very valuable commodities. The coke which results from the burning of crude oil was formerly dumped into the river; now it is used in the manufacture of the carbons for electric lights, and we can not get enough of it. The vapors arising from the oil are condensed and recondensed, and are added to our list of by-products. In fact, nothing is permitted to get away which can, in any manner, shape or form, be utilized, and this is ascertained by our chemists and inventive men.

"There is not a thing designed or invented that will aid us either in our manner of refining the oil, or in effecting a saving so that we can utilize what was formerly wasted, that we do not have in our refineries. The changes that have taken place in the last ten or fifteen years are simply wonderful. Take refined oil, for instance. Many of our people can easily recall when it was almost as yellow as saffron; now it is as clear as crystal, and has been refined to such a degree that not a drop of it need be wasted. Our oils are used in soaps, perfumes, liniments, vaseline, and in so many different ways that I have neither the time nor the inclination to try to define their varied uses."

Petroleum in commercial quantities was first produced in Indiana in 1889, in a well put down by the Northern Indiana Oil Company, on the D. A. Bryson farm, near Keystone, Chester township, Wells County. From that date until January 1, 1904, the industry has gradually grown, until it has become one of the greatest in the State. From 33,375 barrels, valued at $10,881, in 1889, the output has increased to 9,177,722 barrels, valued at $10,476,369, in 1903. That the yearly output depends largely upon the price, and not upon the capacity of the field, is shown by the fact that the years 1897 and 1898 were the only ones, since the striking of oil in the State, in which the production fell off, and during those years the price was low, ranging only between 40 and 60 cents per barrel. Since 1898 there has been, for the most part, an upward tendency in price, and as a result the output has nearly trebled.

Petroleum in commercial quantities has been found in three distinct geological formations in Indiana, viz., the Trenton limestone of the Lower Silurian Age; the Corniferous limestone of the Devonian Age, and the Huron sandstone of the Sub-Carboniferous Age. It is, however, from the Trenton limestone that the great bulk of the crude petroleum of the State is produced. Each of these formations will now be taken up in order and its petroleum output treated.

TRENTON ROCK PETROLEUM.

FORMATION OF THE TRENTON LIMESTONE.—The Trenton limestone is one of the lower or older formations of the Lower Silurian System. Like other limestones, it owes its origin mainly to the presence of minute organisms in the water in which it was first laid down. The animals from whose remains the oil of the Trenton limestone was, for the most part, derived, were probably very low forms—the polyps and bryozoans of the ancient Silurian seas. In untold numbers they existed, and the carbonate of lime which makes up 80 per cent. of the unmodified Trenton rock is largely the remains of their secretions and incrustations. Associated with these lower forms were myriads of higher ones—crinoids, brachiopods, trilobites, gastropods, and even fishes. The presence of such swarms of animal life made necessary the existence of an abundance of plants, since the plant must ever precede the animal and gather for the latter the energy, and form for it the food, the living protoplasm, necessary to its existence. These plants were mostly marine algæ, or seaweeds and fucoids, though doubtless many other forms existed of which no remains have been preserved in the rocks of that age.

The Trenton limestones were evidently formed in rather clear water, at moderate depths. Near the bottoms of these shallow seas great beds of calcareous sediment were gradually collected, and were swept to and fro by the tides and currents. Rivers from the older Cambrian rocks brought down their eroded particles and added to the thickness of the ocean floor. Within these beds of sediment both plants and animals found a grave, their bodies in vast numbers being buried beneath the slowly accumulating deposits of centuries. Once buried in such deposits, they did not decay, as do animals on land, because by the waters above and the calcareous ooze around them they were shut off from free oxygen, which is the chief agent in decay. Gradually this ooze or fine sediment was, by the agency of the sea water, cemented and consolidated into limestone. In this manner that great layer of Trenton rock, which underlies at variable depths the whole of Indiana, was formed. From it has been derived, directly or indirectly, more wealth than from any other formation either underlying or

Origin of Petroleum.—In time the waters of the ocean containing this vast stratum of Trenton limestone, with its enclosed accumulation of undecayed plants and animals, became turbid, and, instead of calcareous sediment, deposited mud and clayey sediment in thick beds on top of the limestone strata. These deposits of mud and silt were afterward, by later deposits, compressed into the fine grained, impervious Utica shale, 100 to 300 feet in thickness, which thus effectually sealed the Trenton limestones, and so retained within them the oil and gas derived from their enclosed organic remains. This oil and its more volatile portion, the natural gas, was probably not formed in a short time, but is the result of a slow decomposition or destructive distillation carried on through thousands of centuries. Accumulating in vast reservoirs, the more porous portions of the Trenton limestone, or mother rock, it there remained until man came with his iron drill and furnished a vent through which it could rise. Then by combustion he caused it to yield up the stored energy, conserved since the sun's rays fell on the plants of the old Silurian seas.

Origin of Natural Gas.—From what has been said, it will be seen that both natural gas and oil have a common origin, viz., the destructive distillation, carried on through thousands of years, of the plants and animals which existed in the Trenton Period. 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 and air a very long period of time will bring about the same results. By this is meant the process of "slow destructive distillation" above mentioned. The primary product of such distillation was probably a light oil, which in the course of ages has, by volatilization, yielded the gas, and has itself been condensed into the heavier petroleum. The gas being lighter and more volatile than the oil, gradually rose into the higher interstices of the limestone. If an open barrel be filled with crude petroleum from the Trenton limestone of Indiana and exposed for a single summer to the air, more than half of the contents will pass away in the form of a vapor, and a sticky, tar-like residue will remain. If by some means the escaping vapor could be collected and analyzed it would be found in the main to have the same composition as natural gas. In fact, it would be natural gas, and would burn as freely as a sample of that valuable fuel, collected in the ordinary way. In the depths of the rock the evaporation of the oil has been extremely slow, and the amount has been limited both by the varying pressure of the overlying gas and the underlying water. There is little doubt, however, but that all the natural gas of the Trenton limestone has been so derived.

DISTRIBUTION OF PETROLEUM IN THE TRENTON LIMESTONE.—Not only Trenton limestones, but every other limestone, as well as most shales, have in the past produced petroleum in greater or less quantities. Distributed in minute proportions through the substances of the rocks, it easily escapes notice, but when intelligently looked for its presence is revealed, and, though the percentage is small, the aggregate is often vast. If, for example, a stratum carries but one-tenth of one per cent. of petroleum and is 500 feet in thickness, it contains more than 2,500,000 barrels to the square mile. Indeed, so common is the occurrence of petroleum in stratified rocks that wherever a close-grained shale occurs there is almost always a small accumulation of oil directly underneath it. The same thing is found when an impervious stratum of any other composition than shale occurs in the geological series.

If petroleum has been thus generally formed throughout the Trenton limestone, why do not all parts of that formation yield it in somewhat equal amounts? Why is it that a bore that pierces the Trenton in one locality is a "dry hole," while another, but a short distance away, results in a "hundred-barrel" well? The answer to such questions lies in the fact that the formation of large accumulations of oil depends as much upon the presence of suitable strata to receive and retain them as upon an adequate source of supply. In the minutely diffused state in which the oil was originally formed it was wholly without value. Like all other forms of mineral wealth, it had to be concentrated into reservoirs, the so-called "pools" of the oil field, before it could be utilized by man. The thousands of bores put down to the Trenton limestone for oil and gas in both Ohio and Indiana have proven that four conditions are necessary before an accumulation and preservation of oil in commercial quantities can take place. If any one of these conditions is absent, a dry hole or salt water well will invariably result. These necessary conditions are:

2. An impervious cover above the reservoir.
3. An arched or anticlinal structure of the rock in which the reservoir is located.
4. A pressure behind the oil to force it into the reservoir.

1. *The Porous Portions of Trenton Limestone.*—We have seen that the Trenton limestone is a sedimentary rock; i. e., one which was laid down in water, the bottom of the sea, ages ago. When first formed it was a nearly pure calcium carbonate or carbonate of lime. In the course of time certain areas of the sea bottom, covered with the incipient limestone, 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 by a distance of one 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 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. *The larger areas of the Trenton limestone deposit beneath the present bounds of Indiana were either too impure to admit of a change into dolomite, or the conditions of sea level were never such that the change took place; hence they are nonporous and barren of either oil or gas.*

Even in rich oil fields the porous dolomite has only been formed in a small proportion of the thickness of the Trenton rock. Usually two or more "pay streaks" or porous strata are found in the upper 70 feet of the Trenton. The upper one of these has a thickness of 3 to 10, or sometimes 15 feet, and usually occurs within 30 feet of the top of the Trenton. If the level of the Trenton is low at the point where the bore is put down, the upper streak is often lacking. The second porous stratum, usually the most productive, lies about 15 to 20 feet below the first and is separated from it by a bed of unchanged, nonporous limestone. This alternation of dolomite and limestone strata is probably due to changes in the sea levels at the time the limestone was being transformed into dolomite. Wherever the Trenton limestone assumes its normal character and ceases to be dolomitic, it ceases also to be oil-bearing. The change from an area containing porous rock into one wholly lacking it, is often abrupt. It is only the former which contains the oil, and there is no known method, except by drilling, of determining where the porous rock occurs.

2. *The Impervious Cover.*—In order to properly retain the accumulated petroleum the porous rock must be entirely covered with an impervious stratum, i. e., one through which neither oil nor its volatile gas will pass or can be forced by the enormous pressure behind it. Such a cover is usually a fine-grained shale, and wherever such a stratum covers a porous rock, petroleum in greater or less quantities is usually found. In the Indiana oil field the Trenton rock is covered by an average thickness of 250 feet of that dark brown, close-grained deposit known as the Utica shale, which possesses every quality of a typical impervious cover. The driller recognizes this stratum as soon as he strikes it by its color, its comparative freedom from fossils, and the ease with which it is drilled and mixed with water. No free oil is found in the Utica shale, though by distilling portions of it an amount equal to three per cent. of the shale* has been obtained.

3. *The Anticlinal Structure.*—The surface of the Trenton limestone is not level as many people suppose, but, like the surface of the earth, 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 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. When the oil was first formed, it was pushed or carried hither and thither by the heavier salt water be-

* Manual of Geology, 4th Ed. 522

hind it. Much of it was carried away by the water and lost, but wherever one of the porous areas existed in the side or top of an anticline, the oil was carried into it and there remained. During the ages which have elapsed much of the oil was changed into a volatile gas, which rose into the higher porous portions of the anticlines or ridges of the Trenton limestone. As this gas accumulated, it pressed back the remaining oil into the sides or flanks of the arch. The oil being lighter than the water, rested upon the latter and prevented it from rising into the higher porous portions of the limestone. When a bore is put down and strikes gas the latter will flow until the quantity which is stored in the porous area of the anticline is exhausted, when the oil, if any be present on the flanks or lower portions of the porous stratum, will rise in the gas well. It may be that the oil has been carried by the salt water into the porous portions of another anticline, and that only salt water occurs beneath the gas. If this be true, the water will fill the porous reservoir as soon as the gas is exhausted. The anticlines vary much in size, their domes running from scores of miles down to a half mile or less in width. The gas in the higher part of each anticline is, therefore, often shut off from that in a neighboring anticline by the intervening oil or water, or both. In the same way the oil in an anticline which contains oil only may be shut off from that in another anticline by the salt water filling all the porous portions of the syncline between. It often happens that a gas bore is put down which strikes the crest of a narrow anticline or raised portion of Trenton limestone which has not before been pierced. As a result the so-called rock pressure of the gas is at first high, but rapidly declines on account of the small size of the anticline. All the wider and higher anticlines in the main gas field in Indiana in which porous Trenton occurs, have been pierced many times, and the stored gaseous product has become almost exhausted.

In the Indiana oil field the production of a new well can usually be foretold by the depth at which the top of Trenton rock is found. If it is from five to ten feet higher than the average in the nearby productive wells, the chances are that it will yield much gas and little oil. On the other hand, if the Trenton is struck ten to fifteen feet lower than the average, the bore has pierced a trough or syncline, and a salt water well usually results. Sometimes, however, there are apparent exceptions. Of two wells in which the Trenton is found at the same depth, one will be a "gusher," and the other, but a short distance away, a "dry hole." The only explanation which can be given in such a case is that the latter has pierced a close-grained or nonporous area of the Trenton, into which no fluid has found its way.

4. *The Pressure Behind the Oil.*—Whenever the drill pierces a stratum of porous rock containing oil, the latter is pushed upward by the so-called "rock pressure" behind it. Sometimes this pressure is so great that when the oil stratum is reached the boring tools are expelled from the drill hole, and the oil escapes in a fountain, rising high above the derrick, much of it being lost before the flow can be controlled. In most instances, even if the well proves to be one of small production, the oil is forced upward several hundred feet in the drill hole. As noted above, this rock pressure has, in the past, had much to do with the accumulation of oil in the porous reservoirs.

It is now almost universally admitted that the rock pressure in any oil field is nothing more or less than water pressure, as in artesian wells, the water entering the Trenton limestone at some point where the latter outcrops and so forming a head or source. Hence, the deeper the well, the greater the head of water and the higher the rock pressure. The porous rock contains a limited amount of oil, held in place by the overlying shale. The salt water is below this oil, ever pressing it upward into the vent furnished by the drill hole. As the supply of oil is gradually lessened, the water rises to fill the pores, and the rock pressure is lowered. The pressure does not tell us anything about the volume or amount of oil stored in the rock; but the rate of diminution of pressure furnishes an excellent index of the rapidity with which that amount is being lessened. When the supply of oil is exhausted, as it naturally will be in time, there is no source from which it can be renewed. The salt water will rise and occupy the space which formerly held the oil and it will come to stay.

Salt water also occurs in the Trenton rock in all portions of the Indiana field. Usually a difference of only six to ten feet in the elevation or depression of the surface of Trenton defines oil and salt water territory. If the well has been located over a syncline, drilling has proceeded very far into that formation, and a well yielding only salt water usually results. If, however, the bore pierces the dome or flank of an anticline, either gas or oil will be struck, and the operator is usually careful to see that the drilling is stopped before the level of the water producing rock is reached.

In some cases, however, both water and oil are found together in the same stratum. Some of the best wells in the Indiana field are big salt water wells, pumping from 150 to 700, or even more, barrels of salt water, and 40 to 150 barrels of oil daily. It costs much more to operate a well of this kind, as it has to be pumped with a beam and, therefore, requires a separate power. Such wells

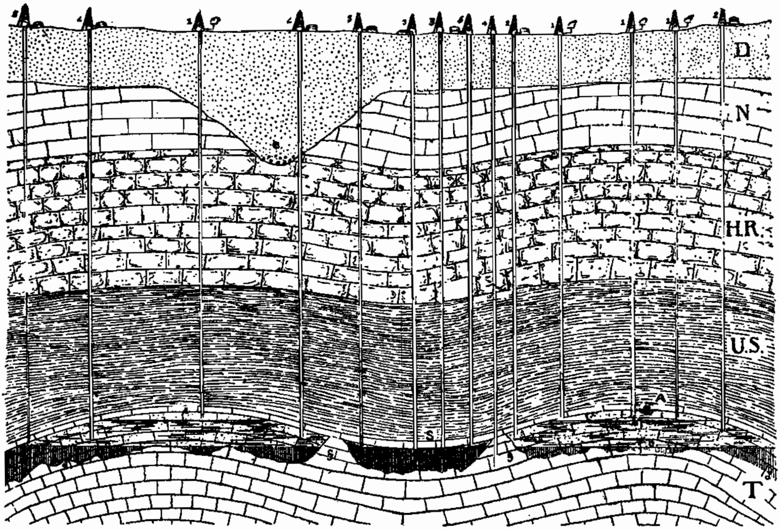


Fig. 1. D., Drift. N., Niagara limestone. H. R., Hudson River limestone. U. S., Utica shale. T., Trenton limestone. A., anticline. S., syncline. a to b, gas bearing stratum. b to c, oil bearing stratum. c to d, water bearing stratum of porous rock. e, preglacial channel through Niagara limestone. f, non-porous Trenton limestone.

Wells, Nos. 1 produce gas; Nos. 2, oil; Nos. 3, salt water; No. 4, dry hole; Nos. 5, oil and salt water.

are usually longer lived, as the salt water seems to renew the quantity of oil by bringing it in from quite an area of the porous stratum which the bore has pierced. Moreover, the salt water seems to keep the pores of the oil rock free from paraffine and other materials which have a tendency to clog them up, and a well producing four or five barrels of water a day in connection with the oil, is preferred by many operators to one that produces oil

The accompanying illustration (Fig. 1) will probably lead to a better understanding of the above mentioned facts regarding the accumulation and preservation of petroleum in the "Trenton rock" fields of Indiana.

Necessity of Accurate Surface Levels.—The trend, width and dip of the anticlines and synclines in the top of the Trenton limestone in any locality can only be ascertained by an accurate determination of the surface levels between a number of wells. 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 site 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 a few places in the State is the top of 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.

For example, the surface level at one point (*a*) near Hartford City is 894 feet above tide and the depth to top of Trenton 969 feet. The latter is, therefore, 75 feet below sea level. At another point (*b*), a short distance away, the surface level of the bore is 890 feet and the depth to Trenton 968 feet. At this bore the top of Trenton is therefore, 78 feet below tide, or three feet lower than at (*a*). The dip of the Trenton is, therefore, from *a* to *b*. The bore at *a* yielded much oil; that at *b* much salt water and little oil.

The location of the first half-dozen or so wells in any area a mile or two square must of necessity be largely a matter of guesswork, 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 guesswork 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.

Pools Not Necessarily Connected.—A fallacy which is held by many would-be operators in the Indiana field 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 anticlines in the Trenton formation, they are not necessarily connected, nor do the anticlines run in straight lines. From what has been said about the origin of the porous areas of the Trenton limestone, it will be seen that 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 the flank or dome of an 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. If any one of these conditions is lacking or has been lacking, the bore is sure to be a dry hole. Inasmuch as the top of the Trenton limestone in the main Indiana field is everywhere from 700 to 1,100 feet below the surface, it will be seen that the problem of locating in advance a paying well is a most difficult one.

Condemned Territory.—During the first few years of drilling for oil in Indiana much territory was needlessly condemned by isolated bores which were dry or very small producers. The average operator, then, as now, was in search of "gushers" or big wells, and turned down in disgust any territory where wells came in for less than ten barrels. With but little knowledge of the conditions governing the accumulation of oil it was thought that a dry hole condemned a square mile or more of the area about it. Experience, gained by the sinking of thousands of bores, has, however, proven that "one well is a test for but one location," that is, for an area of but a few acres about the bore. As a result, much of the condemned territory has been redrilled, and, in most instances, good producing wells have been developed where at one time it was thought no oil existed.

When oil was but 40 to 60 cents a barrel it did not pay to pump wells which averaged only three barrels a day. Now that the price has risen to $1.30, wells which yield but one barrel are pumped with profit, provided a number of them are operated by a single power. In a number of places leases have been abandoned as non-productive or as not paying the cost of operating, and have since been taken up by new parties and found to be very productive.

Examples of such leases are near Montpelier, Blackford County, where in section 3 Harrison township, the Baltes Oil Co. is operating a lease on which nine small wells had been drilled and abandoned up to 1900. In 1903, three new wells were drilled which averaged 30 barrels each at the start. On the Miller lease just north of Montpelier, four wells were pulled out in 1899 and the lease abandoned. It was retaken and three new bores sunk in 1903, all of which are fair producers. Still a third example is that of the Penrod and Hart leases in section 19, Washington township, Blackford County. These were held for some time by the Fort Wayne Gas Co., but only small producers were obtained and the leases and power house were finally sold for $350 to Miller & Davenport, of Bluffton. The new owners, at a cost of $1,400, put down a well on the Penrod farm which made two tanks of oil in 14 days. This brought $356, or more than the original cost of the property, and they then sold the leases and well for $15,000, after owning it but 42 days. The last owners have sunk two additional paying bores, and are well pleased with the property. These are but three examples of scores that could be given. They go to show that the operator in the Indiana oil field is taking chances with every bore he sinks. He has no way of knowing beforehand what the results will be. He may pierce the center of a reservoir and get a 300 barrel well; he may strike near its outer rim and get a 10 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 of oil from the immediate vicinity of his bore.

SURFACE INDICATIONS OF OIL.—Scarcely a day passes but that I am in receipt of a letter asking me to come to some point in Indiana and locate a well which will produce oil; or stating that bubbles of gas are continually escaping from some pond, spring or stream; or that a scum of oil occurs upon the surface of some body of water. The writers of these letters evidently believe that I possess a knowledge of the surface which will indicate where paying wells can be located, or that such bubbles or scum are certain indications of the presence of gas or oil in paying quantities. If they possess either or both of these suppositions they are woefully mistaken, for in Indiana *there are absolutely no surface indications which denote the presence of either gas or oil in paying quantities in the underlying rocks.* The conditions are such that no man on earth can, with certainty, locate in advance a productive well in any portion of the Indiana field. Gas and oil are found in commercial quantities in the State only at depths ranging from 500 to 1,600 feet below the surface.* Between the formations containing the gas and oil, namely, the Trenton and Corniferous limestones and the Huron sandstone, there are always one or more close-grained shales 50 to 300 feet in thickness. These shales are wholly impervious to both gas and oil; i. e., no particle of either of these fluids can find its way through them. In fact, such a shale is an absolute necessity to the presence of a commercial body of either gas or oil, else both of these would have long since found their way upward into the atmosphere. The bubbles of gas, noted as escaping from water, are, in almost every instance, marsh gas, which is formed by decaying organic matter at the bottom of the water, or in some deposit of carbonaceous material near by. The oil has exuded in minute quantities from some shale, clay, limestone or sandstone, as all such rocks contain some oil. But a drop or two is necessary to form many square feet of film or scum over the surface of a spring or pool. In many instances the supposed oil on the surface of a spring is not oil, but a brownish yellow precipitate of iron oxide.

*The Jasper County field is an exception to this, a heavy form of oil being there found in the Corniferous limestone at 100 to 120 feet below the surface. However, a shale impervi-

Again, the oil producing rocks in Indiana follow no definite direction, as in some other States. There is no northwest-southeast, or northeast-southwest axis or trend which the intelligent operator can follow and sink a productive bore 99 times out of a hundred. His operations in Indiana have always an element of chance connected with them. If he keeps well within the bounds of productive territory his chances of failure are much fewer than if wildcatting on the outside of such limits. But on the best area of known productive territory an occasional bore will come in dry.

Oil Smellers and Oil Finders.—The man with the "hazel rod," the "magnetic finder," and other forms of instruments which can locate oil a thousand feet below the surface is still in existence —still invades our State and catches suckers by the score. He is usually a fair guesser who knows enough to keep inside the limits of known producing territory. There, by chance, six wells out of ten which he locates come in as fair producers and from them he gains a prestige which enables him to land more of the innocent and unwary.

One of these so-called oil wizards has been operating extensively in Indiana during the winter of 1903-'04. He is fathered by a Chicago firm which advertises stock for sale and promises to guarantee the finding of oil to all who will invest. The inventor and handler of the instrument sent out by the company says that it is electro-magnetic in character, and that no one can successfully operate it but himself. According to his belief, all oil flows in streams which are continuous from one State to another and also from one geological formation to another. With this instrument he claims that he can locate these "oil streams" wherever he goes, whether on railway train, on horseback, or afoot. Thirty-five or more of such streams enter Indiana, mostly from the northwest, etc., etc.

It is strange that in an enlightened age like the present such claims and opinions should find credence, and that a company making such pretenses should be able to sell its stock, yet many believe, a number invest, but how many ever have or ever will realize one penny on the investment? There is one instrument and but one that can be used in locating oil in Indiana and that is the *drill*. All others are and ever will be humbugs; and all men who rods, instruments or what not, are either harmless innocents or fakirs of high degree. The man sent out by the Chicago company above mentioned evidently believes in his instrument and can be classed with the "innocents;" but the company back of him, which guarantees to find oil and pay its investors a handsome profit, is evidently composed of men who take advantage of his innocence to fleece the unwary.

Fake Oil Companies.—During the year 1903 most of the fake oil companies which came into existence with the discovery of oil at Beaumont, Texas, went to the wall. They reached the acme of their growth and income in 1902 and during the next year gradually dwindled and died. Not one out of a hundred ever paid back a small percentage of the amount invested. The highway robber who takes the money of his victim at the point of a gun is an honest man in comparison with some of these barefaced scoundrels who fleeced victims of high and low degree with the glittering advertising sheets and stock certificates of their mushroom oil companies. In Indiana alone hundreds of thousands of dollars went into the coffers of these fake companies which had their headquarters in Chicago, in Cleveland, and even in Indianapolis. Adams & Sarber, of Cleveland, were at the head of several of these fake companies. This firm failed in June, 1903, with liabilities of $309,792. Their books showed that the income from the stock sold in October, 1902, was $149,709; in November, $156,424; December, $83,601; January, $113,322; February, $113,131; and March, $85,931, or a total for the six months of $702,118, all taken from the pockets of the gullible, and much of it doubtless representing the savings of years.

A large amount of Indiana capital went into the hands of promoters who claimed to operate at Beaumont, Texas. This is lost, even to a penny, as the conditions there existing were at no time such that operations could be carried on with profit, even had honest men been at the head of the company. The Oil Investor's Journal, in speaking of these conditions, says: "Sometimes the failure to obtain revenue from properties has been the result of bad management, sometimes the extraordinary conditions that have arisen on Spindle Top from time to time have prevented the realization of profits, but at the bottom of the whole matter is the unheard of price which most of the companies paid for their property. Such figures as those obtained for Spindle Top acreage—and fractional acreage—up to a few months ago, could only prevail where there was some inducement beyond the producing and selling of oil. This inducement was the demand for property for promotion purposes. The promoters felt the pulse of the investing public and with trained faculties for perceiving the heart's desire of this same public, discovered that *what the people wanted was Beaumont oil stock.*

"Without previous experience they went into the field, bought their little piece of proven land, let a contract for a 'guaranteed gusher' and went to work selling stock.

"The 'oil business' on a thirty-second or a sixty-fourth of an acre, even in the Beaumont field with its marvelous production per well, was a speculative experiment, with the odds very heavily against the speculator. The promoter seldom took any chances, but allowed the purchasers of the stock to enjoy the excitement of taking all the risks.

"Those who bought freely of the stocks of these thirty-second-of-an-acre companies are now realizing the difficulties of conducting a successful oil business on a piece of land about the size of the small front yard which goes with a six-room dwelling in a crowded city. It was possible, when the wells first quit gushing, to operate these wells on small lots by compressed air or steam-heads. Compressed air is about played out at Beaumont and steam-heads are giving way to walking-beams, and now the little fellows find they havn't room on the property for a walking-beam outfit."

A number of fake companies were organized to operate in the Jasper County and other Indiana fields and some of them are yet in existence. Their available assets consist of little more than a superb allowance of gall; leases on a few hundred acres of supposed oil territory and a hundred or two dollars invested in prospectuses and stock certificates. All persons are warned against investing any money in any company having stock for sale which claims to operate in Jasper County or vicinity. All holdings of importance in that field, which are yielding any oil of consequence, are owned by the Federal Oil and Asphaltum Company, of London, England, which is a responsible company, but which has no stock on the market. A few other companies whose responsibility ... operating there on a small scale, but they have no stock for sale. The whole Jasper County field, at the present rate of production, will not yield in 20 years, what a single one of the fake companies offers to produce in one year. Better it would be for the person who has money to invest, to buy grass seed and scatter it abroad for the sparrows, than to invest in the stock of these or other similar companies. The assurance of some kind of returns from the investment would be infinitely greater.

I would go farther, and say do not invest money in the stock of any oil company unless you are well acquainted with the promoters and know them to be honest men who are experienced oil operators. However, if the speculative tendency is too strong to be withstood, either go into the field personally, or send some one in whom you have implicit confidence and investigate the holdings of the company whose stock you are thinking of buying. By so doing you will lessen the profits, as well as the number of such fake companies as we have mentioned. The oil business is a big enough gamble within itself—that is, the risks of losing in the legitimate companies are great enough—without taking a thousand-to-one shot in the stock certificates of those get-rich-quick concerns whose members do not know a walking-beam from a derrick. In investing in oil stock, or anything else, it never pays to "buy a pig in a poke."

Shallow Bores in Central-Southern and Western Indiana.—Investigations carried on during recent years in the central-southern and western portions of Indiana and records of many bores which have been sunk in those regions, have led me to believe that the majority of the drill holes sunk therein in search of gas and oil failed to reach Trenton limestone, the rock formation which produces the most of the gas and oil in this State. This failure to sink the bores deep enough was due to several causes, chief among which is the great difference in the strata overlying the Trenton limestone in those portions of the State from those overlying the same formation in the main gas and oil-producing areas. In the latter areas the Niagara limestone of the upper Silurian age and the Hudson River limestones and the Utica shale of the Lower Silurian, are the only formations to be pierced by the drill between the drift or surface and the oil and gas-bearing Trenton. In the central-southern and western portions, especially the latter, a number of formations which are wholly absent in the main gas and oil field, intervene between the surface and the top of the Niagara limestone. The drillers employed during the gas and oil excitement of 1887 to 1895 to sink the bores in these regions were, for the most part, from the gas fields. Their knowledge of geology was small, and in many instances, after passing through a shale which resembled the Utica, and which they doubtless thought was that formation, they called the underlying rock "Trenton limestone," and soon abandoned the bore as barren. The shales which they had pierced may have been any one of a half-dozen carboniferous shales, or, what is more likely, the black Genesee shale, no one of which occurs in the main gas field.

Again, strong flowing veins of salt water were struck in a number of the bores, and the local companies, whose members were paying for the drilling, became alarmed at the extra cost necessary to case off such water, and often abandoned the bore before reaching Trenton. In a number of instances in the southwestern counties, the Corniferous limestones and Huron sandstones which in places, as Loogootee, Birdseye, Terre Haute, etc., are oil and gas bearing, were not even reached, though they lie 900 to 1,400 feet above the Trenton. Wherever a bore was thus abandoned without reaching Trenton, all the money spent was wholly wasted, there being neither negative nor positive results. Moreover, much territory was condemned as non-productive without being given a fair test.

The foregoing statements are not made because I believe that gas or oil in paying quantities will eventually be found in the Trenton limestone of southern and western Indiana, for I have no reasons for such a belief. Neither have I reasons for believing the contrary. If the earlier bores had of a certainty reached Trenton and proven barren, then negative evidence would have been available. The one fact which I do wish to impress upon the citizens of the regions mentioned is that much of their territory has not been properly tested. Another and more important reason for the statement is to induce companies who sink future bores to see to it that nothing stops the drilling before Trenton limestone is reached, or, rather, before that formation has been pierced at least 100 feet. Beyond that depth there is little possibility of finding either gas or oil. A contracting driller of experience can easily him trouble. An accurate record of the thickness of each formation passed through, together with a small vial of the drillings of each, will aid much in determining the horizon which the drill is piercing at any depth, and such record and samples should always be kept.

In contracting for the drilling of oil wells to the Trenton limestone in all parts of Indiana aside from the main field, a written contract should always be made with the driller to sink the bore a certain number of feet, with the privilege of stopping before the distance designated, if so desired, or of going beyond it at a certain stipulated price per foot. The contract should never be worded "to drill to Trenton rock" or "100 feet into Trenton rock," as a dispute is very likely to arise as to that formation. Inside the main field the different formations are well known, and the experienced driller knows within a few feet the distance at which the Trenton will be found. Outside that field, he is apt to be confused, especially if he has to pass through formations not represented in the main field, which he will have to do if the drilling is being done any distance to the south or west. If it is not possible for the parties who desire the drilling done to determine approximately the distance to Trenton limestone, information regarding that point can be obtained in this office. The distance to be drilled should always include 100 feet into the Trenton, as either gas or oil is likely to be found up to that depth. Bores in untested territory which are to be sunk 1,500 or more feet in depth should begin with holes at least 12 inches in diameter, so as to allow the insertion of several sizes of casing if necessity requires. Oftentimes in such bores a stream of water is struck unexpectedly, or a cave of shale or other soft rock occurs, making a new casing necessary. If the hole has been started too small, it often happens that no additional casing can be inserted. It then has to be abandoned or else reamed down, the latter being a tedious and expensive process. By beginning with a large opening there is often much saving of both time and expense.

THE MAIN TRENTON ROCK OIL FIELD OF INDIANA.

The area of Indiana at present producing Trenton rock petroleum in commercial quantities occupies a portion of nine counties ington, Grant, Blackford, Jay, Madison, Delaware and Randolph. As shown on the accompanying map, it may be said to comprise about 1,350 square miles, being included within an oblong strip of territory 52 miles long by about 26 miles wide, extending from the Ohio-Indiana State line. westward to the western limits of Liberty township, Grant County, and from Warren, Huntington County, south to Summitville, Madison County. This territory comprises all or a part of each of the following civil townships: Monroe, Blue Creek, Jefferson, Wabash and Hartford, Adams County; Nottingham, Chester, Jackson, Liberty and Harrison, Wells County; Salamonie, Jefferson and Wayne, Huntington County; Van Buren, Washington, Franklin, Center, Monroe, Mills, Jefferson, Fairmount and Liberty, Grant County; Washington, Harrison and Licking, Blackford County; Penn, Jackson, Bear Creek, Wabash, Knox, Miami and Wayne, Jay County; Monroe, Randolph County; Washington, Center and Liberty, Delaware County; Van Buren, Boone and Monroe, Madison County. Of these, Monroe Township, Randolph County, and Center and Liberty townships, Delaware County, lie some distance outside the main field, but it is probable that in a year or two they will be connected with it by the finding of productive territory in the intervening area. Aside from this main field, Trenton rock oil is produced in limited commercial quantities in small areas in Allen, Wabash, Miami, Hancock and Marion counties.

The surface of the main area now yielding Trenton rock oil in Indiana was originally one great plain, with only occasional small undulations to break its monotony. This plain has been eroded in many places by the streams, which in the past have been much larger than at present. Wherever bluffs or hills are found they are but the results of such erosion. But few outcrops of rock occur within the oil field, and they are found only along the streams, where the water has eroded deep channels through the drift and boulder clay, everywhere covering the oil territory to a depth of from 50 to 250 feet. These outcrops belong to the Niagara group of the Upper Silurian Period.

The formations passed through by the drill in all parts of the field before the Trenton limestone is reached are, therefore, as follows: Drift, Niagara limestone, Hudson River limestone, Utica ing the thickness of each formation passed through would be about as follows:

1. Drift .... 125 feet
2. Nigara limestone .... 150 feet
3. Hudson River limestone................................. 425 feet
4. Utica shale .... 300 feet

In the western portion of the field the average bore shows:

1. Drift .... 175 feet
2. Niagara limestone .... 325 feet
3. Hudson River limestone .... 310 feet
4. Utica shale .... 200 feet

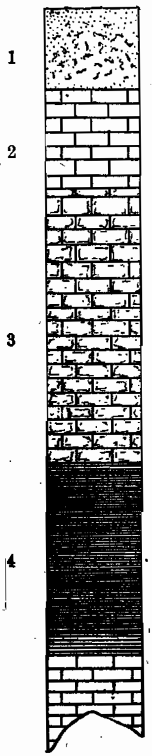


Fig. 2.
Eastern.

Throughout the Indiana field an eight or ten-inch drive pipe is forced down through the drift to the Niagara limestone. The fresh water usually found in the Niagara is cased off by an iron tube $5\frac{5}{8}$ or $6\frac{1}{4}$ inches in diameter, which reaches from the surface 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 the hard crust of the Trenton limestone. Two "pay streaks," or porous layers, are usually found in the Trenton, and it is only in them that oil occurs. The first or upper one is usually 15 to 25 feet below the top of the Trenton; the other is 15 to 25 feet below the bottom of the first. While the Trenton rock in Indiana varies in known thickness from 470 to 586 feet, the porous portions containing oil are usually found only in its upper fourth. It has for the

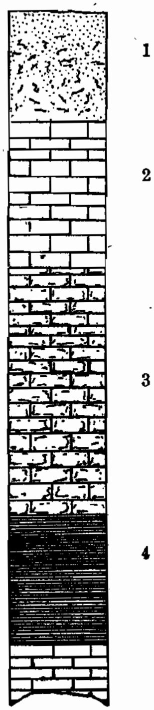


Fig. 3.
Western.

most part been found useless to drill into the Trenton more than 100 feet, since of the 20,000 and more bores which have been put down in the State but few have found oil or gas below that depth. Within the past year several bores have been sunk in Delaware County which have developed a pay streak at 260 to 300 feet below the top of Trenton. It may be possible that in limited areas such deep bores will prove productive, but this can only be ascertained by future drilling.

In the well records given on subsequent pages the length of the drive pipe represents the thickness of the drift. By subtracting the number of feet of drive pipe from the number of feet of casing the thickness of the Niagara limestone may be ascertained. The distance from the bottom of the casing to the top of Trenton represents the combined thicknesses of Hudson River limestones and shales and Utica shale. The driller calls both of these formations "shale," usually distinguishing them by the terms "blue" and "brown," or "black." The average operator and driller pays little attention to the names of the rock formations passed through, but can tell to an inch how much iron has been used in the bore. The records as given are practically the only ones kept in the field.

THE OIL MAP.—The accompanying map of the main Indiana oil field is the third issued by this Department in recent years. The first, showing the exact area tested up to January 1, 1897, was issued in the 1896 (21st) Report of this Department. The field then embraced but 400 square miles. This map, enlarged and modified so as to show the field as it was on January 1, 1901, was published in the 1900 (25th) Report. The area had then increased to 900 square miles. The third and present map brings the field up to January 1, 1904, and embodies an area of 1,350 square miles, not including a large portion of Madison, Delaware and Randolph counties, which were added to embrace the Parker-Selma pools. Comprised within this 1,350 square miles are many sections which are as yet non-productive, not having been fully tested, owing to the high gas pressure which still exists. Over much of this undrilled territory oil will eventually be found, and the seeming gaps now shown on the map will be obliterated.

During the year 1903 quite an area of producing territory was added to the field. This addition was not due to any notable strike, territory, notably in Washington and Fairmount townships, Grant County; in Bear Creek and Wabash townships, Jay County, and in Blue Creek and Monroe townships, Adams County.

Adams County

lies adjacent to the Ohio State Line and south of Allen, east of Wells and north of Jay counties. It is 24 miles in length from north to south, and 14 miles in breadth, comprising therefore an area of 336 square miles. The surface is comparatively level, but is well drained by the St. Mary's and its tributaries in the northern half, and the Wabash and its tributaries in the south. Three railways pass through the county—the G. R. & I., from north to south; the T., St. L. & W. (Clover Leaf), and the Chicago & Erie, from east to west—the three having a common junction point at Decatur, the county seat. The population of the county in 1900 was 22,232, as against 20,181 in 1890.

The elevations in feet above tide of the principal railway stations in the county are as follows: Berne, 849; Ceylon, 849; Curryville, 842; Decatur, 800; Geneva, 840; Monmouth, 788; Monroe, 822; Peterson, 817; Pleasant Mills, 799; Preble, 813.

Only the southern third of Adams County has as yet produced petroleum in commercial quantities. The townships of Hartford and Wabash, in the southwestern corner of the county, possess the oldest and best wells; while Jefferson, Blue Creek and Monroe have, in recent years, yielded quite a number of producers. During the year 1903, 317 bores were sunk for oil in the county, as against 291 in 1902. Of these, 30, or 9.4 per cent., were dry. The decrease in dry holes for the year was five, and the percentage of decrease, 2.6. The average initial output of the 287 productive wells was 15.1 barrels, as against 23 barrels in 1902.

Hartford Township.—The southern two-thirds of this township has in the past proven quite productive of oil. No territory of importance has been added to the producing area since the former map was issued. Test bores on the Shephard and Cusac leases, south half of section 16, sunk in 1903, came in as very light producers. The recent wells in sections 24 and 28 are to be classed as only fair, most of them coming in at 5 to 20 barrels each. The most successful operations in the township during the year were on the J. A. Watson farm in section 34, where four wells, out of ten drilled, came in with an iniital output of more than 100 barrels each.

Wabash Township—Quite an area of territory, marked as untested on the former map, has become productive during recent years. The southwest quarter of section 7 has a few fair wells to its credit, while the southeast quarter of 12, the west half of 13 and the east half of 14 have each a number of light producers.

The south half of 20 has yielded some good wells and the west half of 22 some light ones. The territory in section 30, just west of Geneva, formerly producing only salt water, is now fairly productive. The west half of section 32 now has a number of good wells within its limits, several of which came in with an output of between 60 and 125 barrels. The west halves of 33 and 35 are lightly productive, the remainder of the township being as formerly shown. The lob, or "deep drive," passes from northeast to southwest diagonally across Wabash township, and has, up to the present, prevented drilling in a number of sections which will doubtless produce much oil in the future.

Jefferson Township.—This township comprises but 24 square miles of congressional township (25 N., 15 E.), the two eastern tiers of sections of the congressional township, being a part of Mercer County, Ohio. The first producing wells in the township were opened up in sections 19, 20, 29, 31 and 32, in 1900. Since then a number of fair to good wells have been drilled in other parts of the township, and its entire area will in time doubtless become productive.

In 1903 two good wells were completed on the Johnson lease in section 4, and lighter ones on the Miller and Hunzicker farms. A dry hole was finished on the Hill lease in section 9; and a test, but little better, on the Bedout farm, south half of 10. The south half of 15 yielded one or two fair wells, but those in the southeast quarter of 16 came in light. Two dry holes were drilled on the north half of 20, but the southeast quarter of that section has a number of fair producers. Several 5 to 30-barrel wells, completed in the north half of section 21, on the Verney, Beeler and Young leases; the top of Trenton being found at 1,065 feet. The north half of 22 yielded one dry hole and three or four fair producers, while tests on the Foster and Reynolds leases in section 34 came in light. The remaining sections of the township are to be classed as shown on the map.

Blue Creek Township.—This township lies north of Jefferson, and like it contains but 24 square miles. Of these parts or all of seven are at present yielding oil.

In 1903 a test on the Cummings farm, in section 8, came in dry, while No. 2, on the Oakley farm in 9, started at only five barrels, with a good supply of gas. A test on the Tague lease, in 16, yielded only gas, but some fair wells were finished on the west half of 15. No. 4 on the D. Studebaker lease in section 31 came in dry, though surrounded on all sides by good wells. A dry hole was also drilled on the Pruden lease in section 29.

Monroe Township (26 N., 14 E.)—All developments in this township have been made since the former map was issued. While a number of the 36 sections included in its area have been tested, but four are at present producing oil in commercial quantities.

On the south half of section 22 several wells have been completed on the Habegger lease, which started at 5 to 20 barrels. The No. 4 on the lease was a dry hole, while a test on the Schug lease adjoining started at 25 barrels. Three bores have been drilled on the Lehman farm in the southwest quarter of section 23, which started at 25, 10 and 5 barrels respectively. A second dry hole was drilled on the Eley farm in section 27, the first having been drilled in 1897. The Baxter lease in 29 has yielded a number of fair wells, while the Causey lease on the northeast quarter of 36 has furnished an extension westward of the noted pool in 31 Blue Creek township. Six bores sunk on the lease in 1903 all came in as fair producers, one of them starting at 125 barrels.

St. Mary's Township.—Two bores sunk on the J. L. Case farm in section 27, this township, came in dry, while another on the Smith lease in 34 yielded a large amount of salt water and about four barrels of oil.

Wells County

lies south of Allen, west of Adams, north of Jay and Blackford, and east of Huntington and Grant counties. It comprises an area of 367 square miles, 112 of which are included within the known productive oil territory. The surface of the county is level or gently rolling. The average altitude above sea level is about 850 feet. The Wabash River flows diagonally across the county, entering it on the eastern side, a little below the center, and flowing in a northwesterly direction. The Salamonie flows across the southwestern corner in the same direction, and these streams, with their numerous smaller tributaries, furnish an abundance of running water, and, in most townships, an ample system of drainage.

The soils of Wells County are above the average in fertility. Made up of a mixture of ingredients derived mainly from the decaying rocks of the far north, ground fine and thoroughly mixed as they were by the mighty glaciers which brought them to their present resting places, they contain all the necessary constituents for the growth of the cereal crops, and therefore do not require an annual outlay for artificial fertilizers. Corn and wheat yield enormously in the southern and western portions of the county, and the majority of the farmers were in good circumstances long before the drill revealed that another resource which had been stored since the old Silurian days lay far beneath the surface of the soil they tilled.

Two railways—the Toledo, St. Louis & Western (Clover Leaf) and the Ft. Wayne, Cincinnati & Louisville—pass entirely through the county, while the Chicago & Erie touches its northern border. The Muncie, Hartford & Ft. Wayne electric line, paralleling the Ft. W., C. & L. Railway, is in course of construction, and will be finished in 1904, thus adding to the excellent transportation facilities already existing. The population of the county in 1900 was 23,499, as against 21,514 in 1890.

The elevations of the principal railway stations of the county above sea level are as follows: Bluffton, 835; Craigsville, 850; Keystone, 862; Kingsland, 856; Liberty Center, 848; Murray, 853; Poneto, 849; Tocsin, 837; Uniondale, 814.

Wells County contains the oldest oil producing area of the State, and for a number of years ranked first in production of petroleum, but since 1901 has been exceeded by Grant. However, the townships of Nottingham, Chester and Jackson still rank as among the most productive territory in Indiana. As few dry holes are drilled in them as in any other similar area, and a large number of new productive wells are each year added to those already existing. Outside of the townships mentioned but small areas in Liberty and Harrison townships have as yet proven productive, and it is not likely that much oil will be found in the county north of the present limits shown on the map, though the greater part of Liberty township may become light productive territory.

Developments in Harrison Township (26 N., 12 E.) in 1903.—In this township but four bores were sunk during the year. One on the Quick lease in the southwest quarter of section 29, and one each in sections 25 and 28, developed dry holes. The fourth, on the J. E. Ballentine farm, southeast corner of the southwest quarter of 32, was drilled 300 feet into Trenton, and made about two barrels when shot. It was soon abandoned, and at the present writing there is not a producing well in the township.

Developments in Liberty Township (26 N., 11 E.) in 1903.—Isolated wells on a number of sections in the vicinity of Liberty Center have come in as light producers since the former map was issued, and some of the sections in this vicinity may do better in the future.

In the northwestern part of the township, section 7 has developed four light wells and several dry holes. The production is on the Thompson lease, in the southwest quarter, and is from a part of the pool opened up just to the west in section 12, Salamonie township, Huntington County. The four wells were yielding 17 barrels a day on November 1, 1903, the last one having been finished in April. A dry hole has been sunk on the southeast corner of the same lease, and another on the Messburg farm on the same section. Two light wells have been finished in section 17, one on the northeast, the other on the southwest quarter; and one or two in the southeast quarter of 18. A 30-barrel producer was completed on the Davis lease, southeast corner of 19, the remainder of the section being untested. The southwest quarter of 21 and the south half of 28 have also yielded light producing wells, the top of Trenton being found at a depth of 1,014 feet in the southeast of 28. Five or six light wells have also been drilled on the southeast quarter of 29. The west half of 30 has become fair territory, 10 or more wells having been completed on it, but the east half has developed only a salt water producer on the southeast quarter. No. 6 bore, on the J. B. Munsey lease, in 31, started off at 85 barrels on December 15, its record being as follows:

Drive pipe	40 feet
Casing	270 feet
Top of Trenton	930 feet
Total depth	1,000 feet

Other leases on the same section are fair average producers. Section 32 may still be classed as fair territory, but the only wells so far drilled in 33 are light.

Developments in Nottingham Township (25 N., 12 E., and a part of 25 N., 13 E.) in 1903.—This township still maintains its record as a producer, and but few changes are necessary in the former map, where most of the productive territory was classed as good. A dry hole has been sunk on the northwest quarter of section 2, and several fair wells have come in on the Stout lease in the southwest quarter of 3. The producing portions of 4 are light; the bores on the northeast and southwest quarters coming in dry. The west half of 5 is not developed, while the wells on the east half are all light producers, as are also those on the developed portions of 6 and 7. Section 8 remains good territory, and the northwest quarter of 9 may now be called the same, the southeast quarter being lighter. The north half of 10 has been recently drilled with fair results, but 11 and 12 are unproductive. In sections 7 and 8, to the east, the only drilling has resulted in a dry hole or two on the southeast of 7 and a good showing on the C. Bierie in the southwest of 8. Just below these sections a dry hole has been sunk on the northwest of 17, and another on the southwest of 18, the south half of 17 having been wrongly marked as productive on the former map. Section 13 is also nonproductive. The northeast quarter of 14 is undrilled. The Trenton is found low and yielding salt water only on the Kirkwood lease, while bores on the south half of the section have been either dry or water producers. All of 15 except the southeast quarter is fair territory. Section 20, southeast of Domestic, has not held up, the new wells coming in light. The salt water wells, formerly marked on the northeast of 19, caused the abandonment of that quarter section for a time, but it was afterward taken up and the wells drilled deeper, when they came in as good producers. The northwest quarter of the section does not rank as high as the rest. The remainder of the sections in the township remain as marked on the former map. As a proof that the old territory still promises much to the operator, four wells sunk in 1903, on the Engle lease, in the southeast quarter of 32, started off at more than 100 barrels each.

Developments in Chester Township (25 N., 11 E.) in 1903.—This township has been more than holding its own in recent years. The former undrilled area in the northern portion has, for the most part, proven productive; while but a small proportion of the new bores in the older territory came in dry.

Section 1 and the northeast quarter of 2 are as yet undeveloped. The west half of 2 contains some light wells, while the southeast quarter is better. Almost all of 3 has become lightly productive. A test bore on the Speece lease, in the northwest corner, struck a vein of "blue lick" water at 1,027 feet. The northwest quarter of 4 is fair territory, the rest light. Some excellent wells were drilled in on 6 and 7 during the year. One on the Shadle lease, southwest quarter of 7, is said to have made 200 barrels the first day, 400 the second and 190 the third. The west half of 9 and the northwest quarter of 10, marked as undrilled on the former map, have become fairly productive, as has also the greater part of 11 and 12, and the west half of 16. The remainder of the township may be classed practically as on the former map.

Developments in Jackson Township (25 N., 10 E.) in 1903.—This township ranks next to Nottingham in its output of oil. But few of the older wells have been abandoned, and all of the undrilled area of the former map has come in as fairly productive. Many of the sections there marked as light or fair, are now classed as fair or good.

On the Huffman lease, south half of section 1, much trouble has been experienced with fresh water, which flooded a number of the wells and caused their abandonment. This mishap was due to some poor wells, whose casing had been pulled, not being properly plugged. Section 5 has increased its rating to fair, while all wells on 6 belong to the same class. One on the Allen lease, southwest quarter of 7, started at 200 barrels, and the whole section is up to the average. The northwest quarter of 8 has only a dry hole to its credit, but the remainder of the section is fair territory; as is also the south half of 9. The west half of 18 has come in as light, but the northwest quarter of 19 has some fair wells to its credit. Section 20, marked as light on the former map, has increased its standing. The wells are lasting, and most of them start in at 20 to 40 barrels. An average record in the northwest quarter of 20 shows:

Drive pipe	153 feet
Casing	385 feet
Top of Trenton	989 feet
Total depth	1,045 feet

The first pay is struck at about 1,012 feet, and there is no water before shooting. Section 22 has also increased its output and become fair to good territory. A 160-barrel well was finished on the northwest corner of 24 during the year. The west half of 25 has been fair territory, while 26 now ranks with 27 and 28 to the west. The northwest quarter of 26, containing 21 wells having, according to the pipe line statements for 14 months, a settled production of 65 barrels, together with some undrilled leases in Randolph County, was sold for $75,000 on October 15, 1903. Some changes for the better have been made in the southeast and northwest quarters of 29 and the northeast of 30. Section 31 has been drilled over in recent years with fair results. A bore on the Palmer lease, east half of the northwest quarter, was finished in October, with an initial output of 125 barrels, its record being as follows:

Drive pipe	130 feet
Casing	340 feet
Top of Trenton	985 feet
Total depth	1,045 feet

The first pay, struck at 1,015, was 18 feet thick. The northeast quarter of 32, formerly bearing only salt water, has recently developed a number of fair wells; while the remaining sections of the township, for the most part, rank high as shown on the former map.

Huntington County.

comprises an area of 385 square miles, lying west of the counties of Allen and Wells and north of Wells and Grant. The general surface is similar to that of the counties already noted—a level plain, unmarked by any prominent hills or elevated points, the average elevation being about 780 feet above the level of the sea. The Southern third of the county is drained by the Salamonie River, the central and northern thirds by the Wabash River and its tributaries.

The soil of the county is mostly of glacial origin, varying much in constituents and quality. In most places it is underlain by a stiff, tenaceous clay which retains the surface water and necessitates artificial drainage. Where properly drained it yields large crops of the cereals and grasses. The alluvial soils of the extensive areas of bottom lands along the Wabash and Salamonie Rivers are above the average in fertility, and their crops aid largely in giving Huntington the rank which it holds among the better agricultural counties of northern Indiana.

As in the other counties comprising the oil area of Indiana, the only outcrops of rock are those of the Niagara formation. In the vicinity of Huntington, the county seat, large quantities of lime are burned from this rock, and the quality of the product has given it a reputation second to none in the State.

Two railways, the Chicago & Erie, and the Wabash, cross the county, the former from the northwest to southeast, and the latter from northeast to southwest, while the T., St. L. & W. (Clover Leaf) cuts across the southeastern corner. The Fort Wayne and Southwestern Traction Line parallels the Wabash Railway across the county. The population of the county in 1900 was 28,901, as against 27,644 in 1890.

The elevation in feet above tide of some of the principal railway stations in the county is as follows: Buckeye, 858; Huntington, 741; Markle, 814; Warren, 831.

The area of Huntington County producing oil in commercial quantities is practically limited to the southern halves of Salamonie, Jefferson and Wayne townships, along the southern border of the county. Some of the sections in this area rank high as producers, the average initial production and length of life of the wells equalling any similar area in the petroleum field of the State. It is not probable that the area of productive territory in the county will ever be found to extend any distance north of the townships mentioned, though it may, in time, cover the greater portion of their northern halves.

Developments in Salamonie Township (26 N., 10 E.) in 1903.—Operations in this township have been confined to sections 12, 13, 19, 20 and 25 to 36, inclusive, though isolated bores in other sections have produced a showing of oil. On the southeast quarter of 12 two dry holes and two wells which started at 15 and 35 barrels have been drilled, while the only bore on the northeast quarter was dry. The top of Trenton in the last mentioned bore was found at 1,027 feet, while an average record of the bores on the southeast quarter showed:

Drive pipe	58 feet
Casing	385 feet
Top of Trenton	1,007 feet
Total depth	1,087 feet

The only drilling in section 13 was on the McElhaney lease, northeast quarter, where a 30-barrel well was completed in March, and a lighter one later in the year.

The field opened up in section 19, just west of Warren, in 1900, has not held its own, the new bores having a decreased initial output. The southwest quarter of 20 has on it a few light wells, but the remainder of the section has been condemned by several dry holes. Sections 25 and 26 remain as shown on the former map, while all of 27 and 28 may be classed as lightly productive. The south half of 29 is undrilled, while the north half has developed only salt water and dry holes. The northeast quarter of 30 has some fair wells, but a number of dry holes have been drilled on the other portions of the section. All of 31 has become fair territory, some high-grade producers having been finished on the north half during the year. The southeast of 32 contains nine fair wells, but bores on the remainder of the section have mostly come in dry. Section 33 contains a number of light wells, except on the northeast quarter, which is untested. One light producer has been finished on the northeast quarter of 34 since the former map was issued; the remainder of the section and 35 and 36 remaining as before classified.

Developments in Jefferson Township (26 N., 9 E.) in 1903.—This is the best productive township in Huntington County. The wells mostly come in as fair to good producers, and hold up for a long time. The greater portion of the north half of the township is still operated for gas by the Huntington Light and Fuel Company.

One or two bores on the northeast of section 16 have made a good showing of oil, but are not operated. A dry hole has been drilled on the southwest corner of the section. In 17 a bore on the northwest quarter developed only salt water, while 18 is undrilled. Section 19 has developed a number of light wells, the southwest quarter averaging better than the rest. The northeast quarter of 20 is fair territory, the remainder of the section light.

The Pike Oil Company controls several hundred acres of leases in this region, including the northeast of 20 and the northwest of 21. On the Weaver farm, in the latter quarter section, two fair pumping wells were drilled several years ago, and in 1903 they and 160 acres of leases were bought by the Pike Company for $4,000. Three bores have since been sunk by the company on the Anderson farm, in the northeast of 20. A record of No. 2, which started at 120 barrels, is as follows:

Drive pipe	267 feet
Casing	478 feet
Top of Trenton	985 feet
Total depth	1,040 feet

The first oil was found at 26 feet in Trenton, and a second pay, 11 feet thick, at 35 feet in. A new bore on the Weaver farm in the northwest of 21 resulted in a big salt water well which yielded, with the water, about 15 barrels of oil per day. The southwest of 21 is covered by virgin forest and is unleased, while the east half of the section, as well as 22, 23, 24 and the north halves of 25, 26 and 27 are unproductive. A dry hole has been bored on the Griffith lease in the southwest of 23, and two of the same kind on the Taylor lease in the southwest of 24. The south halves of 25, 26 and 27 have yielded a number of fine wells. A 200-barrel producer was finished in October on the Holman lease in the northeast quarter of 28, which was making 20 barrels when a month old. The northwest quarter is undrilled, while the south half contains a number of fair wells. All of 29 has developed into fair territory, there being nearly 40 producers on the section. The northeast quarter of 30 is unleased. The south half contains a number of fair wells, while on the northwest quarter there is one light well which has never been pumped. An average bore on the Sparks farm, southwest quarter, showed the following record:

Drive pipe	199 feet
Casing	489 feet
Top of Trenton	1,001 feet
Gas pay	1,012 feet
First oil pay	1,025 feet
Second oil pay	1,045 feet
Salt water	1,059 feet
Total depth	1,064 feet

The east half of section 31 contains 25 oil wells, whose output is above the average. The northwest quarter is undrilled, while the southwest quarter has a number of fair producers. Section 32 has developed into good producing territory. The Troy Oil Company controls the whole section, and on November 1st had 68 producing wells thereon. The oldest of these had been producing four years, and the net production was about four barrels each on the date mentioned. A record of an average bore on the section shows:

Drive pipe	200 feet
Casing	450 feet
Top of Trenton	1,004 feet
Total depth	1,059 feet

Gas is usually found at 15 to 24 feet in the Trenton before the oil is struck. The former is just about sufficient in quantity to operate the field.

Section 33 is probably the best in the township. On December 1st there were 48 producing wells on its area, with an average production of 7 barrels each. In this section the average record shows:

Drive pipe	250 feet
Casing	450 feet
Top of Trenton	925 feet
Total depth	1,025 feet

The north halves of 34 and 35 have become fair territory, as has also all of 36.

Development in Wayne Township (E. ⅔ of 26 N., 8 E.) in 1903.—The greater part of this township is fair gas territory. Most of the productive oil sections are distant from railway facilities, and hence the operation is light for at least five months of the year. Being on the border of the field, many of the new wells partake of the "wildcat" variety, and the percentage of failures is greater than inside known productive limits. But eight sections in the southeast corner of the township have as yet proven anyway productive, though a few bores with a fair showing have come in in other localities.

A well on the A. E. Billiter farm, near Mt. Etna, on the southeast quarter of section 1, was completed in 1902, and produced at first a heavy flow of gas and a good showing of oil. In August, 1903, it was put to pumping and made 15 barrels the first day. This well is farther north and northwest than any other in the main Indiana field. It is on the edge of a "deep drive," 340 feet of drive pipe being necessary. Dry holes have been drilled on the northeast quarter of 9 and the corresponding quarter of 10, while 11 and 12 have produced much gas and a showing of oil in some bores. Three light producers have been finished on the Cramer lease, northeast quarter of 15. A bore on the Wilson lease, southwest quarter of 16, came in as a dry hole, with the following record:

Drive pipe	108 feet
Casing	525 feet
Top of Trenton	991 feet
Light gas pay	1,006 feet
Salt water	1,041 feet
Total depth	1,101 feet

On the Parrott lease, northeast quarter of 23, two bores were producing about 15 barrels of oil in November, the record of No. 2 being:

Drive pipe	331 feet
Casing	525 feet
Top of Trenton	993 feet
Gas and oil pay	1,007 feet
Second oil pay	1,029 feet
Total depth	1,053 feet

In No. 1, 600 feet east, the drive was but 208 feet. The most of the section is light productive territory, the southwest quarter being undrilled. All of 24 and 25 may be classed as light productive territory, the Searles farm in 24 showing up better than the rest. The Bond farm, northeast quarter of 26 has some fair producers to its credit, but the remainder of the section is as yet mainly gas producing, as are also sections 27 and 28. On the Hawkins lease in the southeast corner of 33 a 10-barrel well was finished in September, and another of similar output is located on the southwest of 34. The northeast quarter of 35 has developed several fair producers. No. 3, on the Price farm, had the following record:

Drive pipe	229 feet
Casing	500 feet
Top of Trenton	1,009 feet
Gas pay	1,020 feet
Salt water	1,030 feet
First oil pay	1,035 feet
Total depth	1,099 feet

When completed it pumped nothing but salt water the first day. The second day it made 35 barrels of oil; the third, 37 barrels; the fourth, 40 barrels, and the fifth, 60 barrels. The remainder of section 35 contains a number of light wells, while all of 36 has become fair productive territory.

Grant County,

in which the most westward extension of the Indiana oil field is located, lies west of the counties of Wells and Blackford, and south of Huntington and Wabash counties. It comprises an area of 416 square miles, the surface of which is, for the most part, level or slightly undulating, though in the vicinity of the Mississinewa River many hills, due to erosion, and from 50 to 100 feet above the level of the river bed, are found.

The Mississinewa enters the county near its southeastern corner, and, flowing in a northwesterly direction, leaves it on the northern border, six miles east of the northwestern corner. In the early history of the county it was navigable for flatboats, which were loaded at Marion and transported, via the Wabash and Ohio rivers, to New Orleans. It and its tributaries drain the greater part of the county; but the western tier of townships is drained by Pipe and Grassy creeks, and the northeastern corner by Black Creek, a tributary of the Salamonie River.

The soils of the county are mostly of drift origin, and for the most part are fertile, though in some localities a lack of necessary drainage has rendered their tillage unprofitable.

The transportation facilities of the county are excellent, the T., St. L. & W. (Clover Leaf), the Michigan Division of the Big Four, the P., C., C. & St. L. and the C., C. & L. railways passing entirely through it, and having a common junction point at Marion, the county seat. Besides these, the C., I. & E. crosses its southwestern fourth, while the Union Traction Company's lines operate between Marion, Anderson and Indianapolis. The population of the county in 1900 was 54,693, as against 31,493 in 1890, while that of Marion was 17,337, as against 8,769. This notable increase was due almost wholly, either directly or indirectly, to the gas and petroleum developments brought about in the county during the decade in question.

The elevations in feet above tide of the principal railway stations in the county are as follows: Fairmount, 880; Fox, 817; Herbst, 851; Jonesboro, 848; Landessville, 864; Marion, 811—814; Miers, 823; Roseburg, 845; Sims, 857; Swayzee, 859; Sweetsers, 844; Upland, 939; Van Buren, 840.

Within recent years, Grant County has come to be the banner petroleum producing county of the State. At the same time the city of Marion has forged to the front as the principal oil center. In 1903 the county yielded more than one-third of all the petroleum produced in Indiana; while the number of new bores sunk was more than twice as great as in any other county. By the close of the year, the townships of Van Buren, Washington and Center had been pretty thoroughly tested. Over most of their area, however, there is room for many new wells, which, in the near future, will undoubtedly be sunk on leases already partially developed. In this way the output of these townships will be kept up, and possibly increased, for a number of years. The greater parts of Mill, Monroe, Fairmount and Jefferson townships will also develop into good oil territory as soon as the prevailing gas pressure is reduced. Monroe and Jefferson townships at present afford as good promise for future production as any within the State. Franklin township is on the down grade and its future output will be light, as will also that of the greater part of Liberty township.

Developments in Van Buren Township (25 N., 9 E.) in 1903.— This township, in the northeastern corner of Grant County, comprises one of the oldest and best known oil producing districts of the State. The first oil well in Grant County was drilled in the outskirts of the town of Van Buren in 1890. From that time up to the present the drill has been kept almost constantly going in Van Buren township, until its area has been pretty thoroughly gone over. The results have been above the average, the township ranking with Nottingham and Jackson, of Wells County, as a reliable producer. The new developments of the year 1903 were mainly in the two southern tiers of sections, most of which were shown as undrilled on the former map, though many bores were sunk on active leases in all parts of the township. The condition of the roads in winter in the south half of this township and in most of Monroe is deplorable, and greatly lessens the development for several months.

The southwest quarter of section 7 has developed into good territory. On the Sanderman lease of 80 acres are 18 producing wells, the last of which was completed in November with an initial output of 150 barrels. A record of its bore was:

Drive pipe	160 feet
Casing	400 feet
Top of Trenton	927 feet
Total depth	1,027 feet

The 18 wells were producing 70 barrels a day on January 1st, 1904.

The south half of section 8, marked as untested on the former map, has become good territory. On the E. Korporal farm the No. 9 bore, completed in December, started at 150 barrels, and was making 45 barrels at the end of two weeks.

The northwest quarter of section 18, unmarked on the former map, has developed into fair territory, while the east half of section 20 has produced a number of good wells. The whole of section 21 has become fair territory, as has also the southeast quarter of section 24. Sections 25, 26 and 27 are uniformly light, the wells coming in from 5 to 20 barrels each. The east half of 28 and the northwest and southeast quarters of 29 are better, and may be classed as fair, as may also all of section 30, the south half of the latter section being as yet undrilled.

In the lower tier of sections, that portion of 31 which has been tested is light. The northwest quarter of 32 is fair, the remainder light. Much trouble has been experienced with deep drives in the southeast quarter of the section. The whole of sections 33 and 34 may be classed as fair territory. One of the best wells finished in section 34 in 1903 was drilled in on the M. Dillman farm, starting at about 110 barrels. The deep drive covers part of the southeast quarter of the section and, as elsewhere, renders the drilling difficult. The north half of 35 is light, the south half fair, the R. J. Reed lease of 20 acres in the southwest quarter, being above the average. The northwest quarter of 36 is light, the remainder, as far as tested, being salt water or gas territory. The other sections of the township are mainly classed as shown on the former map, there having been but little change. The wells on the northern two-thirds of the township have come in with a larger initial production than those on the southern third, and, for the most part, have held up remarkably well. Many bores will have to be sunk in the township before all the territory therein is developed as it should be.

Developments in Washington Township (25 N., 9 E.) in 1903.—The year 1903 proved that this township is destined to take high rank as an oil producing center. Enough drilling had previously been done to remove it from the "wild cat" area, and as the season advanced the greater portion of the township as far west as the Huntington pike was pretty thoroughly tested. West of that thoroughfare the drills have, on account of high gas pressure, revealed but little of importance. The results of the season's work in the township were equal to the expectations. While no phenomenal strikes were made, most of the wells were above the average in initial output.

Taking up the area in detail, we find that section 1 may be classed as fair, except the northeast quarter, which is light. All of 2 has been proven fair, the southwest quarter showing up better than the rest. Not much drilling has, as yet, been done on the southeast quarter. Section 3, as far as drilled, is light except the west half of the southwest quarter, which is better. The only bore sunk on the B. H. King lease, north half of the northwest quarter, resulted in a dry hole.

A fair average lease in this territory, which is operated carefully on a moderate capital, is that of the "Poor Rut Oil Co.," J. R. Bennett, Superintendent, on the E. J. Hunt farm of 160 acres, southwest quarter of section 2. This farm, up to 1902, was considered gas territory, and was so marked on the former maps. The first bore was finished for oil on June 1, 1902. Up to October 1, 1903, nine wells had been completed on the east half of the quarter section, and three on the southwest quarter. They are located 600 feet apart and the twelve are operated by one power. Gas is used for fuel in both pumping and drilling, enough being yielded by the wells on the lease for this purpose. All the wells started at about 20 barrels each, but soon settled to an average of 4 barrels which they were doing in October. On the northeast quarter of the quarter section the drift runs about 260 feet in thickness, necessitating that amount of drive pipe. On the southeast quarter of the lease it increases to nearly 400 feet, while on the southwest quarter it is but 250 feet. An average well on the lease shows the following record:

Drive pipe	300 feet
Casing	500 feet
Top of Trenton	980 feet
Total depth	1,055 feet

Two pay streaks are found, the upper being 30 to 35 feet and the lower and most productive 55 to 63 feet in Trenton. Each pay is about 10 feet in thickness. Between the two, at a depth of about 45 feet in, a screw, in most of the bores, develops salt water which rises about 300 feet in the well. This is easily pumped down, a two inch pipe serving to carry all of it from the twelve wells. The company, up to October 1, 1903, had about $30,000 invested in the lease, and was averaging $1,000 a month income above the one-seventh royalty and cost of operation.

On the E. E. Hewett lease, west half of the southwest quarter of section 3, one mile west of the Hunt farm, a record of bore No 1 was as follows:

Drive pipe	199 feet
Casing	504 feet
Top of Trenton	1,004 feet
Gas struck at	1,014 feet
First oil pay	1,019-1,040 feet
Salt water	1,040-1,045 feet
Second oil pay	1,055-1,079 feet
Total depth	1,079 feet

The well was a fair producer, as were several others on the same

The east half of section 4 has developed a number of light wells, but west and immediately south of this, the gas pressure is, as yet, too strong to try to operate for oil, so that no drilling has been done in sections 5 to 10 inclusive, nor on the west half of 11. The east half of 11 and all of twelve are fair territory, the H. M. Creviston farm, northeast quarter of 11, and northwest quarter of 12 having yielded a number of wells above the average in initial production. The No. 7, finished July 28, had the following record:

Drive pipe	250 feet
Casing	455 feet
Top of Trenton	1,014 feet
First pay	1,026 feet
Salt water	1,073 feet
Total depth	1,077 feet

After shooting with 160 quarts, the well started in at 60 barrels.

All of section 13, just northwest of Landessville, and comprising part of the town lot development of that place, may be classed as good territory. On the Elizabeth Cory lease, west half of the northwest quarter, ten wells had been drilled up to October 1st. An average record of these was as follows:

Drive pipe	104 feet
Casing	460 feet
Top of Trenton	1,001 feet
Total depth	1,079 feet

In a number of the wells but one pay streak was found. Most of them came in with an initial production of 35 to 50 barrels. The wells sunk on section 14 have, up to the present, proven light, while those on 15 are fair producers. The only producing well on 16 is on the L. W. Smith farm, south half of the northwest quarter, where the Marion Gas Co. drilled a well for gas, but found the gas-bearing rock barren. Concluding to drill the well deeper they went 65 feet into Trenton rock and struck oil, the pay streak being about 20 feet thick. The well was then shot with 200 quarts, and a great flow of gas was the result. The well, on January 1, 1904, was making about five barrels of oil while pumping against a heavy gas pressure. It is considered that it has opened up some new territory, as there is not a well nearer than two miles, and very little water to contend with. The record of the bore was as follows:

Drive pipe	220 feet
Casing	470 feet
Top of Trenton	930 feet
Total depth	1,000 feet

Section 17 is undrilled. On the west half of the southeast quarter of section 18, near the north border of the H. Cretsinger lease, two light producers have been finished. The record of No. 1 was as follows:

Drive pipe	221 feet
Casing	450 feet
Top of Trenton	970 feet
Total depth	1,032 feet

The remainder of 18 and all of 19 are undrilled. The only developments on 20 are on the W. Bocock farm, west half of the northeast quarter, where a 20-barrel well was finished October 1st, the bore having the following record:

Drive pipe	210 feet
Casing	450 feet
Top of Trenton	978 feet
Total depth	1,023 feet

On the G. & M. Bocock farm, southwest quarter of section 21, a bore drilled for oil in June came in as a 1,000,000 foot gas well. The southeast quarter of the section is also gas producing, while the northwest quarter is undrilled. On the south part of the E. W. Creviston farm, in the northeast quarter are several fair producing oil wells. A portion of section 22 has proven fairly productive, especially the northeast quarter, where No. 4, on the C. Sears farm, came in as a 100 barrel producer in September. The record of its bore is as follows:

Drive pipe	318 feet
Casing	455 feet
Top of Trenton	1,018 feet
Total depth	1,061 feet

The few wells drilled on the south half of the section showed lighter. Section 23, as far as drilled, is fair territory, while the of 25 has proven fair territory; the south half has, as yet, produced only gas. However, deep drives have prevented much drilling, the drift proving 440 or more feet thick. Only dry holes have been found on the southeast of 26. On the B. Smith lease a bore was sunk 325 feet into Trenton, but developed nothing except a little gas at 70 feet in. The southwest quarter of the section is fair territory, as is also the north half of the northeast quarter. The remainder of the section is, as yet, light and gassy. The southeast quarter of 27 is fair, the remainder generally light. On the northeast quarter of 28 a bore was started for oil December 21, 1902, on the E. Conn farm; at 100 feet gravel containing an abundant supply of fresh water was encountered. At 250 feet, a deposit of what the drillers called "red mud" was struck. It is a tough, sticky mud, almost impossible to drive through. The record of the well is as follows:

Drive pipe	286 feet
Casing	420 feet
Top of Trenton	987 feet
Struck gas at	1,000 feet
Total depth	1,074 feet

The well proved to be a big gas producer, yielding 2,000,000 feet a day for 20 days, with no showing whatever of oil. At the end of that time it was shot with 160 quarts, when a pocket of oil near the bottom of the bore was evidently broken into, as the fluid rose 20 feet above the top of the derrick. The pressure immediately decreased from 180 to 80 pounds. The well made 24 barrels the first day and settled down into a fair producer. It is one of eight on the lease, all of which started with much gas. The northwest quarter of 28 is undrilled. The east half of the southwest quarter has some fair wells, while the southeast quarter has yielded only gas and dry holes. Only the east half of 29 has been drilled. A bore on the Kinney lease on the northeast quarter, came in dry, while the southeast quarter has produced several light wells. Sections 30, 31 and 32 are untested. A dry hole has been drilled on the southwest quarter of 33 and a very light producer on the northwest quarter. The east half is untested. All of section 34 is fair to good territory. On the H. Blinn farm, in the southwest quarter, seven producing wells are in operation,

Drive pipe	300 feet
Casing	455 feet
Top of Trenton	998 feet
First oil pay	1,014 feet
Second oil pay	1,035 feet

A small amount of water is found between the pays, as on the Hunt lease in the north part of the township, already mentioned. The Chas. Brown farm, in the southeast quarter of the section, has furnished eight wells, Nos. 2, 3 and 7 coming in at 60 barrels, or better, each. The gas supply is just about sufficient to furnish fuel for pumping and drilling. The Hawkins lease, on the northeast quarter of 34, has also seven or eight fair producers. The record of No. 7 being as follows:

Drive pipe	173 feet
Casing	440 feet
Top of Trenton	997 feet
First oil pay	1,027 feet
Second oil pay	1,054 feet
Total depth	1,070 feet

It is to be noted that there is quite a difference in the thickness of drift between the northeast and southwest quarter sections. Section 35 is not so good, the east half being, as yet, mostly gas territory. The Williams farm, on the center of the north half, has produced several light wells and the Howard, in the southwest quarter, a number of fair ones. The south half, as well as the northeast quarter, of 36, has yielded only light wells, while three dry holes have been drilled on the northwest quarter.

Developments in Monroe Township (24 N., 9 E.) in 1903.—As an oil producer this township has not as yet been thoroughly tested, mainly for two reasons: 1st. The gas pressure has been too high in most sections. 2d. No railway passes through its area and in winter and spring but little hauling of oil well supplies can be done over the mud roads. However, it is slowly coming to the front, and there is little doubt but that in a few years it will rank with its neighbors on the east and north. Its bounds lie wholly within known productive territory, and such wells as have been sunk have staying qualities. With the going of gas, oil is sure to be found over most of its area in good paying quan-

Joshua Strange, of Arcana, was the pioneer oil operator in Monroe township. He sank the first well on the northwest quarter of section 15 in 1892. It came in as a dry gas well without a showing of oil. The second well, on the southwest quarter of 10, was finished in October, 1895. It was drilled only 25 feet into Trenton, when the oil rose 600 feet in the bore. The top of Trenton was struck at 987 feet. The third well was on the middle of the north line of the northeast quarter of 15. It was finished in December, 1895, and was at first thought to be a light gas well; but on standing open one night it started to flow oil and flowed for two years before it had to be pumped. The fourth well was on the middle of the west line of the northeast quarter of section 15 and was finished in 1897. It sprayed a little oil but was not pumped until 1900. The fifth well, on the southwest corner of the northeast quarter of 15, came in as a light gasser in December, 1898, but soon began to flow oil over the top of the derrick. By that time Mr. Strange realized that he had a small oil field on his hands and began to operate it in the proper manner. Nos. 4 and 5 were put to pumping in 1900, and No. 3 was flowed by heads. Before any pumping was done, however, he had produced 3,000 barrels by flowing alone. The Ohio Oil Company had meantime put in a pipe-line from Van Buren, five miles to the north, to take care of the product. The surplus gas was piped to Landessville for house consumption. In 1901 Mr. Strange sold his five wells and 440 acres of leases to the National Oil Company for $12,000, retaining a one-eighth royalty on future production. In October, 1903, there were 26 producing wells on the property. During one year, July 1, 1901, to July 1, 1902, the west half of the northeast quarter of 15 produced $24,000 worth of oil at market prices.

Taking up the sections of Monroe in detail, we find that the east half of 1 is fairly productive; the southwest quarter light, while the northwest quarter contains two gas wells and a dry hole. Section 2 is also light. During the year a number of old gas wells were drilled deeper on the northwest quarter, but came in with only a two to five-barrel production. A dry hole has been drilled in the corner of the southwest quarter. The Hodgson lease, which comprises the greater part of the south half, has not yet been wells on the north half of the northwest quarter, and one light one on the east half of the southwest quarter. The north half of 4, although in the deep drift and requiring 400 or more feet of drive pipe, has produced a number of fair wells, and the southeast quarter some light ones. The southwest quarter is untested, the west half of the southwest quarter being as yet unleased. The greater part of 5 is also untested. The northeast quarter has yielded some fine producers and the north half of the northwest quarter a few light ones. Section 6 has produced three or four fair wells on its west half, but the east half has, as yet, shown only gas. In section 7 two light wells have come in on the north half, the south half and all of 8 being untested. The greater part of 9 is yet producing gas, but some light oil wells have been found on the north half of the northwest quarter, and on the east half of the southeast quarter. Section 10 is also gas territory, though one or two light producing oil wells are on the southwest quarter. The greater part of the north half is as yet unleased. The northwest quarter of 11 is undrilled; the remainder of the section contains a number of light wells in which the gas pressure is still high. The deep drive occurs in the southwest quarter, where the best output has been obtained. All of 12 is as yet light territory, though a number of the bores presage better results when the gas subsides. The record of a bore on the W. L. Thompson farm, just north of Jadden, showed:

Drive pipe	425 feet
Casing	430 feet
Top of Trenton	990 feet
Total depth	1,050 feet

An old preglacial stream, called by drillers the "Lob," had cut its way down, almost through the Niagara limestone at this point, rendering the deep drive necessary through the drift, which had filled up the channels. The Smith farm, on the southeast quarter of section 13, has yielded some fair wells, one, finished in October, producing 70 barrels the first day. The remainder of the section is undrilled. The northeast and southwest quarters of 14 are undrilled; the southeast quarter contains some light wells and the northwest a number of fair ones. Section 15 has been previously mentioned. It has produced more oil than any other section in the township, but this has been mostly found in the northeast quarter. The southwest quarter of the section is yet light producing on account of the gas pressure. Section 16 has not been drilled for oil but furnishes gas from two or three bores.

A light producer and a gas well have been finished on the northeast corner of 17 and a fair producer and a dry hole on the northwest corner. On the Chas. Nelson farm, west half of the southwest quarter of the section, a well was drilled for gas in November. No gas was found at the depth where usually struck, but at 60 feet in Trenton both oil and gas were found, the latter having a pressure of 180 pounds and being too great in quantity to allow the development of the oil. The record of the bore was as follows:

Drive pipe	240 feet
Casing	420 feet
Top of Trenton	930 feet
Total depth	1,010 feet

In section 18 the only producing wells are on the south half of the northwest quarter, the remainder of the section is yet producing too much gas for development. Drilling for oil on 19 has been confined to the A. Drake lease in the southwest quarter, where a light well or two was finished. In 20 but one light well has been completed, and it is near the south line of the section. Sections 21 and 22 are undrilled for oil. On the Wood farm, northeast quarter of 23, four or five wells were finished during the year, one of which started at 50 barrels and the others at about 10 barrels each. A few light wells have been found on the north half of 24, the south half being untested. In 25 a well on the Kiser farm, northeast quarter, which had yielded gas for two or three years began to show oil in the spring of 1903, and when put to pumping produced about 10 barrels a day. A number of other light producers were finished in the section during the year. Sections 26 to 35 inclusive, where drilled, have, as yet, yielded only gas. In the southeast corner of 36 a number of small producers and one which started at 25 barrels were drilled in during the year on the B. F. Bish farm. Several bores on the C. Brown farm, in the southwest of 34, just north of Upland, were finished in August and showed oil with the gas. The latter had a pressure of 140 pounds. Enough of the bores drilled in the south half of Monroe township have proven sufficiently productive to warrant the belief that when the gas is exhausted the region will yield oil in good paying quantities.

Developments in Center Township (Sections 1 to 24 inclusive, 24 N., 8 E.) in 1903.—That portion of this township east of the city of Marion has been pretty thoroughly tested. The year 1903 saw a large number of bores go down within its bounds, the most of which resulted in fair to good producing wells; thus opening up an area of territory which had hitherto been supposed to be barren. But little drilling has been done in section 1. The Conn lease, northwest quarter, has furnished a dry hole; while the south half has four light producing wells. Section 2 contains 30 or more fair producing wells, those on the southwest quarter being above the average. The record of the bores in the section ran about as follows:

Drive pipe	220 feet
Casing	430 feet
Top of Trenton	930 feet
Total depth	1,010 feet

The south half of 3 may be classed as fair, while the northeast quarter is good. No. 1, on the Thos. Myers farm was one of the first wells in the Marion field. It was drilled in 1899, and showed some oil but had about 200 pounds gas pressure and was not successfully operated until 1902. Up to the present ten wells have been completed on the lease, all of which are productive. The No. 9, finished in August, 1903, made 200 barrels the first 24 hours.

Section 4 has proven to be a spotted area. The Levi farm, southeast quarter, contains nine fair producing wells, and the owner has received as high as $300 per month royalty from them. The Riley and Bowman leases in the northeast quarter have also several fair producers, but those on the Barley farms are light. Three large salt water wells, which were abandoned after pumping for a year or two, have been drilled on the Coon lease. One of the first wells to show oil in the Grant County field was on the William Brinker farm in the northwest quarter. It was drilled about ten years ago by the Mississinewa Gas Company. In 1900 the company put a separator on the well, had a 25 barrel tank set and ran several tanks of oil. They finally drilled the quarter of the section is untested, and west of that no drilling has been done in the northern tier of sections, Nos. 5, 6 and 7 being within the city limits and fair-grounds. The north half of 8 developed a few wells which came in at about 10 barrels. The southwest quarter of 9 is better, but the remainder of that section has shown up light. All of 10 is fair territory with the exception of the southwest quarter. On the east half of this quarter a dry hole was bored, the record being as follows:

Drive pipe	62 feet
Casing	393 feet
Top of Trenton	963 feet
Total depth	1,076 feet

The greater part of section 11 has proven above the average in productiveness. Two 75-barrel wells were finished on the section during the year. On the T. J. Neal farm in the south half of the section, four wells have been yielding for three years and were still doing 3 barrels each per day in October. The southwest quarter of 12 is undrilled; the remainder of the section has produced only light wells. All of 13 may be classed as fair territory. A 100-barrel producer was finished on the Phillips lease and a better one on the J. R. Nelson farm during the year. The most of section 14 may be classed as light, the majority of the wells coming in at 10 barrels or thereabouts. On the Carriger lease in the northeast quarter of the section a record of No. 4 was as follows:

Drive pipe	169 feet
Casing	449 feet
Top of Trenton	999 feet
Total depth	1,069 feet

Section 15 is better, the west half ranking high. Nine wells on the Van Vactor farm in the northwest quarter were making 75 barrels daily in October. The Ratcliff lease, just south, had also nine or ten producers the average record of which was:

Drive pipe	75 feet
Casing	400 feet
Top of Trenton	972 feet
Total depth	1,058 feet

The east half of section 16 developed the first producing well in the Marion field. A number of others have since been drilled but are, for the most part, small producers. Sections 17 and 18, most of which lie within the city limits, have developed a number of light to fair producers during the year. On the Eli Thomas farm, in the southeast corner of 18, a bore finished in December started in at 50 barrels. Several dry holes had previously been drilled within half a mile of it. The record of the bore was as follows:

Drive pipe	190 feet
Casing	410 feet
Top of Trenton	960 feet
Total depth	1,020 feet

The north half of 19 is light territory, the remainder of the section being either dry or undrilled.

On the grounds of the Soldiers' Home, in the northeast quarter of section 20, the United States government is operating three or four fair producing wells. Six or seven bores have been drilled on the grounds but some of them as yet produce only gas.

The west half of 21 is light to fair territory with some gas. The east half, especially the northeast quarter, is better. On the south half of this quarter the Griffin lease has developed into one of the best in the Marion field. It was first drilled in 1900, when three bores were sunk 50 feet into Trenton. They resulted in light producers. In 1903 these were drilled in 30 feet additional, a second and more productive pay being passed through. Several new bores were also finished, one of which started at 125 barrels. The records of Nos. 1 and 5 were as follows:

	No. 1.	*No. 5.*
Drive pipe	160 feet	220 feet
Casing	440 feet	400 feet
Top of Trenton	930 feet	940 feet
Total depth	1,014 feet	1,020 feet

The north half of 22 is also high grade territory. The Futrell farm, on the northwest quarter, after being abandoned for both oil and gas, was released and nine wells sunk on it in 1902 and '03. Three of these started at 75 barrels or more each. Most of good producers afterward. The south half of the section is not so productive. The only bore on the north half of 23 resulted in a dry hole. The south half is fairly productive. Section 24 may be considered light. As in most other parts of the Grant County field there is yet room for many more bores in Center township and the territory can not be said to have been fully developed until they are sunk.

Developments in Franklin Township (24 N., 7 E.) in 1903.—This township lies just west of Marion, and only a small portion of it has been found to be productive. This is mainly in what is known as the West Marion Town Lot development, in sections 11, 12 and 13, where about 90 producing wells were averaging three barrels each in October.

This territory was mainly drilled in 1901 and '02 and while a number of fair wells were finished, it is doubtful whether enough oil was sold to bring back the money invested. The results in both Peru and West Marion have proven that in Indiana, at least, town lot operations are not a shining success. Extra precautions must be taken to prevent damage to adjoining properties, and but few wells can be operated by one power on account of the lots being leased by different companies. A correspondent of the Oil City Derrick correctly sized up the situation in this field in March, last, as follows: "The town lot operators who have been attempting to make the West Marion field represent an elongated pepper-box cover are now having time to think it over, and some of the results of their work are apparent. What was once the liveliest portion of the Grant County field is no longer shining as an example of commemorative industry—in fact, West Marion has gone the way of every other town lot development and those who come out on the good side of a bank account will be fortunate.

"During 1902 there was an air of activity about the West Marion field which indicated that it would long hold a prominent position in Grant County reports. Then it was a common monthly occurrence for the pipe-line company to run 50,000 barrels of oil from the field, and some months it went even higher than this. A survey of the pool during the past week revealed some interesting information. As nearly as can be learned, there are 296 wells in that portion of Franklin township extending southward to Mill wells have been operated throughout the winter, and at the present day it may be accurately estimated that the production is not running over 875 barrels per day, less than half the runs when the field was new last summer. Some of the operators in the field might have hired one fireman to tend the boilers on half a dozen leases, so closely were they planted. A majority of the wells are included within the area of one section, one mile square, and are located on lots hardly large enough to accommodate a derrick.

"This is the only portion of the Grant County field which is not at present showing a revival of activity after the cold weather. While many of the leases are being gotten into shape for pumping, there is a noticeable lack of new work—and this is not due entirely to the fact that operators havn't the inclination, but in most cases they can not find unoccupied land."

In section 1 some fair producers have been drilled in on the south half, and some light ones on the northwest quarter since the former map was finished. The northeast and the southwest quarters of 2 each have a number of light wells, but the remainder of the northern tier of sections has produced nothing worth noting. Section 11 may be classed as light territory, while the wells drilled in on 12 during the year mostly started at 10 to 30 barrels.

The first well west of Marion was finished on the Sohn lease in 13 in 1901, and the section proved for a time an excellent producer, but most of the bores sunk in 1903 were below the average in initial output and a number of them were dry holes. On the P. Kiley lease, in the southwest quarter, ten wells were averaging a total production of 30 barrels per day in October. An average record of them was as follows:

Drive pipe	80 feet
Casing	375 feet
Top of Trenton	917 feet
Total depth	1,062 feet

A dry hole or two was completed on the farm during the year. The northeast quarter of 14 is light, the remainder of the section being barren. A bore drilled 300 feet into Trenton on the Wilcutt lease in the southwest quarter of 15 came in dry. The re-

Developments in Mill Township (Sections 25 to 36 of 24 N., 8 E., and 1 to 12 of 23 N., 8 E.) in 1903.—This township, lying southeast of Marion, contains only 24 square miles. It is composed of parts of two congressional townships and hence the sectional numbers are confusing. Most of the drilling for oil in the township was done in the years 1902 and '03. The bores, while showing much gas, were fewer of them dry than in 1901, and enough oil was found to denote that the greater portion of the area will eventually be light to fair productive territory.

Sections 25 and 26, in the northeast corner are as yet credited as gas producing, though but little drilling has been done on the two sections. On the County Infirmary tract, northwest quarter of 27, is one light oil well and one dry hole, the remainder of the section being untested. Section 28 may be classed as fair, though a few dry holes have been opened on its northern half. An extension of the known field was opened up on the E. Thomas farm, northwest quarter of 29, during the year, when a 40-barrel well was finished, but the Wright farm, just north, has produced three dry holes. The north half of 30 has furnished seven or eight light producers; the southeast quarter one gas well, and the northwest corner a dry hole. Another dry hole was drilled on the northeast corner of 25, Franklin township, the two stopping developments in that direction. Section 31, northwest of Jonesboro, is undrilled. The west half of 32 is light territory but the east half is fairly productive. Five wells on the Metzler lease, finished in 1901, were making four barrels each in October, 1903. Two or three dry holes were finished on the Schrader lease, southeast half of the section, but several fair producers both preceded and followed them.

The most of section 33 lies within the limits of Jonesboro and Gas City. The northwest quarter of the section is fair, but wells drilled between the two towns have come in light or as water producers. East of Gas City, sections 34, 35 and 36 have not been tested except for gas. The A. M. Swain farm, on the southeast quarter of section 1, near the east-central border line of the township, produced some fair wells during the year, in territory before considered good for gas only. An average record of these wells was as follows:

Drive pipe	150 feet
Casing	340 feet
Top of Trenton	935 feet
First oil pay	995 feet
Second oil pay	1,015 feet
Total depth	1,055 feet

Section 2 is yet considered gas territory. A dry hole was drilled on the southeast quarter of 3, and as yet the section is unproductive. Section 4 is mainly occupied by the town of Jonesboro. Three dry holes were finished on the Johnson and Jay tract in the southwest quarter, and two light producers a little farther west. Section 5 has proven a very spotted area. A number of dry holes, a few wells and some big salt water pumpers were finished on it during the year. Much trouble has been experienced in drilling several of the wells on account of irregularities in the drift. On the A. S. Jones farm in the northwest quarter a record of the average bore is:

Drive pipe	140 feet
Casing	380 feet
Top of Trenton	930 feet
Total depth	1,010 feet

The east half of 6 is light territory, while the west half yields only gas. Section 7 is as yet untested. A number of bores have been sunk on 8 with varying results. On the E. Russell farm, in the northeast quarter, a 45-barrel well was finished in April, its record being as follows:

Drive pipe	70 feet
Casing	350 feet
Top of Trenton	925 feet
Total depth	1,042 feet

It was producing 15 barrels in October. The west half of the quarter section is light. The Knight leases on the southwest quarter are fair producers. The southeast quarter is untested. Some dry holes have been finished on the northwest quarter of 9, and a light well or two on the northeast quarter; the south half of the section, as well as all of 10, is undrilled. The northeast quarter of 11 produced two or three fair wells during the year. One on tract showed much gas and little oil, but the latter will doubtless come when the pressure is lowered. The territory in the region is mainly under lease by large gas companies, which will probably operate it for oil when the lighter fluid is exhausted. A light well or two was finished on the southeast quarter of 11 and a dry hole near the center of the northern half. The Mason farm, in the north half of 12, developed a 30-barrel well during the year, but the gas pressure in other bores sunk in the section was too great to permit of their successful operation.

Developments in Jefferson Township (23 N., 9 E., and Sections 1-6, of 22 N., 9 E.) in 1903.—Up to 1903 this township was one of the big gas producing areas of the State. During the year a number of wells, in different parts of the area began to show oil with the gas, and it will be but a year or two until the greater portion, if not all of the township becomes productive oil territory. The gas pressure in all the wells about Upland on January 1, 1904, was about 140 pounds. T. N. Barnsdell, of Marion, has put in a gas line between Marion and Hartford City and is prepared to take care of all the surplus gas, thus giving the oil men a chance to pump their wells. About 40 strings of tools were in the field on the date mentioned between Gas City and the Renner Stock farm in section 6, Licking Township, Blackford County.

In the southwest quarter of section 3, Jefferson township, just southwest of Upland, a 10-barrel well was finished in October. A bore on the Chas. Brown farm in the northwest quarter of the same section came in as a big gas well with a showing of oil. In section 4 two light oil wells and two gas wells have been drilled in on the Safe Glass Co.'s property and a light oil well on the T. Myers farm in the southwest quarter. Section 5 is as yet gas territory. All of 6, except the northeast quarter, is producing oil; four or five wells on the Parks farm, southwest quarter, starting at 30 to 40 barrels each. An old gas well on the S. Johnson farm was drilled deeper and produced 20 barrels the first day. The north half of 7 produced a 90-barrel well on the J. Johnson lease, and some lighter ones on the H. P. Wilson farm, and a well on the J. Johnson farm, northwest quarter of 8, came in with a fair showing. Sections 8 to 16 are as yet gas producing. Bores on the Fergus lease, near the center of section 17 and the Duling farm, northwest quarter of 19, showed the following records:

	No. 1 Fergus.	*No. 4 Duling.*
Drive pipe	100 feet	162 feet
Casing	365 feet	375 feet
Top of Trenton	886 feet	925 feet
Total depth	911 feet	953 feet

These bores and others in the two sections were gas producing, but their records will show the future oil operators in the region what he has to drill through.

A test well on the E. J. Byall farm, southeast quarter of section 21, finished in August, pumped for a time five barrels of oil against a heavy gas pressure. On the southwest quarter of the same section the Carter lease developed three oil wells and a gas well, the former starting in at 10 to 25 barrels each. Another test on the J. W. Little farm, southeast quarter of 28, was at first thought to be barren, but after drilling 85 feet into Trenton a pay streak 15 feet in thickness was encountered. After shooting with 200 quarts, a gas pressure of 160 pounds developed, but the well produced 60 barrels of oil the first day. It was then shut down on account of the gas. The record of the bore was as follows:

Drive pipe	100 feet
Casing	420 feet
Top of Trenton	920 feet
Total depth	1,020 feet

In the southeast corner of the township there are two producing wells on the Millhollin farm, northeast quarter of section 1, which are making about five barrels a day. One of them is a big salt water well, pumping through a three inch pipe. A dry hole has also been drilled on the southwest quarter of section 2.

Developments in Fairmount Township (Sections 13 to 36 of 23 N., 8 E., and 1 to 6 of 22 N., 8 E.) in 1903.—This township first began to show oil in 1902. Most of its area had been under lease for years to glass companies and to corporations under contract to furnish gas to manufacturers. As the gas supply gradually failed a number of the old wells were drilled deeper and when shot and cleaned began to produce oil in paying quantities. The year 1903 showed a great development in the township and proved that its best paying portion is in the southwest corner, where three has proven rather "spotted" but the fair to good wells have held up their production. The greater part of the township will in all probability produce oil in the near future.

On the Duling lease, northeast quarter of 13, in the northeastern corner of the township, eight bores have been completed, but one of which was productive of oil; the remainder being gas wells. An average record showed:

Drive pipe	175 feet
Casing	414 feet
Top of Trenton	941 feet

Most of the bores were sunk only 40 feet in on account of the high gas pressure. A number of gas wells are also located on the northeast quarter of 14, but as yet the section shows no oil. Sections 15 to 18 inclusive, have not been drilled for oil. In the southwest quarter of 19 several light wells have been finished, while a dry hole and light producing one are on the southeast quarter. Sections 20 to 23, inclusive, are yielding only gas as yet. The G. E. Duling lease, in the southwest quarter of 24, yielded two light producers which started at about 15 barrels each, but which, after filling a couple of tanks, had to be shut down on account of gas pressure. The record of No. 2 was:

Drive pipe	166 feet
Casing	410 feet
Top of Trenton	944 feet
Total depth	1,045 feet

On the Leach farm, in the south half of 25, just north of Fowlerton, a well was drilled in 1901, but was not put to pumping until July, 1903, when it produced two tanks in 40 days. Another bore or two on the same farm came in as light producers. Sections 26 to 28, inclusive are, as yet, unproductive of oil. The Fairmount Glass Works finished a light producer and a gas well on its own property in 29. Section 30 has proven a spotted area. The northeast quarter is undrilled, being a part of Fairmount. The south half of the Seal farm on the northwest quarter has produced four or five light wells. The north half of the same farm has several dry holes. The Winslow lease on the southwest quarter is light producing, but the Oakley on the southeast is better. The first well started at 200 barrels, and held up for several weeks, but the next three or four yielded only 5 to 12 barrels initial output. On the Galloway lease of 10 acres in the east half of the northeast quarter of 31, three wells were drilled which were producing about 90 barrels a week in October. An average record of them was:

Drive pipe	25 feet
Casing	380 feet
Top of Trenton	930 feet
First oil pay	965 feet
Second oil pay	995 feet
Total depth	1,030 feet

A number of fair producers were also finished on the Bell and Myers leases, in the west half of the northeast quarter. Bores in the northwest quarter came in light. The southeast quarter produced a dry hole, the southwest a 35-barrel well. Two dry holes were drilled in the southwest quarter of 32 and a gas well on the northeast quarter; while the only bore sunk on 33 was also gas producing. Sections 34, 35 and 36, and section 1 in the southeast corner of the township are as yet classed as gas territory. The south half of section 2 has yielded some fair producing wells, several of which started in at 25 to 40 barrels. The west half of 3 has produced a number of light wells, but the only test on the east half came in dry.

Section 4 has produced more oil than any equal area in the township, but the best wells have been on the south half. On the N. Reif lease of 20 acres in the southwest quarter, three producing wells and two dry holes have been drilled, the average record being:

Drive pipe	98 feet
Casing	380 feet
Top of Trenton	966 feet
First oil pay	994 feet
Second oil pay	1,027 feet
Third oil pay	1,051 feet
Total depth	1,071 feet

In the dry holes the Trenton was found very fine and hard. The first producer on the lease was an old gas well which began to show oil in January, 1903. It was then drilled deeper and shot, when it yielded seven tanks of oil the first eight days, or an average of 190 barrels per day.

On the W. H. Fellows farm of 40 acres, in the northeast quarter of the southwest quarter of 4, seven wells were finished during the year, all but one of which were productive, starting in at 40 to 125 barrels each. The average bore showed:

Drive pipe	104 feet
Casing	385 feet
Top of Trenton	974 feet
First pay	1,008 feet
Second pay	1,060 feet
Total depth	1,076 feet

The first well was finished in February and the first oil shipped April 1st. The owner, up to October 1st, had received $1,300 for his royalty of one-sixth, and on that date was averaging $300 a month. No. 1, on the A. J. Leach farm just south, made a tank a day for 20 days, bringing in the owner $4,000 for his one-sixth royalty. No. 2 on the same lease started at 90 barrels, while Nos. 3, 4 and 5 were light. The surplus gas from the pool was being piped to Fairmount, but the back pressure had lowered the oil output of a number of the best prospective wells. The texture of the pay streaks in the pool varied from coarse-grained and porous to fine-grained and close, and the output of each well varied accordingly. On the A. R. Dillon farm in the north half of the section, the first well drilled started at 110 barrels, but in two months was down to a 10-barrel producer.

Section 5 is more spotted. The northeast quarter has developed only dry holes, while the Keever farm in the northwest quarter has a 150-barrel well and one or two light ones to its credit. The first wells in this "pool" were drilled in on the Sluder farm in the west half of the southeast quarter and the farm contains six fair producers. The quarter section is fair territory, some good wells having been drilled on the Underwood leases. The Wood farm near the center of the section has proven light. Section 6 has only one or two light wells and a dry hole to its credit. The latter was drilled on the Sell lease, northwest part of the southeast quarter. On the C. Dean lease, a little farther north are several fair producers, No. 3 of which showed the following record:

Drive pipe	25 feet
Casing	280 feet
Top of Trenton	945 feet
Total depth	1,038 feet

This bore, when shot, made a tank of oil in eight days.

Developments in Liberty Township (23 N., 7 E., and Sections 1-6, 22 N., 7 E.) in 1903.—The greater portion of this township lies along the western edge of productive territory. Only its eastern and southern portions have yet produced oil in commercial quantities. During the year a dry hole was completed on the northeast quarter of section 12, and two light producers on the southeast of 24. The east half of 25 has produced some fair wells. About a dozen were drilled on the M. L. Gaddis lease where the top of Trenton was found at 940 to 950 feet. The Hodson lease, a little northwest, yielded ten wells, nine of them being producers; and the John Seal farm, in the northeast corner of the section, five which were above the average. A bore on the Davis lease in the southeast quarter of 26 resulted only in a small amount of gas. Tests on the Coomler and Rich leases in the northeast quarter of 27 resulted in dry holes, which stopped drilling in that direction. Drilling in 36 has been confined to the northeast quarter. Two light producers and one which started at 60 barrels were completed on the R. Lindley farm in the northeast corner, but two bores on the Cox lease just to the west came in dry. On the Brookshire lease, in the northwest quarter of section 1, in the southeast corner of the township, a bore was drilled for gas in 1901, which partially filled with oil, but yielded neither gas nor water. In November, 1903, it was drilled deeper and started with an output of 25 barrels. Its record was as follows:

Drive pipe	80 feet
Casing	380 feet
Top of Trenton	945 feet
Total depth	1,010 feet

This well was the farthest southwest of any producing oil in the main Indiana field on January 1, 1904. A gas well on the Call lease, southwest quarter of section 3, has shown signs of oil for some time, but has not been drilled deeper into Trenton in search of it.

Pleasant Township.—A test bore, one and a quarter miles northeast of Jalapa, on the D. Steuben farm, northwest quarter of section 10, Pleasant township, Grant County was finished in December, and came in as a light producer. A previous test sunk in the same vicinity in 1901 made a good showing, but was drilled in too deep, and the oil drowned out by salt water.

Sims Township.—Two bores have been sunk on the King lease in the northwest quarter of section 12, Sims township, Grant County, in both of which a small quantity of oil was obtained. The pay was found from 88 to 98 feet in Trenton. One of the wells was drilled 141 feet in and struck a large salt water vein. It was pumped three months and then plugged and the lease abandoned. A half tank of oil was obtained from the two wells.

During the year 1903, 1,383 bores were sunk for oil in Grant County, or nearly twice as many as in any other county in the State, Wells County standing second with 735 bores to its credit. Of the 1,383, 94, or 6.8 per cent., were dry. The average initial output of the producing wells was 15.1 barrels as against 18.5 barrels in 1902. The number of bores sunk in the county was 333 more than in 1902, while the number of dry holes was 14, or 3.4 per cent., less than in that year.

Blackford County

comprises but 167 square miles, embraced in four civil townships. It lies west of Jay, south of Wells, east of Grant and north of Delaware counties. The surface is for the most part level or slightly rolling, the only hills being due to the eroding action of water. The soil, like that of the surrounding counties, is fertile, being of glacial origin and containing, therefore, all the constituents needed by the cereals and grasses. The principal products are the standard cereals, wool and live stock.

The Salamonie River flows diagonally across the northeastern township and with its tributaries drains the northern half of the county; while Lick Creek, a tributary of the Mississinewa, drains the southern half.

The Fort Wayne, Cincinnati & Louisville Railway crosses the county from north to south, and the Pittsburgh, Cincinnati & St. Louis from northwest to southeast, the two crossing at Hartford City, the county seat. The former is paralleled by the Muncie, Hartford City and Fort Wayne Traction line. The population of the county in 1900 was 17,213 as against 10,461 in 1890, the increase being mainly due to the oil and gas developments over its area during the interim.

The elevations in feet above tide of the principal railway stations in the county are as follows: Hartford City, 887-901; Mill Grove, 931; Montpelier, 867; Renner, 907.

About two-thirds of the county is at present producing oil, Washington township, in the northwest quarter, ranking among the best productive territory in the State. Harrison township contains as yet much gas territory. Montpelier, near its northern boundary, being the closest railroad town to the rich fields of the southern part of Wells County has, for a number of years, been one of the principal oil centers of the Indiana field. From it most of the drillers and operators of Wells and Blackford counties draw their supplies, and several Eastern companies which manufacture such supplies have branch houses located in the town.

Developments in Harrison Township (24 N., 11 E. and Sections 6, 7, 18, 19, 30 and 31, 24 N., 12 E.) in 1903.—This township comprises 42 square miles, 27 of which are producing oil in commercial quantities. But few changes are necessary in the three northern tiers of sections on the new map. Some abandoned territory in sections 3 and 4 has been released and proven profitable.* Section 6, in the northwest corner, has developed into fair territory in recent years; while the south half of 7 has become good, a second pay streak having been found in the later bores at a depth of 60 to 70 feet in Trenton. The wells in 8 have fallen from good to fair producers. The southeast quarter of section 10 embraces the only unleased area in the northern part of the township, the owner holding out for a larger royalty or bonus than has been offered. A dry hole was drilled in the northwest quarter of 14 and a gas well on the Blount lease just to the east. The northwest quarter of 17 remains undrilled and the southwest quarter contains but a few light wells. The gas pressure is still high in section 18, registering

*See ante p. 93, under "Condemned Territory."

140 pounds on the Hart lease in October. However, some fair wells were finished on the area during the year and the whole section may now be classed as fair. A number of bores have been sunk on 20, but for the most part they have proven very light or dry. The only production is from two light wells on the west half of the northeast quarter. Sections 21 to 24 have not, as yet, proven much better. The north half of 21 has a few light wells and the southwest quarter three dry holes, while two gas wells and a few dry holes are the only results of drilling in 22. In 23 one gas producer and in 24 two dry holes have been sunk in recent years. Sections 25 to 30 are still, for the most part, gas yielders. In 25 there is one small oil producer on the Jackson lease in the southeast corner, and in 26 one of a similar kind in the southwest quarter. Section 31 has developed a number of fair producing wells, though two dry holes have been sunk on the northeast quarter. On the Woodward lease, northwest quarter, one well started at 75 barrels and held up for three months, then gradually dropped to 7 barrels. Its record showed:

Drive pipe	275 feet
Casing	380 feet
Top of Trenton	980 feet
Total depth	1,060 feet

The first pay was struck at 37 feet and the second at 70 feet in Trenton. The bore is located just on the edge of the "deep drive."

Sections 30 to 36 inclusive are to be classed as dry or salt water territory. The only productive bore in them was finished in January, 1903, on the east half of the southwest quarter of 32. Here, on the Martindale farm, a bore was sunk which developed a large vein of salt water at 50 feet in Trenton. After pumping five days the water began to color up and the well made six tanks of oil in a month and averaged 40 barrels a day for six months. Its record showed:

Drive pipe	135 feet
Casing	315 feet
Top of Trenton	975 feet
Total depth	1,025 feet

Four dry holes were soon bored just around it and a light gas producer was finished 600 feet to the west.

Developments in Washington Township (24 N., 10 E.) in 1903.—This township has a record for bringing in good producers in unexpected localities. A number of them were finished in 1903, and the township produced more oil than all the rest of Blackford County. Developments since the last map was issued have made necessary a number of changes in the then productive sections, while a number then marked as untested have become producers.

The wells in section 1, the south half of 2 and all of 3 and 4 have dropped down from good to only fair average producers, the initial output being much lower than when the area was first opened up. All of section 6 has become fair territory. A bore on the C. Woodward lease in the northwest quarter came in as a 150-barrel producer and made 100 barrels a day for more than a week. All of section 7 has produced fair average wells. Bores sunk in recent years have reduced the standing of 10, the northeast quarter being classed as light, the remainder as fair. The south half of 11 has changed from barren to fair producing territory. Section 12 has fallen back, most recent bores coming in light and reaching a settled production of 2 barrels per day in a week. The older wells in 13 are slowly being abandoned, but the new ones are coming in with a fair average initial output. Section 14 has been pretty thoroughly tested. Some good wells have been finished on the southwest quarter, but the remainder of the section is light and some of the wells yet show a high pressure of gas when first completed. The bores over the greater parts of 15 and 16 come in as fair producers, those on the southeast quarter of each section being lighter. On the Harold farm, southeast of 16, the average record shows:

Drive pipe	200 feet
Casing	365 feet
Top of Trenton	970 feet
Total depth	1,050 feet

There are six wells on the farm which came in as 5 to 8-barrel producers and dropped to a settled production of 2 barrels per day in a month. Section 17 has become good territory, ranking up with 18 on the west. No. 2 on the J. Futrell farm, west half of the northeast quarter of 18, proved to be the banner oil well of Blackford County in 1903. It was finished September 25th and started at 275 barrels. The first 32 days that it was pumped it yielded 36 tanks, or a total of 9,000 barrels, for which the company operating it received $11,970. Of this one-sixth, or $1,995, went to the farm owner as royalty. The well, on January 1, 1904, was producing 35 barrels per day. Its bore showed:

Drive pipe	442 feet
Casing	444 feet
Top of Trenton	1,016 feet
Total depth	1,081 feet

Good paying sand was found from 20 feet in Trenton to the bottom, or a pay streak 45 feet thick, a very unusual occurrence in the history of the Indiana oil industry. Not over 10 barrels of water a day was pumped from the bore. The latter probably struck the center of a small area or pool of very porous Trenton, in which the oil had accumulated. Section 19 remains as before marked. The famous well drilled in on the E. C. Storms lease, west half of the southeast quarter of 19, in 1898, which started at 350 barrels or more and pumped a tank a day for several months, finally went off into salt water and was abandoned for 18 months. In April, 1903, the lease was bought by a new company, the well cleaned out, and put to pumping with a gas engine. It pumped only water until September 15th when the fluid began to color up, and for two months it made 60 barrels of oil a day. The record of its bore was:

Drive pipe	180 feet
Casing	365 feet
Top of Trenton	972 feet
Total depth	1,033 feet

Other abandoned territory on section 19 has been recently redrilled with good results. (See p. 93.) Section 20 remains light, but 21 has become one of the best areas in the township. A bore on the J. B. Scott lease started in at 300 barrels and was making 180 when it was six days old. Another bore on the same farm came in at 180 barrels. The bores on 22 usually come in as fair producers, 15 to 40 barrels each, but settle down rapidly to 3 to 5 barrels. The northeast quarter of 23, marked as gas territory on the former map, has developed some fair wells, but the remainder of the section is light, as is also all of 24. The "deep drive" covers most of 25. The southwest quarter has proven barren. The bores on the other quarters come in as light producers with a quantity of gas. Section 26 has developed into fair territory. The "deep drive" covers a part of 27, but most bores sunk through it on this section have proven fair producers. No. 1, on the H. Carrull farm, west half of the northeast quarter, was commenced in April and not finished until July, trouble being experienced in landing the drive-pipe on the Niagara stone. The drive in this bore was 455 feet and no casing was used, as the Niagara was but two feet in thickness. In the deep drives in this vicinity much trouble is experienced with boulders between 200 and 350 feet below the surface, and also in passing through a sticky red clay below the boulders, which reaches to within 15 feet of the limestone. The well started at 60 barrels when completed. The southwest quarter of 27 is lighter, as is also the adjoining southeast of 28; the remainder of the latter section being better. On the Long lease, southwest quarter, are 15 bores, 12 of which are producing oil, two gas, and one dry hole. An average bore shows:

Drive pipe	185 feet
Casing	365 feet
Top of Trenton	965 feet
Total depth	1,045 feet

All were drilled in 1903, and the 12 producers were averaging five barrels each in October. Sections 29 and 30 are mostly light. Several bores have been abandoned in the northeast quarter of 30. Section 31 and the greater part of 32 are as yet gas territory. The northeast quarter of 32 has developed a dry hole and two light wells. The wells on the north halves of 33, 34 and 35 are fair; those on the south halves are generally light producers. The southeast quarter of 35 and most of 36 have, as yet, produced only gas.

Developments in Licking Township (23 N., 10 E. and Sections 1-6, 22 N., 10 E.) in 1903.—This township has, up to the present, proven a great disappointment to oil operators. It was thought, after the Hartford City pool was opened up in 1900, that a wide extension of good productive territory would be ultimately developed south and southwest of that city, but the drill has, so far, failed to locate it. Most of the bores sunk have come in dry, as water wells or as small producers. The pool in the northwest part of the Hartford City limits had the history of all other town-lot pools. While some good wells were opened, their production rapidly dwindled and, as but two or three could be hitched to one power, all but six or eight of them were finally abandoned. While 70 per cent. of the wells in the pool probably paid out, not over five per cent. made a profit. The best lease in the pool was the 40 acres of Widow Downey. On it five bores were sunk, two of which came in dry. From the other three, located on five acres of the lease, $70,000 worth of oil was sold, and the three, when four years old, were still producing 25 barrels a day in November, 1903. Such results, more than anything else, show the gambling feature of the oil industry in Indiana.

Taking up the productive area of Licking township by sections, we find that section 1 is a spotted area. One big salt water well on the north side of the S. Carrell lease made 100 barrels a day for a time, but on the south side of the same farm only gas has been found. All of 2 and three-quarters of 3 are light territory; the northwest quarter of the latter section being better. The east half of four contains a few light producers, but only a few light gas wells have been drilled on the west half and on 5.

The Renner stock farm of 540 acres, comprising the greater part of 6, has recently developed three wells, the average initial output of which was about 15 barrels. A gas well on the Townsend farm, southeast corner of the same section, was recently drilled deeper and shot when it made 10 barrels of oil and a fair supply of gas. No. 2 bore, on ~~the same lease,~~ came in as a 5-barrel ~~producer.~~ A small oil well has been drilled on the Rogers lease, northeast quarter of 7, and some gas wells with a showing of oil on the Smith, in the northwest quarter. Section 8 is unproductive, while 9 has only a few light wells on the northeast quarter. The north half of 10 comprises the Hartford City pool, and may yet be classed as fair. The Johnston Window Glass Company, drilled in a dry hole and a 5-barrel well on its lots in this area in 1903. The northeast quarter of 11 may be classed as light, while 12 and 13 as yet produce only salt water. One or two very light producers have come in on the northeast quarter of 14, but all bores on 15 have proven barren. The east half of 16 is light productive territory and a small well has recently been finished on the Johnson lease in the northwest quarter of the same section. Several gas wells on the southeast of 17 have sprayed oil from time to time, but as yet there is no producing well on the section. A test well on the Stanley farm, northeast quarter of 18, came in as a 6-barrel producer and two gas wells on the Williams, northwest quarter of 19, contain more or less oil which has not been pumped. Section 20, as yet, has shown no signs of oil, but a gas well on the Chapman farm, northwest quarter of 21, has sprayed it in quantity. On the Swift lease, southwest quarter of 22, are several light wells, and on the Drayer, southeast quarter, a bore drilled for gas came in as a 50-barrel producer. In section 27, just south, two bores were sunk, one of which yielded a small amount of oil while the other was barren. Tests on the Moonan farm in the southeast quarter of the section yielded gas only. The remaining sections of the township are wholly unproductive of oil, though a number of them still produce gas.

Developments in Jackson Township (23 N., 11 E.) in 1903. —Although this was counted one of the best gas producing townships in the State, but a few sections in the northwest corner have yielded oil. Where the gas has been exhausted, salt water seems to have taken its place. Therefore the chances of successful drilling for oil over the greater part of its area seem at present very slight.

In section 5 two dry holes have been drilled in the northwest quarter, while a bore sunk 250 feet into Trenton, on the Taylor lease near the center, developed only a little gas. Section 6 has produced a number of light wells. Four on the Hemminger, in the northeast corner, came in with an initial production of 10 barrels and soon dropped to 3 or 4 barrels. On the Hiatt farm, on the northwest quarter, are four big salt water wells, each pumped with a separate power and with a three-inch tubing to carry off the water. The four, in November, were making about 30 barrels per day. An average record shows:

Drive pipe	116 feet
Casing	320 feet
Top of Trenton	965 feet

The Stroble lease, in the southwest quarter of 6, has developed two dry holes and two light wells. One light producer has been finished on the northeast of 7, the remainder of the section being barren. A test on the Wingate farm on the south half of 10 brought a bountiful supply of salt water at 35 feet in the Trenton; while another on the southwest of 14 came in wholly dry. A bore which showed a large quantity of oil was finished on the Wentz farm, southwest of 17, but it was plugged on account of a too bountiful output of gas. Two gas wells were also sunk on the southwest quarter of 18 during the year. The remainder of the township is either untested or gas territory.

Jay County

comprises an area of 370 square miles, lying adjacent to the Ohio State line, south of Adams and Wells, north of Randolph and east of Blackford and Delaware counties. The surface of the county is gently rolling or nearly level, and the soil of most portions proves very fertile where properly drained and tilled. The Salamonie River flows through the county from southeast to northwest and drains its western and southern halves. The Wabash River touches its northeastern corner and through its tributaries drains the townships of Wabash, Bear Creek and Jackson.

The G. R. & I. Railway, passing north and south through the center of the county, crosses the L. E. & W. main line, running east and west, at Portland, the county seat. The P., C. & St. L. crosses the southwest corner of the county, passing through the thriving towns of Dunkirk and Redkey, so that the facilities of transportation in all directions are excellent. The population of the county in 1900 was 26,818 as against 23,478 in 1890.

The elevations above sea level of the principal railway stations in the county are as follows: Blaine, 930; Briant, 869; Brice, 924; Como, 949; Dunkirk, 946; Portland, 909; Powers, 991; Redkey, 966.

During the year 1903 Jay County forged rapidly to the front as an oil producer. Quite an area of new territory was opened up in Wabash and Bear Creek townships, while several light producing wells in Wayne and Noble townships bring a portion of their area within the limits of future prospective territory. But few leases have been abandoned in the county since the former map was issued, and most of these abandoned leases have been released and are being redrilled. During the year 213 bores were sunk in the county as against 94 in 1902, a gain of 127 per cent. Of the 213 bores, 33, or 15.5 per cent., were dry, the percentage showing a decrease of 5.5 from the previous year. The average initial output of the new wells in the county was 13.4 barrels as against 14.1 in 1902.

Developments in Wabash Township, Sections 3 to 10, 15 to 22 and 27 to 34 (24 N., 15 E.) in 1903.—This township comprises only 24 square miles, in the northeastern corner of Jay County. The area of producing territory in southern Jefferson township, Adams County, shown on the former map, has been extended southward, and covers parts or all of seven sections in Wabash township. Several fair producing wells have been finished in the north half of section 4 and some lighter ones in the north half of 5. Section 6 and the east half of 7 is fair productive territory, while the west half of 7 has yielded a number of good wells. The average bore in these sections shows:

Drive pipe	40 feet
Casing	290 feet
Top of Trenton	1,025 feet
Total depth	1,115 feet

A number of light to fair producers have come in on the north half of 8 and one or two on the southwest quarter. A dry hole was bored on the Bricker lease, northwest quarter of section 17, and another on the Miller lease in section 30. The northeast quarter of 18 is light territory, but the west half of the section is better, as is also the northwest quarter of 19. In sections 18 and 19 the drive pipe runs from 80 to 300 feet, the top of Trenton being found at about 1,040 feet.

Developments in Bear Creek Township (24 N., 14 E.) in 1903.—Of the 36 square miles embraced in this township, 17 are at present producing oil in commercial quantities. Quite an area of new territory was opened up in the northeast corner of the township during the year.

Section 1 and the north half of 2 embrace some fair productive territory, but the south half of 2 is lighter, tests on the Macklin and Bloom leases in that area coming in dry. A few light wells are yielding on the southeast quarter of 3, the remainder of the section being undrilled. The west half of 4 has some fair wells to its credit, but all new bores recently sunk on section 5 have proven light; while those on 6 are coming in only as fair producers. A bore on the southeast quarter of 6, completed November 6th, yielded quite a quantity of gas instead of oil, the rock pressure starting at 130 pounds, but soon falling to 20 pounds. The record of the bore shows:

Drive pipe	115 feet
Casing	238 feet
Top of Trenton	1,087 feet
Total depth	1,157 feet

The portion of 8 marked as undrilled on the former map at present contains some light to fair wells, while a test on the Chaney lease on the southeast quarter of 9 started at 5 barrels. The northeast quarter of 10 produced one or two light wells during the year, as did also the northwest of 11. Several fair producers have been finished on the northwest and southeast quarters of section 12. An average bore of these shows:

Drive pipe	40 feet
Casing	260 feet
Top of Trenton	1,034 feet
Total depth	1,107 feet

The pay streak is struck about 15 feet in Trenton and is usually softer and more porous than in the counties to the west.

The wells on the east half of 13 and the northeast quarter of 24 are light to fair producers. The west half of 16 and the east half of 17 are now producing some oil, though at one time a number of dry holes were drilled on them. A test bore on the Bishop farm, northwest quarter of 20, showed up dry, as did another on the Francks lease in section 26 near West Chester. The remaining sections of the township remain either undrilled or as shown on the former map.

Developments in Jackson and Penn Townships (24 N., 14 E. and 24 N., 13 E.) in 1903.—But few changes are necessary in the old map in these two townships. The north half of Jackson still retains its record as the best productive territory in Jay County, while the southern half remains very spotted. Recent bores in section 6 have proven light. Some of these are on the south half, hitherto undeveloped. Section 7, being in the deep drive, is yet untested. A dry hole was sunk on the Williams, southeast quarter of 8, during the year. The east half of 9 is now fair territory, while the south half of 13 has come in with several good wells. A dry hole was drilled on the northwest quarter of 15; while a test on the Ganey lease, north half of 25, was a 5-barrel producer. A dry hole was also completed among some gas wells in the northeast quarter of 32, but the southeast quarter of that section is now lightly productive, as is also the southwest of 33. A light well has also been finished in the southeast quarter of 36.

The territory in Penn township has, in the past, been distant from railway facilities, and many farms which doubtless contain oil beneath their surface have, for that reason, not been tested. A new railway has just been completed from Camden (Pennville) to Portland, which will doubtless prove a factor in causing more extensive operations in that portion of Jay County.

The lob or "deep drive" runs through both Jackson and Penn townships, and renders drilling very tedious and often expensive. It is not uncommon to use 400 or more feet of drive pipe in a number of the bores sunk in it before striking limestone. As a result, the region of the lob has been avoided, but since the wells hitherto sunk near it have mostly come in as fair to good producers the present high price of oil will doubtless lead operators to take the risk, and a number of the untested sections in Penn township will in the future become productive. But few bores were sunk in the township during the year. Two tests on the Gray farms, west half of 12, proved dry, as did another on the Brown lease, southeast quarter of 14. Old gas territory in the southeast quarter of 27 produced a fair well or two; as did similar territory in the southeast quarter of 30. With the exception of three wells in Pike township, the four townships above mentioned comprise the only area in Jay County at present producing petroleum in commercial quantity. A number of test as follows: In Wayne township, sections 5, 6, 10, 21, and 26, had a bore or two sunk on them, all of which made a showing of oil, sufficient to insure more extended operations in the future.

In Noble township a bore sunk on the southwest quarter of section 27 developed a small well. In Pike township, the three wells on the Ware and Lush leases in sections 8 and 9, sunk in 1901, are still producing 4 or 5 barrels; while a test put down on the northeast quarter of section 34 has recently come in as a small producer.

During the latter part of the year four or five fair producing wells were finished near Redkey, on sections 24, 25 and 36, Richland township. Two of these on the W. Barnell lease, southwest quarter of section 24, started at 25 barrels each, their record showing:

Drive pipe	135 feet
Casing	265 feet
Top of Trenton	964 feet
Total depth	1,040 feet

It is probable that a large portion of this township may become productive in the future, thus serving to connect up the Jay County territory with that now yielding oil in Monroe township, Randolph County.

According to records gathered by Benjamin Fulton, one of the most experienced operators in Jay County, he gives it as his opinion that "There is a ridge of Trenton lying between Redkey and Portland and between Redkey and Camden or Pennville, which seems to be too high for oil. Every well around the edges of this ridge where the Trenton was found as low as 950 feet, showed indications of oil. However, where the Trenton was found at shallower depths, nothing but gas was obtained. This ridge comes within three miles of Portland on the west and southwest, and at Portland Trenton is found at 985 to 990 feet; four miles south of Portland at 1,050 feet, and two and a half miles northwest and two and a half northeast of Portland, at 1,030 to 1,045 feet. In section 27, Noble township, Trenton was found at 1,045 feet. In section 21, Bear Creek township, at 1,040; in section 25, Jackson township, at 1,030; in section 24, Green township, 970 to 980. From this data of depth, I will go on record that the oil field will extend eventually clear through Wabash, Bear Creek, Noble, Wayne, Pike, Jefferson and Madison townships in Jay County, and connect up with a new field that will open up in Randolph County."

Madison County

lies south of Grand and west of Delaware and Henry counties. It comprises an area of 460 square miles, the surface of which is level or gently rolling. The drainage is to the southwest by way of White River, which crosses the county from east to west near its center, and has numerous tributaries permeating all portions of its area.

The railway facilities of the county are ample, the Michigan Division of the Big Four passing through it from north to south while the Cleveland Division connects Anderson, the county seat, with Muncie and Indianapolis. The P., C., C. & St. L. crosses the county diagonally from northwest to southeast. The Chicago and Southeastern (old Midland) crosses the county from east to west near its center and the L. E. & W. runs across its northern third. Besides these, the lines of the Union Traction Company run in various directions from Anderson.

The discovery of natural gas over much of its area about 1885 led to a rapid growth in its wealth and population. The towns of Elwood, Alexandria, Summittville and Frankton in the northern half, which had before ranked only as country villages, rapidly assumed the size and prerogatives of cities, while Anderson, the county seat, almost doubled in size. The phenomenal growth of these places in ten years may be seen by the following comparative table of population:

	1890.	*1900.*
Alexandria	715	7,221
Anderson	10,741	20,178
Elwood	2,284	12,950
Frankton	520	1,464
Madison County	36,487	70,470

The elevations in feet above sea level of the principal railway stations in the county are as follows: Alexandria, 855; Anderson, 854-894; Chesterfield, 907; Elwood, 862; Florida, 881; Frankton, 834; Gilman, 901; Orestes, 871; Pendleton, 847;

Only the northern third of Madison County has produced petroleum in paying quantities; and that only in limited areas in Boone, Van Buren and Monroe townships. In the first two mentioned the developments were mainly during the year 1903, but about Alexandria, Monroe township, a number of wells have been producing since 1898. These three townships have been large gas producers in the past, and there is little doubt but that they will develop many paying oil wells in the near future. Outside of their area the chances of opening up productive territory in the county seem small.

Developments in Boone Township (Sections 7 to 36, 2 N., 7 E.) in 1903.—In this township I could learn of but two bores in which oil had been obtained. One on the Howard lease, northeast quarter of section 9, is said to contain several hundred feet of oil. It was sunk for gas and penetrated the Trenton only 32 feet, the top of that formation being struck at 972 feet. One-half mile west, in the northwest quarter of the same section, a well on the J. Campbell lease has been pumping a small quantity of oil for some months, and in October had filled nearly a tank.

Developments in Van Buren Township (Sections 7-11, 14-23, 26-35, 22 N., 8 E.) in 1903.—This township has up to the present produced oil only in the northern tier of sections; 7-11, next to the Grant County line, and in 21, just east of Summittville. In the northeast quarter of section 8, several bores, yielding only gas, were sunk on the Sluder lease in a vain endeavor to extend the Fairmount township, Grant County pool in that direction. The C. S. Wood farm, in the southeast corner of 10 developed one or two light wells, but three bores sunk on the C. M. Leach lease in the northwest quarter found gas alone.

Quite a pool of fair productive territory has been opened up in section 11. The wells mostly came in good for 10 to 30 barrels initial output, though a few of them were better. About 30, scattered over the section, were completed by October. An average record ran about:

Drive pipe	180 feet
Casing	380 feet
Top of Trenton....................................	978 feet
Total depth	[illegible]

In section 20, near Summittville, a dry hole was located on the Vardeman lease. In 21, just east of that town, several productive wells and dry holes have been drilled. The Crystal Glass Company owns two of the producers. No. 1 was drilled for gas on a town lot of their property in the northwest quarter of the section in April, 1902. It came in as an oil producer, starting at 120 barrels. At the end of two months it was cleaned, when it made 175 barrels for a few days. The Standard put in a line and piped the oil to Montpelier. The output gradually decreased, and after producing about 8,500 barrels the well ceased to yield. A record of its bore showed:

Drive pipe	140 feet
Casing	400 feet
Top of Trenton	951 feet
Total depth	1,077 feet

The first pay was found 40 feet, and the second between 70 and 80 feet, in Trenton. The second bore of the same company, half a mile east on the northeast quarter of the section, was finished in October, 1903, and started at 50 barrels, but was down to 3 barrels in two weeks. A bore 1,500 feet northwest of No. 1 was sunk 165 feet in the Trenton but was dry. Another a little farther northwest, on the Cowgill lease, in the southeast quarter of 17, was also dry.

On a town lot just south of the schoolhouse, in the eastern limits of Summittville, a bore sunk for gas in 1902 began to show oil and in the spring of 1903 was drilled deeper and shot. It started at 120 barrels and produced 11 tanks, when it ceased to yield. Its bore showed:

Drive pipe	120 feet
Casing	440 feet
Top of Trenton	940 feet
Total depth	1,042 feet

A dry hole was drilled 50 yards west and another 300 yards northeast, while a small producer was finished 50 rods east which was making 5 barrels a week in October. This shows the spotted nature of the Trenton in the section. Scattered bores sunk over the remainder of Van Buren township have developed only gas; though most of them have been drilled only a shallow

Developments in Monroe Township (Portions of 21 N., 8 E. and 21 N., 7 E.) in 1903.—This is the township in which Alexandria is located, and in the immediate vicinity of that place a number of wells have been producing since 1899. The high gas pressure has interfered greatly with their operation and the drilling of a number of dry holes has not added prestige to the region. As a consequence a large number of the wells first in operation have been abandoned. However, a number of light producers were finished in the township during the year, so that the annual output of the field has been maintained.

In section 10, one bore which yielded 50 barrels, natural flow, the first day, was finished on the Hughes lease, while others on the same farm came in very light, or dry. A dry hole and a small well or two were completed in the northwest quarter on the Baker lease, and a fair well in the northeast quarter on the Markle farm. The latter, when finished in August, started at 50 barrels and was down to 10 barrels by January 1st. One or two bores in the northwest of 13, just west of Alexandria, were dry or very light. On the southwest of section 15, four miles east of Alexandria, a test on the Swindell farm in comparatively new territory came in for 75 barrels. The southeast quarter of 17 produced two fair wells and a dry hole. A test on the Miller lease in the northeast quarter of 22, (21 N., 7 E.) started at 50 barrels, while a second bore is said to have been a little better. Two or three fair wells and a dry hole were also finished on the northeast quarter of 29. Of the 34 bores finished in the township during the year, 14, or 41 per cent., were dry; while the 20 producing wells had an average initial output of but 9 barrels, so that the Alexandria field was not remarkable for its record during the year. The output of the field by months during 1903 was as follows:

PRODUCTION OF THE ALEXANDRIA, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1903.

	Barrels.
January	16,742
February	17,382
March	22,903
April	18,760
May	22,424
June	22,717
July	25,914

August	26,345
September	25,214
October	26,505
November	24,310
December	22,667
Total	271,883

On the William Shafer farm, southwest quarter of section 24, Duck Creek township, three and a half miles east and four miles north of Elwood, The Pittsburgh Plate Glass Company drilled a well in October, 100 feet into Trenton rock. It came in with an initial production of 20 barrels. The well has since been shut down, as the company claims that it did not pay to operate it. On the same farm, 500 feet south, the same company drilled a well 300 feet in the sand. They found gas and a little oil at 65 feet, but nothing from there on, and the well was abandoned. The record of its bore showed:

Drive pipe	36 feet
Casing	228 feet
Top of Trenton	938 feet
Total depth	1,238 feet

Delaware County,

comprising an area of 399 square miles, lies east of Madison, north of Henry, south of Grant and Blackford and west of Randolph and Jay counties. Its soil is of drift origin and very diversified, but is, for the most part, noted for its fertility. White River crosses the county from east to west a little south of the center, and together with its tributaries drains the southern two-thirds. The Mississinewa, flowing in a northwesterly direction, crosses the northeastern fourth and, with its tributaries, furnishes ample drainage for the northern third.

The transportation facilities of the county are most excellent. The Cleveland Division of the Big Four; the Lake Erie & Western; the Chicago, Cincinnati & Louisville, and the Ft. Wayne, Cincinnati & Louisville, all intersect at Muncie, the county seat, and from that point diverge in all directions. Besides these, the Chicago, Indiana and Eastern from the northwest and three interurban traction lines, two running west, and one north, have their terminals in Muncie.

The discovery of natural gas over the larger portion of Delaware County and a consequent increase of large and important manufactories, led to a rapid growth in population. The increase from 1890 to 1900 of the three larger towns, as well as of the county, is shown as follows:

	1890.	1900.
Muncie	11,345	20,942
Albany	571	2,116
Eaton		1,567
Delaware County	30,131	49,624

The elevations in feet above tide of the more important railway stations in the county, are as follows: Albany, 939; Cammack, 931; Daleville, 910; De Soto, 956; Eaton, 910; Gilman, 901; Muncie, 950; Oakville, 1,008; Reeds, 929; Royerton, 928; Selma, 1,005; Shidelers, 911; Yorktown, 924.

While Delaware County is not, as yet, noted for its output of petroleum, it promises much for the future. Washington township, in the northwestern corner, has been producing more or less since the first wells came in near Gaston in 1897. The gas pressure in that part of the county has, however, for the most of the time since, been too high to permit of the lawful securing of the oil. Liberty and Delaware townships east and northeast of Muncie have been the scene of extensive operations for several years, while more recently, that portion of Center township just northeast of the city limits has developed a number of producers. All the area tested in these three townships seems, however, to be very spotted territory, and up to the present the chances of securing a dry hole or a fair producing well are about equal. The field is remarkable in that three or four bores sunk during the year developed a pay streak rich in oil at 240 or more feet in the Trenton. Isolated bores in other sections of the county have from time to time developed a fair showing, and the greater part of the northern half of the county will eventually produce more or less oil. But it is doubtful if the industry in Delaware County ever reaches the magnitude it has assumed in Grant, Wells, Blackford and other counties, to the north and northeast.

Developments in Washington Township (Sections 7-36, 22 N., 9 E., and 12, 19, 24, 25 and 36, 22 N., 8 E.) in 1903.—The first producing wells in this township were drilled in on the W.

H. Broyles lease, northeast quarter of section 36 (22 N., 8 E.) in the fall of 1897. They produced large quantities of both gas and oil, and were closed by injunction on March 12, 1898. Four wells, located on adjoining farms to the south were closed at the same time. The three wells on the Broyles lease struck Trenton at 940, 935 and 933 feet respectively. In October, 1900, Howland & Company put down a fourth well, 24 rods north of No. 2, striking Trenton at 937 feet. In order to shut off the gas they used ten-inch drive pipe and six and a quarter inch casing. Inside of the latter, five and five-eighth-inch casing was used clear down to the oil. Two pay streaks yielding gas were found, the first 25 to 45 feet, the second 65 to 80 feet in. The inner casing was sunk to a depth of 1,019 feet, or below the gas "pay." A packer was put in below the gas and one above. Below the gas, 18 feet of oil rock was found, the oil being raised through two-inch tubing without waste of gas. The outfit was quite expensive, but was, for a time, fairly successful, the output of the well being about 40 barrels daily, which flowed by heads. An arrangement was utilized by which enough gas for running the engines was secured from the supply held between the packers. After the well had been pumped a while the oil became partially exhausted for a distance around the foot of the bore and the gas found its way down and up inside of the tubing, the experiment thereby proving a failure. Mr. Broyles received from Howland & Company $2,000 bonus and one-sixth royalty for 82 acres of his farm, and the same amount for a second 80 acres, from the American Window Glass Company, the latter company agreeing to pay also $100 per year for each gas well drilled, from which the gas was piped away for use. Most of the bores since sunk on the lease have proven small gas producers.

The only new bores sunk in the township in 1903, were on the north half of section 12 (22 N., 8 E.), where eight were finished on the Couch and Richards farms. Much trouble was experienced in some of them with both salt water and gas. Seven of the eight came in as producers, the average initial output being 12 barrels. The best of the wells started at 25 barrels, while one bore yielded only gas. This is an eastward extension of the pool in the northeast corner of Van Buren Township, Madison County.

Developments in Delaware Township (Sections 1 to 25, 21 N., 11 E.) in 1903.—The first producing oil well sunk in this township was finished in 1901, on the Krohn farm, southwest quarter of section 11, and a mile southwest of the town of Albany. Trenton rock was struck at 925 feet and penetrated 50 feet. The bore yielded 60 barrels of oil and a large amount of salt water the first day it was pumped. Two other bores sunk in 1901 in the same vicinity proved dry.

During the year 1903, 17 bores were finished in the township. Of these nine, or 53 per cent., came in dry. The eight producers had an average initial output of 21 barrels each. Two dry holes were completed on the Brammer lease in the northwest quarter of 18, but a third bore, sunk 306 feet in Trenton, made 85 barrels the first day and was good for 50 barrels when a month old. Its record showed:

Drive pipe	28 feet
Casing	294 feet
Top of Trenton	921 feet
Total depth	1,227 feet

A dry hole was drilled on the Bartlett farm, in the south half of 2. The north half of 4 has produced several fair wells and the southwest quarter one or two light ones. Of two bores sunk on the Davis farm, northeast quarter of section 6, one, finished in November, started at 12 barrels, and on January 1st was making half as much. Another, 600 feet north, developed salt water, 40 feet in Trenton and did not pay to pump. The average record showed:

Drive pipe	44 feet
Casing	337 feet
Top of Trenton	940 feet
Total depth	1,000 feet

Test bores on the northeast quarter of 5 also came in light, while others on the Bartlett lease in the southeast of 13 produced only gas. The best strike of the season in the township was on the D. Michael farm, northeast quarter of 15, where a test bore finished on November 3d, started without shooting, at 160 barrels, and for 35 days pumped natural 70 barrels per day. It is said that no oil was struck until the drill had pierced Trenton 240 feet. A record of the bore was as follows:

Drive pipe	40 feet
Casing	370 feet
Top of Trenton	920 feet
Total	1,195 feet

This big strike in territory hitherto unproductive and at so great depth in Trenton caused much excitement among the oil fraternity, and by January 1st, five other bores were drilling on the same lease, and four on adjoining tracts. One of these, located 800 feet north and east of the Michaels well, on the E. Black lease, southeast quarter of section 10, came in as a 100-barrel producer, its record being as follows:

Drive pipe	27 feet
Casing	310 feet
Top of Trenton	921 feet
Oil pay	270 feet
Total depth	1,232 feet

Another test on the Peterson farm, southeast quarter of section 18, came in as a 25-barrel producer, while two or three bores on the Dowell lease, southeast of 22, were light or dry. A test on the Williamson farm, in 23, showed only gas, as did another on the Payton farm, in the northwest of 30.

Developments in Center Township (Sections 1-25, 20 N., 10 E., and 31-36, 21 N., 10 E.) in 1903.—Operations in this township were wholly on sections 1, 2, 11, 12, 35 and 36, just northeast of Muncie. On this area 13 bores were sunk, 7 of which came in dry, while 6 had a total initial output of 126 barrels, 100 of which was yielded by a single well.

In section 36, northeast corner of the township, one light producer and a dry hole were finished on the McCormick lease, and a light one on the Reed farm just west, while a test on the Sears lease came in dry. What was at first a dry hole, but which after shooting became a million-foot gas well, was finished in the southeast corner of 35, its record being:

Drive pipe	47 feet
Casing	350 feet
Top of Trenton	920 feet
Total depth	1,015 feet

On the north half of the southwest quarter of section 1 the big the E. E. McGalliard farm, where three or four light wells had been previously drilled. It started at 12 barrels an hour and made 1,800 barrels in seven days, but by September 20 was down to 35 barrels a day. A record of its bore showed:

Drive pipe	42 feet
Casing	341 feet
Top of Trenton	969 feet
Total depth	1,011 feet

Another bore, 600 feet south, was a dry hole, while another the same distance northwest developed a pay streak but four feet thick and came in as a 5-barrel producer. Two others on the Shirey lease, just north, were both dry. This is a good illustration of the spotted character of the territory in this region. In section 2, just to the west, a bore on the Crews lease also came in dry with the following record:

Drive pipe	30 feet
Casing	328 feet
Top of Trenton	907 feet
Total depth	949 feet

A big salt water vein was tapped at 25 feet in Trenton and the bore was soon after abandoned. Two light producers were finished south of the Crews on the southeast quarter of 2 and a salt water well on the Watt lease, northeast of 12. In the latter salt water was found at 20 feet in Trenton and a stronger vein at 90 feet in. Drilling was continued to 140 feet in, with the hopes of striking an oil pay, but without results. In a bore on the Haney lease, northeast quarter of 11, it is reported that the Utica shale was a reddish brown in color. The Trenton was pierced 417 feet, and it is claimed that a pay streak was struck at 202 feet in, and after shooting there was 100 feet of oil in the bore, but the latter caved and the well was abandoned.

In this Center township area about the only pay is found 18 to 30 feet in Trenton and it runs about 15 feet thick. It is, for the most part, fine and gritty. If no accidents occur, a well can be completed ready for shooting in 12 days, but the majority of them take 15 or more days.

Developments in Liberty Township (Sections 1-25, 20 N., 11 E., of the production in Delaware County. In 1903, 81 bores were sunk within its limits, 28, or 34 per cent. of which were dry. The 53 productive wells had an average initial output of 21 barrels, but the greater part of the total initial production was from six or eight big wells.

Dry holes were sunk on the northeast quarter of section 36 and on the northwest quarter of section 1. A few light wells were finished on the south half of 3, while a test on the southeast quarter of 6 came in barren. The county farm, on the southeast quarter of section 8 has proven one of the best productive areas in the township. The first oil well completed on it was an old gas well which was drilled deeper and shot in 1901. It started in at 35 barrels and additional bores were at once sunk around it. On October 1, 1903, there were 11 producing wells and three dry holes on the farm. The producers were making a total of 70 barrels a day. The cost of operation was $125 per month. The records of a salt water bore and the No. 11 producer, both of which were completed in 1903, show:

	Salt water well.	*No. 11.*
Drive pipe	76 feet	55 feet
Casing	333 feet	343 feet
Top of Trenton	914 feet	917 feet
Total depth	969 feet	975 feet

Two light producers and a big salt water well have been finished on the northeast quarter of section 8. On the Abergast lease, northeast quarter of 9, an old gas well began to show oil in 1899. It had been sunk but 20 feet in Trenton, but was drilled 50 feet in and shot, when it produced a small amount of oil. As there was then no pipe-line to carry away the oil, the well was abandoned after about 100 barrels had been pumped, most of which was wasted. In 1903 a second bore was sunk 600 feet east, which produced a large amount of salt water and some oil. If it had been shot and put to pumping it might have developed into a fair well. A dry hole was finished on the Hindman lease, southwest quarter of 9, during the year.

The Schrack farm, southwest of 12, furnished one big oil well, two light ones and a gas well in 1903. The big well started at

Drive pipe	85 feet
Casing	335 feet
Top of Trenton	976 feet
Total depth	1,030 feet

Test bores on the Jones farm, northwest quarter of 13, and on the Patty lease, southwest quarter of the same section, came in barren. The latter was a big salt water well and its record showed:

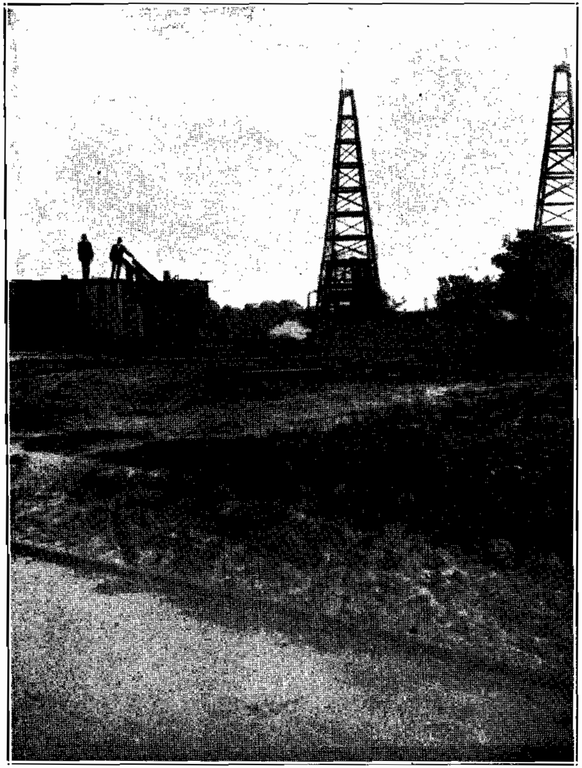
Drive pipe	95 feet
Casing	352 feet
Top of Trenton	980 feet
Total depth	1,013 feet

Section 14 has proven the leading producing area in the township. The L. Winget lease, near the center of the section, had, on October 1st, six wells producing an average of 200 barrels daily. The No. 3, finished July 16, started at 200 barrels and on October 1 was still yielding 75 barrels. A record of Nos. 3 and 4, 300 feet west, follows:

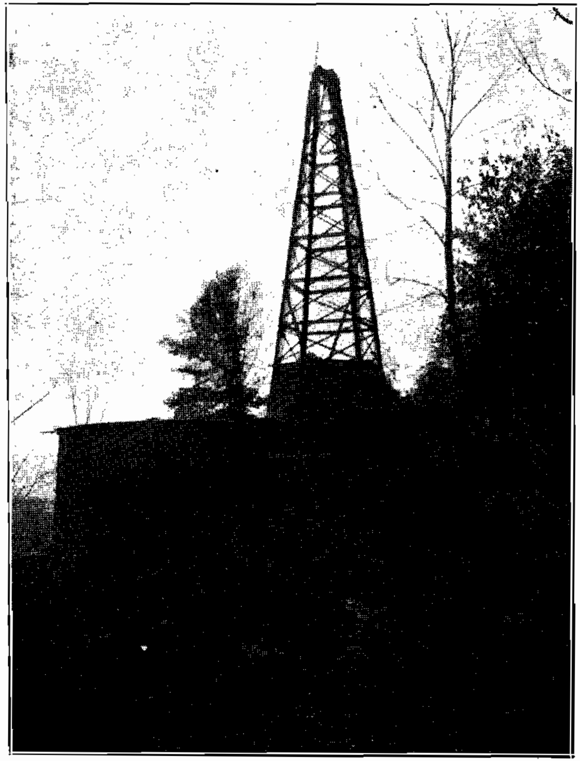
	No. 3.	*No. 4.*
Drive pipe	104 feet	97 feet
Casing	350 feet	364 feet
Top of Trenton	984 feet	988 feet
Total depth	1,040 feet	1,035 feet

Two pay streaks were encountered, the first 14 feet, the second 27 feet in Trenton. Gas is used for fuel while drilling and gas engines for pumping. The lease averaged a tank a day between July 16 and October 1. On the Winget, Anderson, Black and Dunkin leases, embracing an area of one-half square mile, five companies were operating December 1st. All these leases were developed in 1903, the nearest producing wells previous to that date being one and a quarter miles east. The Anderson farm of 40 acres, just north of the Winget, was sold by the owner for $5,000 early in the season. The buyers, up to October 1st, had sunk on it five producing wells which, on that date, were yielding 65 barrels a day. The Dunkin lease west of the Winget, yielded three or four small producers, as did also the Black lease in the south half of the northwest quarter of 14. A bore completed in the northeast corner of the section was also good for only five barrels. A dry hole was finished on the Sweeny lease, north half of southeast quarter of 15, while the Campbell and

Plate II.



Wells on the Winget Lease, East of Selma, Ind.



Kitterman Well, Near Birdseye, Ind.

East farms on the west half of 16 had several light wells to their credit. The top of Trenton in this section is found at about 938 feet. An old gas well on the Burt lease north half of 17, was drilled deeper and started at 10 barrels, but two others found salt water only. A test on the Graham lease, northeast of 18, was light, but No. 1 on the Guthrie lease just west, developed a 35-barrel producer, while No. 2 started at 150 barrels. Records of their bores showed:

	No. 1.	*No. 2.*
Drive pipe	65 feet	61 feet
Casing	321 feet	330 feet
Top of Trenton	886 feet	890 feet
Total depth	1,172 feet	1,161 feet

The principal pay streak of oil in the two wells was found at 42 feet in Trenton.

Just south of Smithfield in the southwest corner of 22, the F. M. Cannaday farm has developed four fair producers, the average record of which shows:

Drive pipe	80 feet
Casing	338 feet
Top of Trenton	940 feet
Total depth	1,017 feet

Two dry holes have been finished on the southwest quarter of 27, while a light producer was finished on the Williams farm in the northeast quarter. The first well to show oil in Liberty Township was on the Cecil farm in the northeast quarter of 28. A gas well began blowing off oil in 1900 and was drilled 80 feet into Trenton and shot. Before shooting, the oil is said to have stood 300 feet deep in the bore, but it came in as only a 5 barrel producer. Soon after this, a bore sunk for gas on the Z. T. Dunkin lease just to the south, yielded 15 barrels of oil when completed. The third bore in the field was on the F. M. Cannady lease in 22. At 35 feet in Trenton a large salt water vein was tapped but the bore started at 50 barrels. The Cecil lease at present contains three, and the Dunkin lease five or six, fair producers. One of these, sunk in 1902, started in at 135 barrels, and produced the usual excitement of a rich strike in comparatively new territory. It was near the corner of the farm, and four bores sunk within 300 feet in different directions came in dry. Just west of the Dunkin and Cecil leases, several light producers have been developed on the A. R. Lennon farm, an average record showing:

Drive pipe	124 feet
Casing	340 feet
Top of Trenton	972 feet
Total depth	1,051 feet

The depth to which the wells are sunk in the Selma field is governed very largely by the appearance of the drillings from the Trenton. Salt water is often found 30 to 40 feet in, and a rather close white sand at about that depth warns the driller of its probable proximity. If there are no signs of water, the drill is often sunk 75 to 100 feet into Trenton. Where the territory is productive, two pay streaks are almost always found, one 15 to 20 feet in, the other 30 to 37 feet. A pipe-line station has been put in by the Indiana Pipe Line Company, just west of Selma, from which the oil from Center and Liberty townships is piped to a larger station at Montpelier, Indiana. The Republic Iron & Steel Company, of Muncie, which is operating a number of the largest producers in the Selma field, has use for all the surplus gas produced from its wells, and so is not bothered as are some of the other oil operators by the gas pressure. When gas at a low pressure is put into a pipe line for factory use it is often forced or held back, and so lessens the output of oil. A pump which will force the gas from a single well into a lead pipe can be had for $75. If used in connection with the oil pump, it will remove the back pressure of gas and so allow the ready production of the oil.

From what has been said about the different parts of the Delaware County field, it will be seen that the oil appears to be in little pockets or pools. No productive area of any size has as yet been found. As one of the leading operators said, "the territory is as spotted as a leopard's back, and the spots are very far apart."

The following table shows the number of barrels of oil piped from the Muncie-Selma-Parker oil field by months for the year 1903;

PRODUCTION OF THE MUNCIE-SELMA-PARKER, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1903.

January	15,108
February	19,639
March	25,268
April	21,714
May	39,155
June	56,159
July	58,474
August	56,667
September	55,914
October	57,597
November	49,632
December	54,204
Total	509,531

Randolph County

comprises an area of 450 square miles lying next to the Ohio State line, and south of Jay, north of Wayne and east of Delaware and Henry counties, Indiana. The surface of the county is generally level or rolling, but the area which it embraces is one of the most elevated in the State, its southern part forming the principal watershed of eastern Indiana. The numerous streams which rise within its bounds flow in every direction. Both Whitewater and White rivers have their sources within the county, the tributaries of the former draining the southern third and those of the latter the central third, while across the northern third flows the Mississinewa, which is also fed by numerous small streams.

The soil of the county is, for the most part, a heavy clay enriched by the vegetable accumulations of ages. The clay, being of drift origin, is composed of the debris of many different formations which contains all the elements necessary for plant food. Wheat, corn and grass are the leading productions; the cereals and live stock furnishing the principal income of the agricultural classes.

The county is supplied with the best of transportation facilities. Two divisions of the Big Four Railway cross it from east to west, one near its center, the other across the southern third.

C. & St. L. cuts across its northeastern fourth, while the C., C. & L. touches its southwestern corner. The population of the county in 1900 was 28,653, as against 28,085 in 1890.

The highest land in Indiana is on the middle ridge near Bloomingsport, on the "Summit" between Green's Fork and Martindale Creek, where the elevation on the Peoria Division of the Big Four has been found to be 1,234.4 feet above sea level. Some of the hills south of this point are estimated to be 50 feet higher, so that 1,285 feet is approximately the highest level in the State. The elevations of the principal railway stations in the county are as follows: Carlos, 1,208; Crete, 1,181; Deerfield, 1,004; Farmland, 1,037; Harrisville, 1,101; Johnson, 1,177; Losantville, 1,128; Lynn, 1,162; Modoc, 1,174; Parker, 1,023; Ridgeville, 982; Saratoga, 1,044; Snow Hill, 1,174; Stone, 1,034; Union City, 1,102; Winchester, 1,089; Woods, 1,183.

Monroe township, on the western border of Randolph county, has developed a number of productive oil wells in recent years some of which have had an output equal to any in the State. The territory has, however, proven to be very spotted, the number of dry holes equaling or exceeding those with an output sufficient to pay for pumping. Isolated bores in White River and Stony Creek townships have also developed small producing wells. From present indications the future production will probably be limited to the northeastern third of the county, which comprised the former principal gas yielding area within its bounds.

Developments in Monroe Township in 1903.—This civil township comprises a part of four different congressional townships and the numbers of the sections are, therefore, very confusing. It embraces the south halves of sections 29 and 30 and all of 31 and 32 (21 N., 13 E.); sections 5 to 8 and 17 and 18 (20 N., 13 E.); the south halves of sections 25 to 29 and all of 32 to 36 (21 N., 12 E.), and sections 1 to 5 and 8 to 17 (20 N., 12 E.). In the north part of the township a gas well was finished on the Thornburg farm in section 27, while a test on the Wood lease in section 32 came in dry. The Keever lease, south half of 33, has a number of fair producers to its credit; while the Boots farm to the west and the Wood lease to the north each possess several light wells. A bore or two on 34 came in light, while east quarter of section 3 has yielded a few fair producers, but tests on other parts of the section were barren. The east half of 4 is first-class territory; the Bennett lease on the southeast quarter having yielded a number of big wells. No. 1, when finished May 22, was apparently dry, but when shot with 400 quarts began to flow and produced 200 barrels the first day and 3,000 barrels the first month. Its record shows:

Drive pipe	99 feet
Casing	337 feet
Top of Trenton	965 feet
Total depth	1,068 feet

The Trenton is said to be in thin strata or layers and has the color of whitewash on the bailers. By the first of October the well had settled down to 12 barrels per day. No. 2 Bennett at first showed a little gas, but no oil. A shot of 400 quarts caused it to start at 250 barrels; while No. 3 also came in as apparently barren, but yielded 150 barrels after shooting. Nos. 4 and 5 on the same lease were dry.

The west half of 4 has produced only light gas wells or dry holes. Several light wells have been found on the Meeks lease, southeast of 5, and the northeast of 8, but a number of dry holes have been drilled with them, and those sections are considered poor property.

Section 9 is the most noted area in the field. The famous "Cecil gusher," probably the best well drilled in Indiana in 1903, is located in the midst of a number of others on the east half of the southeast quarter. It was No. 10 on the E. E. Cecil lease, finished May 2, 1903, when it started at 420 barrels, and averaged more than 300 barrels a day for four months. The oil was almost wholly free from water, so much so, in fact, that it became necessary at times to run water into the tanks and steam it in order to get rid of the sediment. A two-inch pipe was taxed to its full capacity to take the oil from the pump to the tanks, and on September 23 a three-inch pipe was put in and the well made 20 barrels an hour for several days. The well was pumped on the beam, 40 strokes to the minute, and a stand of 3 tanks was necessary to take care of its production. A record of its bore showed:

Drive pipe	136 feet
Casing	346 feet
Top of Trenton	1,007 feet
Total depth	1,047 feet

The top of the oil pay was found at 1,025, and a continuous pay streak 22 feet thick was passed through to the bottom. The top of Trenton in this particular lease seems to be very uneven, the drill showing it to be in waves or crowded anticlines. Bore No. 13, on the southeast corner developed the Trenton at 974 feet, while 40 feet east, on the adjoining lease, it was found at 960. In No. 10, the big well, it was found lower than in any other bore, being struck at 1,007 feet. No. 9 well, on the same lease, finished April 4, started at 320 barrels and was making 65 on October 1. On the same date there were 15 wells on the E. E. Cecil farm of 143 acres, and eight on the Z. Cecil lease, just to the west. On the latter lease the first bore, finished in July, 1902, made two tanks in 27 hours, but soon dropped to a 25-barrel producer. The record of No. 3 on this lease was exactly the same as No. 2 on the E. E. Cecil, showing:

Drive pipe	120 feet
Casing	345 feet
Top of Trenton	965 feet
Total depth	1,015 feet

The 23 wells on the two leases were producing 900 barrels a day on October 1st, and several good ones were drilled later in the year. On the northeast quarter of 9 the wells are fair producers, but those on the west half of the section are light. The southwest quarter of 10, just east of the E. Cecil lease, contains some fair wells, but tests on the remainder of the section are either barren or water wells. A gas well was finished on the Grove farm in 11, and the only producing well in the section, located on the southwest quarter, is light.

A test drilled on the Macy farm, section 12, just north of Farmland, came in dry, as did another on the Mason farm in section 14. The Ezra Cecil lease in 15 developed two producing wells and three dry holes during the year. One of the wells started at 45, the other at 125 barrels. A half dozen wells on the north half of 16 are light producers while one or two other bores in the section are dry. Two old wells on the Scott lease in 17 and one new one finished in 1903 have an output of 3 to 5 barrels a day.

The above comprises the development in the famous Parker field up to January 1, 1904. It will be seen that four or five sections produce practically all the oil in the township. The results of the drilling during the year showed that 116 bores were sunk in the Parker field. Of these 42, or 36 per cent., were dry. The 74 producers had an average initial output of 45 barrels. Fourteen of the producers in sections 4, 9 and 15 started in at 100 barrels or more each, their total initial output being 2,100 barrels, or 150 barrels each. The other 60 producing wells had an average initial production of 20 barrels each. The field is thus seen to be very spotted and one well tests only a location. Public attention has been called to the big wells, but the dry holes and small producers have been seldom mentioned.

Developments in Stony Creek Township During the Year 1903. —This township lies just south of Monroe on the western side of the county. But few bores have, as yet, been sunk within its limits. A test on the McIntire lease, section 19, three-quarters of a mile west of Macksville, started at five barrels, while another on the N. Knobe farm, in section 30, south of Macksville, struck the top of Trenton at 984 feet. This formation was then pierced 99 feet before a pay streak was encountered. This was seven feet thick, and the total depth of the bore 1,084 feet. It came in as a three-barrel producer. A dry hole or two was completed on the Swingley lease south of Windsor, on the northeast quarter of section 32, and another on the Anderson farm in section 36.

Developments in White River Township in 1903.—This is the township in which Winchester, the county seat, is located. Some light producers have been finished on the Clayton farm in section 9, three miles northeast of Farmland, but they developed much gas with the oil. A test on the A. Brown lease, six miles southeast of Winchester, developed a light showing of oil and some gas, the record of the bore being:

Drive pipe	227 feet
Casing	335 feet
Top of Trenton	1,113 feet
Total depth	1,214 feet

Two bores on the Pickett farm, two and a half miles southeast of Winchester, southwest quarter of 23, were finished in October and started in at about 20 barrels each. Their average record shows:

Drive pipe	85 feet
Casing	226 feet
Top of Trenton	1,091 feet
Total depth	1,156 feet

By January 1, 1904, they had produced 900 barrels of oil, and the indications of the new pool were sufficient to cause the Indiana Pipe Line Company to put in a line to them. A third bore on the same lease was a light producer, as was also one on the Hunt lease, in the south half of the same quarter section. The only other producing well in the township on January 1st, 1904, was on the E. Owens farm, northeast quarter of section 35, four miles southwest of Winchester, which yielded 100 barrels the first two weeks after its completion.

Developments in West River Township During the Year 1903. —Eight or ten test bores sunk in this township during the year resulted in dry holes or light gas wells. The only one showing oil was on the B. T. Olwin farm, in section 29, which yielded about two barrels a day after it was finished. Dry holes were drilled on the Haynes, Macy and Fletcher farms, section 20; on the Johnson farm, section 9, on the Lumkins farm, in 17, and on the Hawkins in 30.

A bore on the Courtner lease, section 25, Greene township, came in dry during the year, as did also several tests in Nettle Creek township; notably on the Clevenger and Lindsay farms in section 15. Outside of Monroe township all bores as yet sunk in Randolph County have been thousand to one shots and 95 per cent. of them have proven losing ventures.

ISOLATED AREAS PRODUCING TRENTON ROCK PETROLEUM OUTSIDE THE MAIN INDIANA FIELD.

In Wabash County.

The only productive area in this county has been in Noble township, on the west side where, in the vicinity of Kellar's Station or Rich Valley, a number of wells have been yielding oil since 1897. During the year 1903 but four bores were completed in this area. Of these one was dry and the others came in as two to five-barrel producers.

In Waltz township, in the southwestern corner of the county and next to the Grant County line, a number of bores have been sunk in recent years by the Marion Gas Company, primarily in search of gas, one or two of which had a showing of oil. One, finished in April, 1903, on the Farley lease, northwest quarter of section 4, struck Trenton at 1,015 feet and developed an oil pay with a good showing at 1,035 feet. This continued for 23 feet, when a strong vein of salt water was encountered which filled the bore to within 100 feet of the surface. There being no gas for fuel and coal having to be hauled 8 miles from the nearest railway station, the well was never pumped. Another bore two miles farther north came in dry. A quarter of a mile west of the big gas well at Somerset a big salt water well was drilled in section 33, Waltz township, the vein of water being struck at 80 feet in Trenton. A bore which showed a trace of oil was also finished on the Garst lease in section 28, while dry holes were opened on the southeast of 23, and on the Hawkins farm in 25. Near Treaty, on the Big Four Railway, in Liberty township, three small producing wells have been opened, but no data is available as to their output or record.

IN MIAMI COUNTY.

The Peru oil field which created such a furor when opened in 1897, is practically a thing of the past. It was, in the main, a "town lot" development and the derricks on Flax Hill in places stood so thick that, in some instances, they had only a board fence between them. Thirty or more companies were drilling at one time within the city limits and a number of them finished as many as five wells and never sold a tank of oil. The rock was very porous and some of the wells were big producers, but so many on so small an area soon drained the reservoir. Of the 356 which were sunk, less than 30 are still in operation and the production has dropped from 50,000 barrels a month to less than 2,500. The best well in the pool, that on the Artis lot, started at 400 barrels a day and is still making 20 barrels. But two or three of the quarter million of dollars was sunk by the unsuccessful ones. For a time the boom added much to the prosperity of Peru, as that sum was mainly put in circulation among its inhabitants.

A new pool was opened up in Erie township, three miles east of Peru, in 1898, which for a time had a vigorous growth, but its limits were soon defined and no new territory in that vicinity has recently been found. No bores were sunk in Peru, and but two in Erie township in 1903; both being on the Butts lease, where the majority of the best wells had previously been found. One developed a dry hole and the other came in as a five-barrel producer. The combined output of the Peru-Erie township-Rich Valley fields, in 1903, was but 63,838 barrels, distributed among the months as follows:

PRODUCTION OF THE PERU-RICH VALLEY TRENTON ROCK OIL FIELDS BY MONTHS FOR 1903.

January	4,790
February	4,874
March	5,456
April	4,556
May	4,695
June	6,526
July	5,904
August	5,855
September	6,117
October	5,511
November	5,823
December	3,731
Total	63,838

In Allen County.

It was thought for a time that quite a pool of productive territory would be opened up near New Haven, Adams township, Allen County, but the results have not realized the expectations. A well drilled on the John Hartzell farm, northeast quarter of section 14 in 1899 made a fair showing of oil, but a second bore resulted in a dry hole. In February, 1903, a third bore was finished about 100 feet from No. 1, and came in as an 8-barrel producer, its record showing:

Drive pipe	96 feet
Casing	700 feet

Quite a quantity of salt water was pumped with the oil. Two bores were drilled on the Mull lease adjoining that of Hartzell, one of which came in dry while the other started at three barrels. A dry hole was also finished on the Roullo farm in the same neighborhood, and another on the G. Doctor lease in section 33, which stopped further drilling in the township. A pipe line was laid from the two producers to New Haven, and 1,072 barrels of oil shipped from them during the year.

A test bore on the Dickason farm, section 3, Monroe township (29 N., 15 E.) in the southeast corner of Allen County, was drilled in October and came in with a large showing of oil and a big supply of gas. By accident the latter caught fire just before the drilling was completed and destroyed the derrick and burned to death the tool dresser. The tools were lost in the bore and at last accounts had not been recovered. One or two other very light wells had previously been completed in the vicinity. A mile west of Baldwin, in section 33, Jackson township, Allen County, a test bore was finished in October, which started at at about 18 barrels. The top of Trenton was reached at 1,402 feet. Still another bore, completed on the Amspaugh farm, section 3, Jackson township, is said to have started with an output of 12 barrels per day.

In Hamilton County.

The only producing territory in this county is in Fall Creek township, in the southeast corner, near Fisher's Station, where several producing wells were sunk in 1900 and 1901. A number of dry holes have since been put down around them, four of which were drilled in 1903. The output of the producers for the entire year was 5,294 barrels. The pool is, as yet, a small one, and at present the chances of its increase in size seem remote.

In Marion County.

The output of the Broad Ripple field in Washington township, Marion County, has been gradually decreasing for several years. No new bores were sunk in 1903, while three or four of the former producers were abandoned. The production of the

OUTPUT OF THE BROAD RIPPLE, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1903.

	Barrels.
January	491
February	486
March	357
April	1,135
May	1,059
June	799
July	534
August	727
September	559
October	668
November	724
December	587
Total	8,126

COST OF A PRODUCING WELL IN THE MAIN INDIANA OIL FIELD IN 1903.—On account of the increase in the price of lumber and iron tubing and piping, the cost of a producing well in the Trenton rock field of Indiana has slightly increased in recent years. A careful estimate of the average cost of drilling and fitting up the first productive well on a lease was made in both the Marion and Parker-Selma portions of the field in October, 1903. These estimates resulted as follows:

	Marion.	Parker-Selma.
Rig or derrick	$420	$425
Drilling	625	560
Drive pipe	160	120
Casing	165	110
Shooting	125	140
Tubing and pumping outfit	225	205
Power house and power	500	500
Two tanks	180	170
Belting and lead lines	125	125
Incidentals	100	100
Total	$2,625	$2,455

In the above estimate the price of drilling is put at 50 cents a foot plus the cost of fuel, which is extra and averages about $50 per well; that of 8-inch drive pipe at $1.05 in the Marion field and $1.10 in the Parker-Selma; 5⅝ casing at 37 cents in Marion and 32 cents in Parker-Selma; tubing at 15½ cents; sucker rods at 4½ cents in Marion and 3 cents in Parker-Selma; pumping jack, $12, and shooting at 70 cents a quart; these being the ruling prices in the two fields. The incidentals include the cost of necessary teaming and the expenses (livery hire, board, etc.) of the operator or field manager while overseeing the work. The second well on the lease will cost about $1,200 less, as the rig, tanks, power house and power can be used for both wells, though there will be a loss of $125 in tearing down and rebuilding the derrick. It is not customary to build a power house until three or four producing wells have been finished on the lease, but if not built, an engine and boiler for pumping must be purchased for each productive well, which will cost $325 to $450. With the advanced methods of pumping by which oscillating pull wheels, rods, etc., are used, 20 or more wells can be connected to one power, and the cost of production be thereby greatly decreased.

No two wells in the field cost the same. One reason for this is that the length of drive pipe necessary is so variable, ranging from 25 to 450 feet. The number of feet of casing necessary also varies greatly in different parts of the field. In the Jay County field, the average well on a 10-well lease costs about $1,500, while in Grant and Huntington counties it runs about $1,750. Some operators use but one or two derricks on such a lease, putting in their stead, as fast as removed from a newly drilled productive well, a set of "derrick poles," costing from $10 to $15. Others leave the derrick over each well. These are often blown down or burned, thus causing a loss of $300 to $400. In many portions of the field an extra charge of 25 cents a foot is made by the driller for all drive pipe above 100 feet; and often also an extra charge of 25 to 50 cents for every foot over 50 feet into Trenton rock. The cost of the lead lines and surface rods on a lease will increase proportionally to the number of producing wells. In 1903 the price of a 2-inch lead line pipe was 13 cents, and of 3-inch, 24 cents a foot in the Indiana field; while that of surface rods was 4¼ cents per foot.

It has been claimed by promoters of Kansas oil properties that the cost of drilling in the Kansas field is much less than in Indiana, but the figures given out by the "Kansas Derrick" do not bear out this statement. According to that paper "The average depth of the Kansas well is 850 feet, and drilling costs 85 cents a foot. The actual expense of completing and fitting up a producing well is about as follows:

850 feet drilling at 85 cents	$722 50
40 feet 8¼-inch casing at 63 cents	25 20
300 feet 6¼-inch casing at 51½ cents	154 50
700 feet 5-inch casing at 38½ cents	269 50
Shooting well	45 00
Tubing, 850 feet at 14 cents	119 00
Pumping outfit for walking beam	22 00
Sucker rods, 850 feet at 4¼ cents	38 25
250-barrel tank, set up	160 00
Teaming	45 00
Total	$1,625 95

"The above figures are made up from actual basis on which material is purchased by the operators, and are sufficiently conservative, and to them should be added the expense of the party having the operations in charge. If a field manager, his salary and expenses must be taken into consideration, or if the party owning the lease is looking after the work, his board at $2.00 a day, buggy hire for getting to the property and other incidental expenses will foot up quite a considerable sum, not less than $50, and before the well can be put in service with other wells on the lease, if a pumping plant is installed, the cost of connecting up with the power must be considered, and also the proportionate cost of the pumping plant on the basis of the number of wells it is required to pump. As the wells are drilled almost entirely by machines, the expense of a derrick, which runs from $300 to $450 in the Eastern oil fields, is not included."

The above estimate does not include the cost of a power house, which has been added to the cost of an Indiana well, and includes the cost of but one tank, where two are absolutely necessary unless the pumping be stopped until the one tank can be emptied when it is full. Neither does it include the cost of lead lines and surface rods which is comprised in the Indiana estimate. If we add, therefore, to the estimate of the Derrick, $500 for power house, $160 for second tank (the price quoted by the Derrick); $125 for lead lines, etc., and $60 more for incidentals, we have a total of $2,470, which is equal to, if not greater than the cost of the first Indiana well. It is far wiser for those who are trying to induce capital to locate in any oil field, to give figures which can be relied upon, rather than to try to convince people that the work can be done for one-half or two-thirds of the necessary outlay.

Cost of Operating a Lease.—The cost of operating an oil lease after the production has been established need not be more than $100 per month, the salary of the pumper being $60, and the cost of fuel about $40. A dozen, or even 20 wells can, however, be operated almost as cheaply as one after they have been connected with the power. An extra pumper may have to be employed, but otherwise no additional expense is entailed.

Where the plant has been established, it will pay to pump as low as two or three wells, even if the yield is only two barrels each per day, provided the price of oil is as high as it was throughout the year 1903.

The estimate of expense and income from three two-barrel wells, after deducting the royalty of one-sixth, is as follows:

Income per month—		
150 barrels of oil at $1.15 (average price in 1903)		$172 50
Salary of pumper	$60 00	
Cost of fuel	40 00	
		100 00
Net income per month		$72 50

With six two-barrel wells on the lease, the income would be $345, and the expense $100, a net gain of $245 per month.

From what has been written it will be seen that the cost of drilling and operating a lease in the Indiana Trenton rock field is as low or lower than elsewhere in the eastern United States for the following reasons: *(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 as yet available in many parts of the field, and if not present, coal is as cheap as in any other locality. *(e)* Transportation facilities are excellent, a system of pipe lines permeating all parts of the main field.

According to some of the leading operators, it costs 60 cents a barrel to produce oil on the average lease in the main Indiana field. Whatever is received above that sum is net profit. If the lease is small the cost is much greater in proportion. Oil at $1.00 or more per barrel, therefore, brings a good price and a fair profit.

Whatever the price, the profits will depend largely upon the way the property is managed. Success as an oil operator depends upon the same watchful energy as brings success in any other business. One's pumps should be kept steadily at work so as to get all the oil possible. The drilling tools, lead pipes and pumping machinery should be kept in good repair; especially in late autumn should they be thoroughly overhauled and put in prime condition for the winter months. If the lead lines are left above ground or are but shallowly buried, they often freeze and burst. A poorly managed lease is liable to be tied up for a month or more on this account; while a neighboring lease which has everything in good shape for the winter produces nearly its normal output of oil.

To properly and profitably develop a lease the wells in average territory should be put down at intervals of 720x680 feet, which will bring eight wells on each 80-acre tract. In exceptionally good territory 10 bores can, with profit, be sunk on 80 acres, bringing them 551 feet apart each way. Above all, one should be on the look-out for overflow and leakage. Much of what would otherwise be profit in oil property is allowed to go to waste. Finally, if the property is inside the limits of productive territory, the successful oil man is he who lets other people do the wildcatting, and who follows where they lead.

Necessity of Good Roads in Oil Territory.—Good roads are necessary to the opening up and thorough development of any productive oil territory, and the sooner the farmer finds this out, the greater will be the income which he will derive from his royalty. The iron pipe, tubing and derrick timbers are all of heavy weight, and if the lease is some distance from a railway and the roads leading to it are of mud, as they are apt to be for four or five months if not graveled or macadamized, operations on the lease will necessarily be suspended for that length of time. Many a farm inside of productive territory in Indiana has not been drilled because the operator has noted that the roads leading to it would compel him to suspend developments from

November to April. He can not afford to be idle five-twelfths of his time, and so operates those leases along pikes over which he can haul his necessary supplies. The farmers living in the oil belt, who are receiving or might receive large sums in royalty for their oil, should, therefore, see to it that their farms are accessible at all times.

Some Big Indiana Oil Deals in 1903.—The gradual rise in the price of Indiana Trenton Rock Oil from 43 cents per barrel in 1897 to $1.31 in 1903 has led to a corresponding increase in the price per barrel paid for settled production on leases which have been partly developed. In 1897 a company which had a lease of 160 or more acres with three or more fair wells on it could get only about $300 per barrel, daily settled production, for the property. In 1903 a thousand dollars per barrel, average daily production, was not an unusual price. More money has been made by many Indiana operators in thus partially developing and selling their leases to the larger companies than in any other way. In such a transaction the lease, which costs little or nothing in the beginning, but which has been proven productive by the test bores sunk on various parts of it, is counted the most valuable part of the property. It bears the same relation to the latter that a long term franchise bears to the assets of a street railway or other corporation.

Several noteworthy oil deals were made during the year 1903. In February the Senior Oil Company, of Bluffton, Indiana, sold its holdings in Randolph County, consisting of 1,224 acres of leases and five producing wells, for $225,000. The new owners, being Missouri capitalists, adopted the name "The St. Louis Oil Company," and immediately started in to spend $100,000 in the development of their property. The latter included the famous Cecil lease near Parker City, on which some of the biggest wells of the season were finished. Starting in with a daily production of only 260 barrels, by the end of the year they had 28 producing wells on the leases and an output of 1,100 barrels daily.

In the fore part of the year the Superior Oil Company sold its holdings in Grant and Huntington counties, consisting of 900 acres of leases and about 40 producing wells, for $120,000.

About the same time the Barnes Oil and Gas Company, of Marion, sold to some St. Louis parties 648 acres of leases, mostly in Grant County, and 15 producing wells, with a daily output of 45 barrels, for $50,000.

On June 1st, the Phœnix Oil Company, of Hartford City, sold 6,000 acres of leases, mostly in Washington township, Blackford County; on which were 90 producing wells with a 250-barrel net daily production, for $300,000. The new company immediately drilled in 50 new wells, and by November 1st had an output of 500 barrels daily.

A fortnight later the Ohio (Standard) Oil Company purchased the property of the Central Oil Company, in Grant, Wells and Huntington counties, consisting of 1,700 acres of leases, 147 producing wells, and 400 barrels net daily production, for $280,000 cash.

One of the largest deals of the year which, however, was in part a pooling of holdings, was that of the American Window Glass Company to the Columbia Oil and Gas Company, of Pittsburg. This sale was consummated October 1st, and by it 40,000 acres of leases in Blackford, Grant, Delaware, Jay and Hancock counties were turned over to the new company. On the leases were 149 producing oil wells, having a net daily output of 600 barrels, besides numerous gas wells and other holdings. The price paid was $2,000,000, and it is said that another half million will be at once spent in improving the property and sinking new wells, 400 of which will be put down as rapidly as possible.

STATISTICS OF THE INDIANA TRENTON ROCK OIL FIELD FOR THE YEAR 1903.

The year 1903 maintained its record and set a new high water-mark in the history of the Indiana Petroleum Industry. The price of Indiana oil was above the dollar mark during the entire year, while from October 17th to the end of the year it sold for a higher figure than ever before. As a consequence, the operators were stimulated to use their best endeavors to increase the sunk was greater than in the preceding year, while the output far exceeded that for any previous year. Starting the year at $1.10 per barrel, it fell to $1.08 on January 21st, and the next day to $1.06, the minimum price of the season. On March 26th it was raised to $1.09 and on April 22d to $1.11. This price it held until May 16th, when it dropped to $1.09, at which figure it was sold until July 16th. Then a slow but steady increase in price set in until it reached a maximum of $1.33 on December 9th, which it held for 20 days. It then dropped to $1.31, the price at which it was selling on December 31st. The average price per barrel for the year, taking both time and amount received into consideration, was $1.14 as against 85.6c in 1902.

The total production of Trenton rock oil in 1903 was 9,161,331 barrels which, at the average price of $1.14 3-20, brought into the State $10,457,659. Compared with 1902, this was a gain of 1,625,770 barrels, or 21.6 per cent., as against a gain of 31.6 per cent. in 1902. However, on account of the high average price, the amount received by the producers was $4,007,219, or 62.1 per cent. more than in 1902.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the 13 years beginning January 1, 1891, and ending December 31, 1903. This does not include the amount used in the field for fuel and other purposes; or that wasted by the burning of tanks or the leaking of pipes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period:

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1904, BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
January	6,171	15,841	111,824	259,000	300,568	365,582	290,746	317,014	297,291	353,451	425,140	554,038	651,355
February	5,981	18,946	96,025	232,107	230,559	241,743	309,922	272,780	220,440	302,493	384,735	460,073	568,789
March...........	5,159	24,794	134,549	282,376	310,303	386,586	341,961	325,301	290,257	364,590	432,922	573,412	724,969
April............	4,973	26,184	146,493	287,330	352,077	395,032	328,779	310,034	325,774	381,804	447,261	579,711	680,921
May.............	5,757	31,033	186.939	321,502	397,001	417,963	340,023	311,208	344,831	426,363	482,118	635,752	751,348
June	8,136	40,888	209,616	333,479	403,569	434,167	369,803	320,477	334,282	446,492	481,807	633,452	809,438
July.............	10,809	49,203	221,666	327,349	434,376	422,968	375,249	314,861	329,086	437,087	506,065	696,911	831,005
August..........	11,603	56,109	248,353	345,031	420,132	407,238	371,921	332,777	347,621	466,127	523,106	697,040	838,615
September	16,500	66,034	245,615	319,588	409,169	415,675	362,528	326,264	332,283	418,716	519,087	672,611	857,117
October.........	19,029	95,699	252,568	339,424	393,153	394,283	408,179	319,490	326,781	467,521	532,960	725,973	873,160
November.......	20,801	129,270	245,607	304,030	373,789	337,331	430,958	300,644	326,802	406,684	510,788	656,457	778,323
December.......	21,715	144,067	236,038	337,450	361,436	362,164	423,069	300,457	332,266	441,347	479,485	650,131	796,291
Totals	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561	9.161.331

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1904, WITH VALUE.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Total production (barrels of 42 gallons).......	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561	9,161,331
Total value at wells of all oils produced, excluding pipeage	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411	$1,871,849	$2,228,276	$3,331,750	$4,740,731	$4,775,045	$6,450,440	$10,457,659
Value per barrel	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63	$0 43	$0 59 2/5	$0 87 1/2	$0 96 1/2	$0 83 2/5	$0 85 3/5	$1 14 3/20

From the first of the above tables it will be seen that the largest production of Trenton rock petroleum in Indiana in any one month was in October, 1903, when 873,160 barrels were brought to the surface. The total production of Indiana Trenton rock oil for the twelve years reached the enormous sum of 55,172,755 barrels, which sold for $42,757,834, or an average of $3,289,064 per year.

In the third table there is shown the number of wells completed in Indiana by months from June, 1891, to January, 1904.

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1904, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	......	......	......	......	......	......	6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897	41	35	40	47	49	52	60	45	55	89	119	54	686
1898	41	23	29	43	38	55	53	80	72	82	92	86	694
1899	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900	113	67	98	148	165	163	158	155	135	152	118	108	1,580
1901	111	72	81	121	167	171	167	169	184	207	220	132	1,802
1902	176	113	169	182	247	297	288	279	323	295	320	243	2,932
1903	168	178	233	236	331	408	377	387	337	366	375	290	3,686
Total....	......	......	......	......	......	......	......	......	......	......	......	......	16,975

From this table we learn that 754 more bores were sunk for oil in the Trenton rock fields of Indiana in 1903 than in any previous year. In 1902 the gain over 1901 was 1,130. The great majority of new bores were sunk in already proven territory by companies whose members were content to sink fair producing wells and develop what oil they could beneath their leases rather than seek far and wide for new territory which might produce a "gusher."

From the table it may also be learned that up to January of Indiana for oil alone. On that date there were 12,098 producing wells in the fields, as against 8,963 on January 1, 1903, a gain of 3,135 for the year. By subtraction it may be learned that of the total number of bores sunk for oil in the Trenton rock fields of the State, 4,877 have proven dry or have been abandoned as non-productive. The number abandoned in 1903 was 175, or 116 less than in 1902, while the number of dry holes drilled during the year was 376, or 66 less than in 1902. Of the total number of bores sunk in 1903, 10.2 per cent., or 4.9 per cent. less than in 1902, were dry.

On October 15, 1903, there were approximately 11,370 producing wells in the Trenton rock fields of the State. The production of oil for the entire month of October was 873,160 barrels, or an average of 2.48 barrels per well, for each day of the month. On December 15th there were 11,980 productive wells in the field. The output for the month of December was 796,291 barrels, or an average of 2.14 per well per day. The average output per well is always less during the winter months than during other seasons of the year. An average for the year would probably be about 2.35 barrels per well per day, a seemingly small amount yet totalling more than nine millions of barrels for the field for the year. These figures go to prove that the days of the gusher are practically over in the older portions of the main field where most of the bores were sunk. It is better for the practical producer that this is true. A well starting at 200 barrels or more a day creates an excitement and a rush for territory that, in the end, proves harmful to all concerned. Large bonuses are paid out and big risks taken which are foreign to territory whose wells are small but sure producers. As has been stated in my former reports, one large well will not make any man a fortune; twenty small ones may in time. The yield of the large producer will quickly grow much less; that of the twenty small ones will hold out for a long time. There is yet room for thousands of wells in the known productive territory. At present prices, eight to ten wells pumped by one power and yielding on an average but one and a half barrels each per day, will prove a paying investment.

The following table shows the number of producing wells,

wells drilled in each of the Trenton rock oil producing counties of Indiana in 1902 and 1903:

County.	Producing Wells, 1902.	Producing Wells, 1903.	Dry Holes, 1902.*	Dry Holes, 1903.*	Total Bores, 1902.	Total Bores, 1903.*	Percentage of Dry Holes, 1902.	Percentage of Dry Holes, 1903.	Average Initial Production of Productive Wells, 1902.	Average Initial Production of Productive Wells, 1903.
Adams	256	287	35	30	291	317	12.	9.4	23.	15.1
Allen	0	2	0	2	0	4	0.	50.	0.	25
Blackford	283	353	75	41	358	394	21.	10.4	15.7	11.1
Delaware	27	74	50	48	77	122	65.	39.3	15.8	20.7
Grant	942	1289	108	94	1050	1383	10.2	6.8	18 5	15 1
Hamilton	1	0	.....	7	1	7	.....	100.	12.	0.
Huntington	141	302	23	10	164	312	14.	3.2	22.	19.4
Jay	74	180	20	33	94	213	21.3	15.5	14.1	13.4
Madison	41	46	54	19	95	65	56.8	29.2	13.6	8.
Marion	2	0	0	0	2	0	0.	0.	3.	0.
Miami	3	1	4	1	7	2	57.1	50.	11.6	5.
Randolph	26	78	33	50	59	128	55.9	39.	23.1	43.
Wabash	2	3	0	1	2	4	0.	25.	7.5	3.
Wells	689	695	40	40	729	735	5.5	5.4	17.1	14.
Totals	2487	3310	442	376	2929	3686	†24.5	†27.3	†15.1	†14.2

*These columns include bores sunk for oil which yielded gas.
†Denotes average.

From the table it will be seen that the average initial production for the year in the entire field fell off slightly, being 14.2 barrels per well as against 15.1 barrels in 1902.

The older producing counties have by far the best average record for the year, Huntington leading them all with an average initial output of 19.4 barrels, while its percentage of dry holes was but 3.2. Grant and Adams tied in average initial production, but the former holds the better record in dry holes, yielding but 6.8 against 9.4 per cent. for Adams. Wells holds its own remarkably well and stands next to Huntington in its low percentage of dry holes, while its average initial output was but 1.1 barrels less per well than that of Grant and Adams. Randolph led them all in average initial output, but nearly tied with a careful study of the table one can learn many other facts regarding the relative importance of each county in the field.

CORNIFEROUS ROCK PETROLEUM.

The Corniferous formation is the lowest or oldest division of the Devonian system in Indiana, being represented in the State by sandstones with a maximum thickness of 20 feet, which are thought to correlate with the Schoharie group of New York, or by limestones 5 to 65 feet in thickness correlated with the Upper Helderberg. The waters in which the materials of the Corniferous limestone were deposited were clear and comparatively pure and in them sponges, corals, crinoids, trilobites and lower animal forms existed in great profusion. From the lime secreted by these marine forms the upper and purer beds of the Corniferous rock are mainly composed; and from the slow destructive distillation of the animals themselves a part of the oil contained in the formation was doubtless derived. The rocks of the Corniferous formation comprise the surface rocks of the State over a strip 5 to 40 miles in width, extending from the Ohio River at Jeffersonville north and northwestward to the vicinity of Logansport and Monticello. The outcrop of the eastern margin of the Corniferous passes through the following counties: Eastern Clark, Western Jefferson, Eastern Jennings, Central Decatur, Eastern Rush, Northeastern Hancock, Central Hamilton, Western Tipton, Southwestern Howard, Eastern Carroll and Eastern Cass. West of that margin the Corniferous is found either on the surface or underlying the later formations in all the counties. North of the Wabash River at Logansport, especially in Jasper and Laporte counties, the Corniferous has also been found in a number of deep bores sunk for oil, but on account of the thick mantle of overlying drift its exact limits are unknown.

Immediately above the Corniferous, west of its surface exposure, there is always found a thick bed of blackish or brownish shale, known as the Genesee or New Albany shale. This ranges in known thickness up to 195 feet and forms the necessary impervious cover which has retained the oil of the Corniferous in the parent rock. The Genesee shale is formed largely of the known as Rhizocarps which flourished in vast numbers during the time the materials afterward compressed into the shale were being deposited. The shale is rich in bitumens derived from the destructive distillation of the spores of these ancient Rhizocraps. When kindled it will burn until they are consumed, and it is, therefore, by the unitiated, often mistaken for coal. These bitumens are, by natural processes sometimes separated from the shale and in the form of gas or petroleum are collected in reservoirs in it or in the underlying Corniferous formation. Much of the oil now being obtained from the Corniferous rocks may thus have entered that formation from the overlying shale.

Petroleum in commercial quantities has been found in the Corniferous rocks of Indiana at Terre Haute, Vigo County, in the vicinity of Birdseye, Dubois County, and northwest of Medarysville, Jasper County. The territory opened up at each of these points is, however, limited in area, and the output, except at Terre Haute, small in quantity.

THE TERRE HAUTE POOL IN 1903.—No new bores have been sunk in Terre Haute in recent years. The famous Phœnix well on a lot near the center of the city, still remains the oldest and best oil well in the State. Finished in May, 1889, it has produced an average of more than 1,000 barrels a month for 15 years. Its output last year was 11,553 barrels, which was sold by the owners mostly to local consumers, though a quantity was shipped in tank cars owned by the operators. Four other wells at Terre Haute are yielding oil, but only one, that operated by A. B. MeWhinney, in any quantity. During the year it produced 2,113 barrels, an average of about six barrels a day; while the other three wells yielded a total of only 274 barrels during the year.

The total output of the Terre Haute wells by months during the year 1903, was as follows:

PRODUCTION OF CORNIFEROUS ROCK OIL AT TERRE HAUTE, INDIANA, BY MONTHS, FOR THE YEAR 1903.

	Barrels.
January	1,448
February	879
March	1,384
April	1,350
May	944
June	1,375

July	835
August	1,135
September	1,358
October	1,044
November	836
December	1,352
Total	13,940

There is little doubt but that a large quantity of oil occurs in the Corniferous rocks beneath the city of Terre Haute and vicinity, else the yield of the Phœnix well could not have been so uniform and long continued. The porous area or reservoir containing the oil must, however, be narrow, and this bore probably struck it at just the right point to get the best results. Some people who know little or nothing of the geology of Indiana believe that the Phœnix well struck a crevice which extends to the main oil field of the State. Such belief is of course preposterous, as the Corniferous rock which contains the oil at Terre Haute outcrops before the main oil field is reached, and is not pierced by any bore sunk in that field. Moreover, it is a younger and much thinner formation than the Trenton limestone, and for that reason there is little chance of developing an oil output near Terre Haute in any way comparing to that of the main Indiana field.

Developments in the Vicinity of Birdseye in 1902 and 1903.—During the autumn of 1902 and the spring and summer of 1903 a number of bores were sunk for oil in the vicinity of Birdseye, a town in the southeastern corner of Dubois County. In some of the bores quite a quantity of oil was developed in the Corniferous limestone, but the wells were sunk too far apart, one from another, to pump with profit. As a consequence the field, as yet, counts for but little in the petroleum industry of the State.

The first bore put down was on the Henry Eckert lease in the southwest quarter of section 24 (3 S., 3 W.), six miles south of Birdseye in Perry County. The Southern Oil Company of Evansville, Indiana, sunk this bore on account of supposed "surface indications" in the way of seepage, and scum of oil on nearby springs. It is also alleged that the late Prof. Edward Orton, of Ohio, had predicted that oil would be found in this region. The bore was finished in September, 1902, at a cost of $2,600, with the following record:

Drive pipe	40 feet
Casing	595 feet
Top of pay	1,010 feet
Total depth	1,030 feet

In a limestone between 300 and 400 feet below the surface there was a small showing of a light colored oil, which was also found in most of the bores afterward sunk in the vicinity. The well, when finished and shot with 160 quarts, was put to pumping and made 15 barrels of oil a day for two days and then slowly settled to 3 barrels at the end of two weeks. It was being pumped with the contractor's power, and as he wished to remove it to another location, the pumping was stopped and has not been renewed; the oil produced still being in the tanks in October, 1903.

The strike, like all others of any consequence in a new field, attracted much attention, and thousands of acres of leases were at once secured within a radius of 10 miles. A number of new bores were at once begun, the second well finished being on the Gerhard Gellhausen lease, a mile and a quarter southeast of the first, in the southeast quarter of section 26 (3 S., 3 W.). It came in as a salt water hole without a showing of oil and with the following record:

Drive pipe	10 feet
Casing	725 feet
Total depth	1,280 feet

The third bore, sunk by the original company, was on the C. Hartwick farm in the northeast quarter of the southwest quarter of 19 (3 S., 2 W.), about one-half mile east of No. 1 Eckert. It was finished in March, 1903, coming in, it is claimed, as a better producer than No. 1, its record being as follows:

Drive pipe	60 feet
Casing	600 feet
Total depth	1,040 feet

The roads in the vicinity being extremely bad, no tank was on the ground, so the contractor pumped the well for three hours into the nearby creek, and estimated its output at 60 barrels. However, the company, being new in the oil business, were looking for a "big well" of the gusher variety. They did not consider the new well good enough to put in a special power to pump, so, leaving the rig and pump, they started their No. 4 bore. This was in Dubois County, on the J. C. Kitterman lease in the northeast quarter of 36 (2 S., 3 W.), about one and a half miles southeast of Birdseye. Here a bore was started on the side of a bluff of Anderson Creek instead of on the level land of the valley of that stream; the theory of the field manager being that there was a crevice in the underlying rock of the valley which had caused the stream to follow its present bed. Wishing to avoid this supposed crevice, the well was located on an almost inaccessible spot, 50 feet above the level lowland. It was finished in May, 1903, and proved to be the best well at any time completed in the field, its record showing:

Drive pipe	92 feet
Casing	702 feet
First pay	981 feet
Total depth	1,000 feet

The oil pay streak was 19 feet thick; and when the first screw was finished the oil stood 400 feet in the bore. As the pay was very porous the well was shot with but 60 quarts. The shot caused the casing to collapse and it was six weeks before the well was cleaned and put to pumping. It then made 35 barrels the first day, 20 the second, 10 the third, and settled down to a 5-barrel producer at the end of three weeks. No pipe line or other means of transportation being present, the well was closed down ready for pumping and remains in that condition, the derrick, etc., still in place.

No. 5 bore of the Southern Oil Company was No. 2 on the Hartwick lease, located in the northwest of the northwest of 19 (3 S., 2 W.), one-third of a mile northwest of No. 1 Hartwick. At a depth of 995 feet the oil pay was found, but was only five feet thick. The oil rose 40 feet on the stem, but salt water soon developed and drowned it out. The well was not shot, and was abandoned after the casing was pulled.

A sixth bore was sunk by the Southern Company on the southeast quarter of section 23 (2 S., 3 W.), three-quarters of a mile northwest of Birdseye. It was completed in November, 1903, and came in as a small producer.

In addition to the six bores sunk by the Southern Oil Company, six others were put down by the Ohio (Standard) Oil Company, in the Birdseye field, as follows:

No. 1. On Mart. Eckert lease, southeast quarter of 15 (3 S., 3 W.), Dubois County, about five miles southwest of Birdseye. Top of pay at 1,015 feet. Came in as a 15-barrel well and pumped 36 hours.

No. 2. On Dixon lease, northeast quarter of 3 (4 S., 3 W.), Perry County, two and a half miles from Siberia postoffice. Drilled to a depth of 1,600 feet. No showing of oil.

No. 3. On Chanler & Brown lease, southwest quarter of section 3 (3 S., 3 W.), Dubois County, two and a half miles southwest of Birdseye. When completed started at 30 barrels, but dropped to nothing in a short time.

No. 4. On Bombolaski lease, northeast of 22 (3 S., 3 W.), 600 feet south of No. 1 Eckert. Dry hole.

No. 5. On Jackson lease, southwest quarter of section 12 (3 S., 3 W.), Dubois County. Came in as a good gas well but with very little showing of oil. On attempting to drill deeper, salt water came in with a rush and drowned out the gas.

No. 6. On the Kiser lease, south half of section 16 (2 S., 2 W.), Crawford County, about three miles northeast of Birdseye. Came in with fair showing but not enough to pay for pumping.

On October 14, 1903, five of the wells put down by the Ohio Oil Company had been abandoned, while the No. 1 Eckert was still standing, as finished, with a quantity of oil in the tank.

In addition to the 12 bores above mentioned, the Highland Investment Company of Chicago, put down another on the Marion Eckert farm, southwest of 14 (3 S., 3 W.), 500 feet east of the Ohio Company's No. 1 Eckert. This bore developed a fair showing of oil, and after shooting was pumped several days into the tank of the Ohio Company's well to the west.

From the above account it will be seen that of the 13 bores sunk to date in the Birdseye field, seven came in as light to fair producers, three as dry holes, one as a gas well and two with a small showing of oil. If the seven producers, or even three or four of them, had been put down close enough together to connect with one power, there is little doubt but that they would have produced a large quantity of oil. Being most of them several miles apart, and with no pipe line in the field, it would not pay to pump them with separate power. The Southern Oil Company should have drilled its second and third wells on the Eckert lease where its No. 1 was located, and its fifth and sixth wells on the Kitterman lease adjoining its No. 4. If the latter had been sunk 300 feet south, on the level bottom land of Anderson Creek, it would doubtless have been as good a producer, and a half dozen or more wells, if necessary, could have been connected up with it. It never pays, when one has a fair well completed, to go a mile or two away in search of a "gusher." As it is, $50,000 or more have been sunk by the three companies in the field, and not a dollar's worth of oil has been sold.

The pay streak in which the oil is found in the Birdseye field is a bluish gray limestone, coarsely crystalline in structure. Pieces from the Kitterman well contain a number of small globular cavities, partially filled with crystals of calcite. The oil bearing stratum is usually found 10 to 15 feet below the top of the bed of limestone in which it occurs. Immediately overlying the latter is a bed of soft, black to brown shale, 10 to 40 feet in thickness. There is no doubt but that the latter is the Genesee shale which, as above mentioned, overlies the Corniferous in the western two-thirds of the State. The limestone containing the pay streak differs in color and structure from the Trenton, and also effervesces more freely. It is without doubt the Corniferous limestone, the samples being identical in structure and color with the outcrops of Corniferous in Clark County.

The oil produced in the Birdseye field was examined for the Southern Oil Company by the chemist of the St. Louis Sampling and Testing works, who reported on it as follows:

COMPOSITION OF CRUDE OIL FROM BIRDSEYE, INDIANA.

"Light oils below 150° C.	17.4 per cent.
Illuminating oil between 150° and 300°	26.9 per cent.
Lubricating oil above 300° C.	42.2 per cent.
Residuum	13.3 per cent.
	100 per cent.

"Began to distill at about 45°C. Ceased to distill at about

"The analysis shows it to be a very good grade of petroleum for the manufacture of light oils (naphtha, gasoline, etc.), and illuminating oil. The percentage of light oils being 17.4 per cent. and of illuminating oil 26.9 per cent. and with the method now employed of destructive distillation or 'cracking' the percentage of illuminating oil would be largely increased to upwards of 60 per cent. but at the expense of much of the lubricating oil. The residuum amounting to 13.3 per cent. consists mainly of coke."

Bore at Taswell, Crawford County, Indiana.—During the winter and spring of 1903, the Highland Investment Company, of Chicago, sunk a bore in search of gas or oil near the eastern limits of the town of Taswell, eight miles east of Birdseye, on the Southern Railway. Since this bore was put down in hitherto untested territory, I include the following account of it which was kindly furnished me by Mr. A. L. Nestlerode of Chicago, the field manager of the company: "Beginning at a point 810 feet above sea level we used but 12 feet of drive pipe, when we struck a bed of sandstone, and from that point went through slate and sandstone alternately to a depth of 254 feet, where we struck a bed of Carboniferous rock nine feet thick. At a depth of 272 feet we struck a similar bed of the same thickness. We found no limestone until we arrived at a depth of 425 feet. From this point we had alternate layers of slate and limestone to a depth of 830 feet, where we struck another layer, 45 feet thick, of the Carboniferous rock. At a depth of 975 feet we cased the bore with $6\frac{1}{4}$-inch casing, but at 1,123 feet we struck a very heavy flow of salt water. We continued drilling, and at a depth of 1,300 feet put in a string of $5\frac{5}{8}$-inch casing just 1,300 feet in length, and had a dry hole from this point on. We expected to strike the Trenton rock somewhere about 1,325 feet, but at a depth of 1,310 feet we encountered what the drillers at Birdseye called 'shale' but which was black limestone with considerable pyrites of iron in it, and so hard that the drill had to be dressed at every screw. At a depth of 1,460 feet we struck what the Birdseye drillers called 'Trenton Rock.' It was the formation in which they found their oil, but we had only a very strong smell of oil, while a white substance looking like refined oil gathered on the surface of the water. [illegible]ntractor, who was a Trenton Rock driller of northern Indirock, but at a depth of 1,565 feet we struck an elegant brown shale. This continued to a depth of 1,690 feet where we encountered the actual Trenton rock and drilled into it 100 feet, or a total depth of 1,790 feet. In drilling through the Trenton rock we again encountered the refined looking oil and an odor that greatly excited us, for it smelled just as if each bailer full of the material was full of the real petroleum, but we got neither gas nor oil. We did not shoot the well, a fact which we now keenly regret."

It would appear from the above statement that the distance between the Corniferous and Trenton limestones at Taswell is but 230 feet. However, I saw no sample of drillings from the well, and hence can not vouch for the accuracy of the statement that the formation in which the drilling stopped was Trenton limestone.

BORE IN LANE TOWNSHIP, WARRICK COUNTY, INDIANA.—A bore was sunk in the spring of 1903 on the Riley Wilson lease, northeast quarter of section 8 (4 S., 7 W.), a mile and a quarter south of Scalesville, Warrick County; and 13 miles northeast of Boonville, the county seat. Its record was as follows:

Drive pipe	40 feet
Casing (6¼ in.)	980 feet
Casing (4¼ in.)	1,045 feet
Total depth	1,168 feet

The last drilling was in a white sandstone, which had been pierced 34 feet when a strong salt water vein was tapped which filled the bore. The diameter of the latter was too small at the beginning to admit of farther casing, hence the well was abandoned before reaching Trenton, and with no trace of a productive "sand." It is claimed that five veins of coal, varying in thickness from 4 to 11 feet, were encountered in the bore; one of them being a 7-foot vein of cannel coal.

THE JASPER COUNTY OIL FIELD IN 1903.—Since 1899 a number of shallow bores in Jasper County have been producing more or less petroleum. A full account of the history of this field was given in the report of this Department for 1900.

The oil is found in a limestone which, without doubt, is a continuation of the Corniferous limestone formation at present prothe limestone being easily recognized throughout a large area of southern Michigan and western Indiana, but being entirely absent in the eastern and central portions of the latter state. The formation is nearest the surface in the section of Indiana which has since developed into the Jasper County oil field, and is found in the most productive portions of this field at approximately 100 feet below the surface.

In eastern Jasper, western Pulaski and the counties to the northward, the New Albany or Genesee brown and black shales immediately underlie the drift and are encounterd in sinking wells for water. As already noted, these shales are rich in bitumens, both oily and gaseous. The Corniferous limestone or oil-bearing rock, underlying this shale in the productive area of Jasper County, is a hard gray limestone which, in a number of test wells which have been drilled through the formation, has been found to be approximately 40 feet in thickness. The upper 20 feet, however, constitutes the oil producing portion of the limestone, and in this 20 feet are found several bands or pay streaks of porous rock which enlarge into crevices with considerable regularity. These crevices are often lined with pyrites of iron and lime crystals. Crevices have been found in quite a number of the producing wells which were two or three feet in thickness. In case a well, while being drilled, encounters one of these crevices, it will often produce a considerable quantity of oil without a shot of nitroglycerine, but almost without exception it has been found desirable to place a torpedo of about 20 quarts in such a position in the formation as to cover 10 or 12 feet of rock, the result invariably being to greatly increase the well's production. One of the large glycerine companies has a magazine in this district and provides the Jasper County producer with the necessary explosive.

The usual formation encountered in drilling a Jasper County well is as follows: Drift, consisting of sand, clay and loam, 50 feet, under which is encountered a bed, 45 to 55 feet in thickness, of close-grained black shale which forms an impervious cover for the Corniferous limestone reservoir. This black shale or slate does not cave in drilling, it thus being necessary to use but a short length of drive pipe to shut off the drift formation. The operators use for this purpose 5⅝-inch casing, and by driving it a sufficient distance into the black shale shut off the surface water. With the usual form of portable drilling machine employed in the Jasper County district, an expert crew has completed a bore in the remarkably short time of 23 hours actual drilling time, it thus being evident that the cost of a well is a very small sum.

The oil obtained is unlike any other product found in the Ohio and Indiana oil districts, it being of a black or very dark green color and of a gravity which ranges from 17 to 21. Its thickness and low gravity is, without doubt, largely due to the shallow depth at which it is found, the more volatile portions having long since escaped through their overlying formations. The oil on examination is found to have a cold test of about 7 degrees F. and a fire test of over 400 degrees. It has a good viscosity test, and is universally used throughout the Jasper County district for lubricating purposes. It is associated with a strong sulphur water of which a large amount is usually encountered whenever a crevice is penetrated. There is usually but little gas found in the district except immediately upon the completion of a new well, when, for several days following, a considerable quantity of gas is often discharged.

An analysis of a sample of the Jasper County oil was made for Mr. E. T. Mudge, of Chicago, by Mariner & Hoskins of that city, who reported on it as follows:

"ANALYSIS OF CRUDE PETROLEUM FROM THE JASPER COUNTY, INDIANA, OIL FIELD.

Specific gravity	0.928 or 20.8° Beaume
Cold test	7° F.
Flashing point	410° F.
Fire test	437° F.
Sulphur	1.26 per cent.
Asphaltic matter	2.90 per cent.

"This oil contains no light oils, and it is not possible to fractionate it, except in a vacuum apparatus. It is, in fact, with the exception of a small amount of asphaltic matter, a desirable lubricating oil, and it is unusual to find less asphaltic matter, than that reported, in crude lubricating oils. It might be added, therefore, that this oil contains approximately 97 per cent. of lubricating oil." *M. & H.*

Statements from numerous engineers who have given the oil thorough tests as a lubricant all certify to its high standard for that purpose.

The Federal Oil and Asphaltum Company, of England—the Byrd Syndicate of my former report—on January 1st, 1904, had 302 completed wells in the Jasper County field. Of these they were pumping but 80, and were delivering about 125 barrels of oil per day to the Indiana Asphaltum Company, at Asphaltum, a station on a branch or spur of a railway which penetrates the main field. This station is 12 miles south of Kersey, a junction point on the I. I. I. Railway. At Asphaltum a refinery capable of utilizing 300 barrels daily of the crude oil was completed in September, 1903. Lubricating oil and asphalt are the only two products of the refinery. Several grades of the lubricating oil are made. The residue or asphaltum has a high melting point and it is sold mainly for roofing purposes. The oil is first pumped from the producing wells into central tanks and then run to the refinery. In the winter season it has to be hauled in tank wagons on account of its viscosity. About 6,200 barrels were in stock when the refinery was completed, this being very nearly the total production of the field up to that date. The Indiana Asphaltum Company was paying $1.10 per barrel in the open market on January 1st, 1904, but their contract price with the English company was for a less sum.

The Jasper County oil is all produced in a small area in Gillam township, the wells of the Federal company being mainly located on the south half of section 29; the southeast quarter of section 32 and all of section 33 (31 N., 5 W.). Aside from this area, E. T. Mudge had 46 wells, 12 of which were pumping, in section 28 of the same township. The average output per well in the summer season is about 1½ barrels. The best well in the field is said to be No. 6 Gifford, which averaged, when pumped, six barrels per day for nearly three years. The Asphaltum company secured 2,050 barrels of stored oil, the output of this well to September, 1903.

There is probably no oil field in the world in which the expense of development is as low as in the Jasper County district. The oil formation lies at an extremely shallow depth, and the area which has been found to be petroliferous seems to be fairly uniform in character, resulting in few wells which are non-productive.

HURON SANDSTONE PETROLEUM.

Within recent years petroleum has been found in commercial quantities in a sandstone in southwestern Indiana. From the record of the bores and the appearance and structure of the oil-bearing rock, the latter is probably one of the sandstones of the Huron Group.* This formation or group comprises the uppermost or latest rocks laid down during the Lower (Sub) Carboniferous period. It is composed of three beds of limestone with two intervening beds of sandstone, their combined thickness reaching a total of 150 feet. The Huron comprises the surface rock over a strip 2 to 15 miles in width, which covers a part of eight counties in southwestern Indiana, as follows: Western Crawford, eastern Perry, central and northwestern Orange, eastern Martin, western Lawrence, eastern Greene, western Monroe and central Owen. Immediately overlying the Huron to the west is the Mansfield sandstone or "Millstone Grit," a massive sandstone, ranging up to 150 feet in thickness, which is the basal formation of the Carboniferous rocks of the State.

A typical section of the Huron group, exposed near Foote's Spring, Orange County, southwest quarter of section 11, (1 N., 2 W.), obtained by Mr. Kindle for the Twentieth report of this Department, was as follows:

Slope with Mansfield sandstone fragments	18 feet
Upper Huron limestone	15 feet
Upper Huron sandstone	35 feet
Middle Huron limestone	16 feet
Lower Huron sandstone	30 feet
Lower Huron limestone	6 feet

Of the sandstones of this group, which comprise the formation yielding the oil, Mr. Kindle says: "These beds, which are separated by the Middle Huron limestone, vary widely in thickness and in lithological characters. They are composed of strata of sandstone of medium coarseness, buff to light gray or white in color. In many places, iron in the form of limonite concretions occurs in the massive sandstone. Thin seams of coal, three to six inches in thickness, are found in them at some localities. Beds of shale, sometimes in part replace the sandstones."

*For a full discussion of this group see the 27th Ann. Rept. of this Dept., pp. 71 et seq.

Oil in commercial quantities has been found in the Huron sandstone near Loogootee, Martin County, and near Princeton, Gibson County.

The Loogootee Petroleum Field.—In 1899 and 1900, 26 bores were sunk to one of the Huron sandstones near Loogootee, in search of gas or oil. Of these, 3 produced oil, 10 gas, the remaining 13 being dry. The results showed that in that region the productive stratum of sandstone is not to be relied upon. It does not appear to be continuous, but is in pockets. It varies much in thickness and also in closeness of texture, in some places being soft, quite porous and productive; in others hard, close-grained and barren. In an account of the Loogootee field, written in the spring of 1901, I gave it as my opinion that, on account of its pockety nature and thinness the supply of oil from any given area of the productive sandstone near Loogootee will never equal that from any similar area of the main Trenton limestone field of northeastern Indiana. Subsequent operations have borne out this opinion. Two producing bores, sunk in 1901, started at seven barrels each, while one in 1902 was dry. The records of the producing wells in the vicinity of Loogootee showed:

Drive pipe	15 to 20 feet
Casing	480 feet
Top of oil sand	473 to 524 feet
Total depth	485 to 543 feet

The pay streak in which the oil occurs is a fine to coarse-grained drab colored sandstone, varying in thickness from 3 to 14 feet. A number of the wells are still yielding a large amount of gas, while several wells, formerly gas producing, now have a small output of oil. In November, 1903, nine wells were being pumped in the Loogootee field, the total daily output being but six barrels. Three of the wells were on the Cannon farm, northwest quarter of section 30, Perry township, three-quarters of a mile southeast of Loogootee; the other six on the Larkin lease, southwest quarter of section 19, a half mile southeast of the town. The total output of the wells for the year 1903, according to figures furnished by the Indiana Pipe Line Company, was 1,459 barrels.

The Princeton Petroleum Field in 1903.—For a number of years it has been thought that petroleum existed in commercial quantities in the vicinity of Princeton, the county seat of Gibson

County. Small deposits of asphaltum encountered in several places in a deep coal mine operated near that city led to the belief that the more volatile petroleum would eventually be found. Finally, in 1901, the Interstate Gas & Oil Company was organized and began the sinking of a deep bore on the Brownlee farm, southeast corner of section 1 (2 S., 11 W.), one-half mile north of the corporate limits of Princeton. It was first intended to drill to the Trenton limestone, but the surface opening was too small and the caves in the shales passed through too numerous to permit the reaching of that limestone. The drill passed through alternating layers of shale, coal, fire-clay, limestone, etc., and after reaching a depth of 1,453 feet the bore was abandoned, mainly on account of a bad cave in the shale. A deposit of asphaltum, said to be six feet in thickness, was struck at a depth of 450 feet and fair showings of oil at 850 and 995 feet.

After the abandonment of the well a new company, styled the "Hoosier Prospecting Company" was organized, mainly for the purpose of developing the deposit of asphaltum, which it was thought was of sufficient size to be valuable. Leases on 700 acres of land just west of Princeton were obtained and a bore started which developed into the first productive oil well in the Princeton field. It was located on the southeast quarter of section 2 (2 S., 11 W.), one and a half miles west of Princeton, and finished May 25, 1903. The strata passed through were alternating layers of sandstone, limestone, shale and coal, varying in thickness from 1 to 134 feet. All belonged to the Upper Carboniferous series of rocks. Five veins of coal were pierced, one of which, nine feet in thickness, was struck at a depth of 785 feet. The depth of the well to the top of the oil bearing sandstone was 871 feet. The record of the bore, in the vernacular of the oil man, was:

Drive pipe	60 feet
Casing	802 feet
Oil pay	871 feet
Total depth	907 feet

When finished, the oil rose nearly to the top of the bore, but the well was not put to pumping for several months.

A second bore was soon begun on the same lease, 800 feet northeast of No. 1, but was not completed until August. Its record showed:

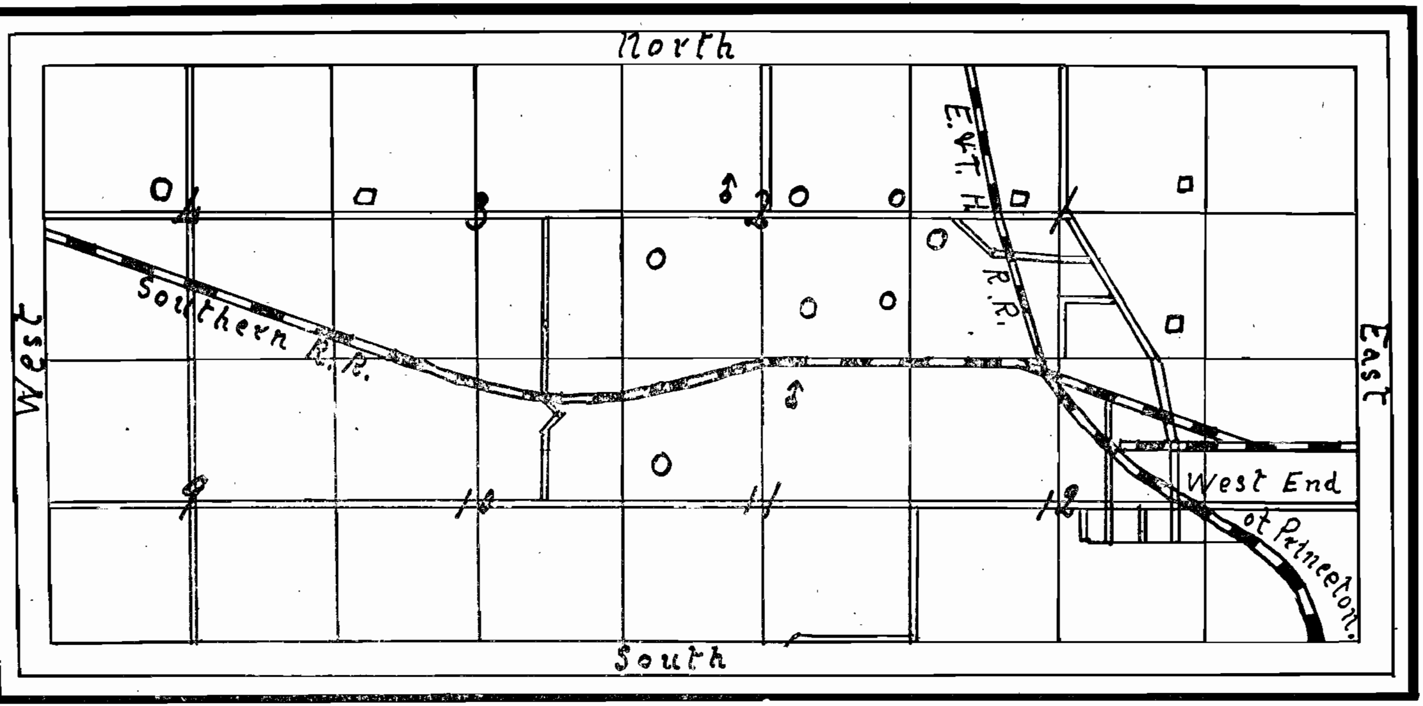
Drive pipe (10-in.)	40 feet
Casing (8-in.)	60 feet
Casing (6¼-in.)	584 feet
Casing (4⅞-in.)	804 feet

The shale immediately overlying the oil pay in No. 1 was continuous, and 62 feet in thickness, but in No. 2 there were two strata of nonproductive sandstone in this shale before the oil pay was reached. One 10 feet in thickness was found 20 feet in the shale. The second, five feet thick, was 35 feet below the top of shale. The third layer of sandstone had the upper 12 feet barren, but the lower six feet proved to be quite rich in oil. Quite a quantity of gas was also present and sprayed the oil above the top of the derrick. A light shot was used, and the production started at 25 barrels per day. The well flowed naturally for some time and was put to pumping about September 15. On October 13 the two wells on the lease were producing about 9 barrels of oil a day.

The bringing in of a second productive well was heralded far and wide, and caused an influx of oil operators from every direction. The country was scoured for leases, and by the middle of October 16 companies had been organized and a half dozen derricks were up. The third well completed was on the Woods lease, northwest corner of the southwest quarter of section 1. It produced quite a quantity of gas and about eight barrels of oil.

Before the end of the year the Ohio (Standard) Oil Company had completed two bores on the Mumford, south half of the northeast quarter of 2, one of which started at 25 barrels, but settled to eight in about ten days. In it the top of the oil-producing sand was found at 913 feet, and the oil between 918 and 930 feet. There was 47 feet of this first sand stratum, the lower portion of which was barren. Then followed a layer of shale, eight feet in thickness, below which was another layer of sandstone, 48 feet thick. At a depth of 1,088 feet a strong vein of salt water was encountered and the drilling stopped. No. 2 well, a quarter of a mile west, was a light producer, starting at about ten barrels.

A bore on the Downey lease in the southeast corner of the northwest quarter of section 2 produced quite a quantity of gas, but was practically barren of oil. A dry hole was drilled just east of the cemetery north of Princeton, in the northeast quarter of



The Princeton Oil Field on Jan. 1st 1904.

O=Productive Oil Wells. ◻=Dry Holes. ♁=Gas Wells.

section 1, and another on the Howe lease, close to the E. & T. H. Railway, in the northwest quarter of the same section. Of two bores just south of the Southern Railway, in the north half of section 11, one on the Emerson farm resulted in a small producer, while the other, on the Woodham lease, yielded a quantity of gas.

The best well in the field, up to January 1, 1904, was No. 1 on the Geiser lease, northwest quarter of the southwest quarter of 2. When shot it flowed 75 barrels for a day or two, but soon settled down to a 20-barrel producer. Its record showed:

Drive pipe (10-in.)	60 feet
Casing (8-in.)	80 feet
Casing (6¼-in.)	600 feet
Casing (4⅝-in.)	800 feet
Top of oil sand	908 feet
Total depth	978 feet

A bore on the Kelch lease in section 27, White River township, five miles northwest of Princeton, came in dry. A light well was finished on the Blair farm on the southeast corner of the northwest quarter of section 4, and a dry hole on the Mauch lease in the southwest corner of the northwest quarter of section 3 (2 S., 11 W.). An important test bore put down on the Rogers lease, northeast quarter of section 27 (1 S., 12 W.), nine miles west of Princeton, produced only a small amount of gas. From the above it will be seen that operations to the close of the year 1903, resulted in eight producing wells, six dry holes and two gas wells. About a dozen rigs were up for new wells in various parts of the territory on January 1, 1904, and the field will doubtless be thoroughly tested before the close of that year.

The oil of the Princeton field is found in a bluish gray sharp-grained sandstone, which is doubtless one of the Huron sandstones immediately underlying the Mansfield sandstone or Millstone grit. The formation is the same as that in which the Loogootee oil occurs, 45 miles to the northeast. At Loogootee the top of the oil-bearing stratum is found at an average depth of about 500 feet below the surface, while at Princeton the average is approximately 890 feet, showing a dip of nearly nine feet to the mile between the two points. The records of the wells in the vicinity of Princeton show a local dip in the oil-bearing sandstone of a little more than five feet to the mile to the southwest. The later wells sunk in the Princeton field have found the best productive portion of the sandstone 25 to 40 feet below the top. Much trouble is experienced with the numerous shales passed through, as all of them are soft and friable and very likely to cave. For this reason most of the wells have to be cased nearly to the top of the productive sand.

The oil found in the Princeton field is darker and thicker than that yielded by the Trenton rock. It registers 31° Beaumé and its percentage of illuminants is low; the quality being such that the price was reduced from $1.31 to 96 cents per barrel about January 1, 1904. The Indiana Pipe Line Company has built a loading rack for tank cars and an 800-barrel storage tank on the Miller lease, west of Princeton. From this point lead pipes are put down to the producing wells as fast as finished. During the month of December, 1903, 992 barrels were shipped from the field.

While the area of productive territory about Princeton will doubtless be found to cover a number of square miles, the output of the field will never, in my opinion, be very large. The oil-producing sand is too thin and pockety to yield many big wells, and the output of those completed will rapidly diminish. The history of the field will, in all likelihood, be a repetition of that at Loogootee, where the conditions confronting the operator were practically the same.

* * *

Adding to the output of the Trenton rock petroleum fields, that produced by the Corniferous limestone at Terre Haute, and by the Huron sandstone at Loogootee and Princeton, we find the value and total production of petroleum in Indiana in 1903 to be as follows:

	Barrels.	*Value.*
Trenton rock oil	9,161,331	$10,457,659
Corniferous rock oil	13,940	15,913
Huron rock oil	2,451	2,797
Total	9,177,722	$10,476,369

As one travels through the oil district of the State a sense of the greatness of the industry grows rapidly upon him. One might finds a vast system of pumps, tubes and pipes drawing a stored liquid from the depths of the earth, and transporting it hundreds of miles to distant refineries, there to be separated into parts, each of which serves as a basis for articles of manifold kinds for the use of man. Depending upon this industry are several thousand men—rig-builders, drillers, tool dressers, pumpers, pipemen, gaugers, etc.; each class performing a special duty and all working in harmony for the advancement of the common industry. Yet the resource itself is seldom seen, except where it overflows in waste, even by the army of workmen who are engaged in its production.

In a study of such resources as coal, clay, building stone, etc., one can see the strata *in situ,* note their arrangement, measure their thickness and study in detail their relation to their surroundings; but in an area covered so deeply with drift as is the main oil field of Indiana, and where the resource in question is contained in a rock formation nowhere exposed to view within the State, the difficulties in the way of a proper presentation of the subject are many. The records of the formations passed through by the bores had to be obtained from drillers and operators, many of whom had little geological knowledge. Moreover, their records were scanty in detail, noting, as we have seen, little else than the number of feet of drive pipe and casing used, the depth at which the Trenton rock was found and the total depth of the bore. However, I found them at all times willing to place at my disposal such knowledge and records as they possessed, and to them I am indebted for such records as are included in the report.

To James McCormick, of Hartford City; Alex. McDonnell, of Montpelier; Albert Stevens, E. F. Aldrich and Geo. E. Scott, of Muncie; Chas. A. McLain, of Parker City; L. C. Davenport, W. H. Mandeville, C. M. Miller and W. A. Kunkle, of Bluffton; Benj. Fulton, of Portland; Ja's. E. Hardison, of Geneva; B. A. Kinney, L. A. Von Berin, Fred Foreman, J. R. Bennett, Joshua Strange and R. J. Heald, of Marion; L. H. Legler, of Evansville, and Harry Kurtz, of Princeton, I am under special obligations for services rendered, both in the field and since my return therefrom.

THE LIME INDUSTRY IN INDIANA.

By W. S. Blatchley.

Lime or quicklime has been manufactured and used in Indiana since the days of the pioneers. The first settlers with their rude log cabins, whose chimneys were formed of sticks and mud, of necessity did without it; but as soon as more substantial log and frame buildings with chimneys of stone or brick were erected, lime for mortar and plaster became necessary. At first rude kilns were constructed in each locality, where stone or marl could be readily secured, and in these lime was burned for neighborhood use. From these first crude stone or "ground-hog" kilns, erected on the side of a bluff or hill and operated by a single man, to the great plants of the present day, with their dozen or more large steel kilns and hundreds of workmen, is a notable advance—in keeping with a similar advance in other and kindred industries of the State. But little or nothing concerning the lime industry in Indiana has heretofore appeared in the reports of this Department. The present importance of that industry, due largely to the many and varied uses to which lime is now being put, is reason sufficient for the preparation of the present paper.

Calcium carbonate, or carbonate of lime, is one of the most abundant chemical compounds occurring in a natural state. Shells of oysters, clams, snails, and all other land and water mollusks are mainly composed of it, as are also those coral reefs which cover thousands of square miles of the ocean's floor. All the larger and purer beds of limestone which form a great portion of the surface or crust of the earth are also made up of carbonate of lime. They were formed of the framework and shells of mollusks, corals and other marine animals which existed in untold numbers in the seas, on whose floors or bottoms the sediment of the limestone was first deposited. Oölite, chalk, marble, travertine, tufa and calcareous marl are but names of other forms of carbonate of lime.

Calcium carbonate, when pure, is composed of one part of calcium (Ca) combined with one part of carbon (C) and three parts of oxygen (O_3), the chemical formula of the compound being $CaCO_3$. If this carbonate of lime be roasted or subjected to great heat it is split up into a gas and a new solid. $CaCO_3 = CO_2 + CaO$. The gas, carbon dioxide (CO_2), escapes and the solid, calcium oxide (CaO), is left behind as the unslacked lime or quicklime of commerce.

It is a common belief among masons, architects and others that the best lime is produced only from the purest carbonate of lime. Statements to that effect are also often found in text-books on chemistry. Experience has proven that such beliefs and statements are wholly erroneous. Some of the best lime in Indiana is made from stone containing a high percentage of magnesia. The Delphi and Huntington limes are burned from this magnesian limestone, analyses of which show the presence of 44 per cent. of magnesium carbonate as against 53 of calcium carbonate. When burned, the magnesium carbonate is reduced to magnesium oxide and the resulting lime is a mixture of magnesium and calcium oxides. These magnesium limes are preferred by many masons, as they claim that the mortar made from them is "cooler" and sets more slowly. Mortar made from pure lime is, in their language, too "hot" and "quick setting." It is also claimed that the magnesian limes have better cementing qualities.

Lime is a brittle, white, light gray or cream colored solid with a specific gravity of 2.3 to 3. It is one of the most infusible compounds known, withstanding the extreme heat of the oxyhydrogen blowpipe, but when exposed to it giving off a light of such exceeding brilliancy as to be almost unbearable to the eye. Lime has a very strong attraction or chemical affinity for water, uniting with it with such vigor as to generate great heat. This process is called slacking or slaking. When the freshly burned lime is exposed to the atmosphere for any length of time, this affinity for water causes it to absorb moisture, or "air-slack." It then crumbles into a white powder and loses much of its usefulness for certain purposes. A sample left in this office for a week and then analyzed was found to contain 8.5 per cent. of moisture which it had absorbed in that time. On account of this attraction for the moisture of the air, lime is termed a perishable product, which should be used as soon as possible.

When water-slacked, pure lime swells very much and ultimately falls into a snow-white powder. Lime (CaO) + water (H_2O) = the calcium hydrate ($Ca(OH)_2$) of chemists; the latter being the white powder. If more water is then added, what is called the "milk of lime" is formed. This is composed of particles of calcium hydrate suspended in water. When this milk of lime is exposed to the air the extra water evaporates, and the calcium hydrate slowly absorbs carbon dioxide from the air and changes into calcium carbonate. Calcium hydrate ($Ca(OH)_2$) + carbon dioxide (CO_2) = calcium carbonate ($CaCO_3$) + water (H_2O).

Uses of Lime.

The most important use of lime is in the production of mortar and plaster. For that purpose it has been used by all modern and most ancient civilized nations. In the earliest masonry of which any remains have been found, as the Etruscan, that of the Island of Cyprus and ancient Troy, walls were laid up with large stones without mortar ("cyclopean" masonry), or with smaller ones packed in clay; but by the Egyptians, Hebrews, Greeks and Romans, the use of lime for mortar was universal.

In the preparation of mortar, sand is added according to the richness or "fatness" of the lime—that is, according to the fineness and uniformity of the powder into which the lime falls when water-slacked. Where the resulting powder is very fine it makes with the water a milk of lime or lime paste which will penetrate the minute spaces between the grains of sand, however closely they may be crowded. The thinner the film of paste between the grains of sand, the stronger their adhesion will be in the future. Hence the value of a lime is roughly measured by the quantity of sand it will serve to unite—the better the lime, the greater the quantity of sand which it will bind together to form mortar or plaster.

As the lime in the mortar gradually hardens by absorbing carbon dioxide from the air, it also unites with the sand to form calcium silicate or silicate of lime. This is one of the important constituents of hydraulic cement and by its formation the strength of the mortar is still farther increased. The latter often continues to absorb carbon dioxide and by its aid form calcium silicate for hundreds of thousands of years before being saturated. Hence the great tenacity of old mortar, that in the Egyptian pyramids being as hard as the stone it joins together. Chemical analyses clearly prove that in these old mortars the silicate of lime is much greater in quantity than in those more recently made.

The great increase in recent years in the number of brick and stone buildings, due largely to the disappearance of our forests and a consequent rapid advancement in the price of lumber, has led to a greatly increased demand for lime for mortar making. Probably 70 per cent. of that produced in Indiana is used for this purpose alone.

Whitewash, much used instead of paint as a surface covering for outbuildings and fences in the country, and also as a purifier and disinfectant, is simply "milk of lime" mixed with a little glue. Much lime is also used in making "bleaching powder" or chloride of lime. This is formed by passing chloride gas into leaden chambers containing slacked lime which absorbs the gas very rapidly. Chloride of lime is a dry white powder which smells faintly of chlorine and has a strong taste. It dissolves partially in water and the solution is much used for bleaching cotton goods.

Lime acts on the skin like a caustic alkali and is therefore used by tanners for removing hair from hides and by glue manufacturers in the making of glue from scraps of hides and hoofs. It is also necessary in the manufacture of caustic soda and caustic potash, and large quantities are used for this purpose. These caustic alkalies are much used in soap manufacture, so that the soap industry depends indirectly upon that of lime making.

Lime is also extensively used in glass making, and as a flux in smelting iron. It is customary, however, to use finely ground limestone for glass manufacture and chunks of pure limestone in blast furnaces. During the melting of the glass ingredients or the smelting of the iron ores the limestone gives up its carbon dioxide and is changed into quicklime, the latter serving as the fluxing agent in both cases.

Large quantities of lime are also used in paper manufacture, especially in strawboard works. Pure lime to the amount of 1,500 or more pounds, is first placed in a large rotary and steam turned in until it is thoroughly slacked. The hot slacked lime is then blown into another rotary containing the straw which it bleaches and aids in reducing to a pulp. In the making of paper from rags, milk of lime and water are added to a rotary boiler which is filled with rags. The boiler is then slowly revolved, steam being admitted under pressure. This cooking thoroughly softens the grease or any dirt remaining in the rags, at the same time rendering them more easily reduced to paper pulp.

The making of a "sand brick" from sand and lime has lately come into vogue and promises to cause a demand for quite a quantity of lime in the near future. Three large factories are already in operation in Indiana and several others will soon be erected. In the making of these brick from eight to twelve per cent. of unslacked lime is used. This is ground fine and mixed intimately with the proper amount of clean, pure sand, and the mixture is then put through a pressed brick machine. The brick as they issue from the machine are piled on iron cars and wheeled into large air-tight steel cylinders, which, when full, are closed and sealed. The brick are then subjected to a high steam pressure for 12 to 15 hours, when they are ready for the market. They are of a white or cream color, and are used the same as ordinary brick for building purposes. Some care must at first be taken in handling and laying them, but they soon harden and in time become more firm and solid than the ordinary kiln-burned clay brick. The reason for this gradual hardening is the same as for that of mortar, viz., the combining of the slacked lime with a portion of the silica of the sand to form a calcium silicate which, in time, binds or cements the particles of sand firmly together. Where the right kind of sand is plentiful and lime can be had for a reasonable price, sand brick can be made very cheaply, as there is a great saving in time and in the amount of fuel required for their manufacture.

Much lime is used either as a fertilizer for soils or as a means of improving the mechanical condition of soils. It can only be used as a fertilizer with profit where the soil is lacking in calcium, as that is the only element of plant food which lime contains. Most soils contain lime enough for practical use, as a lime content of one per cent. in a soil is always sufficient. When the amount falls below one per cent. the application of lime fertilizers is occasionally beneficial, and always so when only one-quarter to one-half per cent. of lime is present. When less than one-quarter of one per cent. of lime is found in the soil, liming is absolutely necessary. Caustic lime or quicklime is the most concentrated form of lime which can be applied as a fertilizer. The finer the state of division it is in when applied the quicker and more direct will be the benefits derived. The hydrated lime manufactured at Milltown, Indiana, especial mention of which will be made on a subsequent page, is for this reason extensively used as a top-dressing for soils.

The use of lime "as a means of improving the mechanical condition of soils" is a very important one, and is worthy of more general practice than it has received from farmers in the past. A soil may contain all the elements or ingredients necessary for the production of a certain crop and yet, on account of its mechanical condition, its extreme looseness or porosity, or its compactness, plants can not grow in it. By the application of certain materials, one of the best of which is quicklime, these unfavorable physical properties of the soil are often modified or broken up, so that the plants can avail themselves of the store of fertility in the soil, and a good crop is the result.

Many clay soils, when wet by rains, are not porous enough to allow the water to pass through them with sufficient rapidity. As a consequence they become water-logged and the air which is necessary for the healthy growth of the plant roots is excluded. In time of drought such soils cake readily, thus forming large clods, and becoming more difficult to till and less adapted to the sustenance of the growing plant. Some compound of lime, when applied in sufficient quantity, will prevent this puddling or caking, thus allowing the water, air and heat to thoroughly permeate the soil. The texture of the soil will also become more suitable for the easy penetration of the roots and rootlets of the plants.

Lime Making Materials in Indiana.

Indiana is rich in materials suitable for the making of lime. Moreover, they are widely scattered throughout the State. In the southern part the Mitchell and Bedford limestones furnish an the Niagara limestone in its outcrops along the valley of the Wabash and its tributaries, has long been the source of a fine grade of magnesian limestone which is noted for the excellence of its lime product. The marl deposits scattered about the lakes and marshes of the northern third of the State, furnish also a good lime-making material which was once quite extensively utilized for that purpose, and could be again if necessity required.

THE MITCHELL LIMESTONE.—This is one of the Lower Carboniferous limestones, which immediately overlies the Bedford limestone and forms the surface rocks in an area three to 25 miles in width in an irregular strip extending from the Ohio River northward to near Crawfordsville, Montgomery County, where it disappears beneath the drift. The area covered by the Mitchell limestone thus embraces parts of the following counties: Harrison, Crawford, Floyd, Washington, Orange, Martin, Lawrence, Monroe, Owen, Morgan, Putnam and Montgomery. In this area the Mitchell limestone has been utilized for making lime on an extensive scale at Milltown, Mitchell, Limedale and Okalla; while at numerous places throughout the area isolated kilns are or have been in operation for burning lime for local use.

The Mitchell limestone varies much in structural character and appearance. In most places it is a fine-grained, crystalline or sub-crystalline stone which is quite hard. In the southern part of its area there are found in a number of localities near the top of the Mitchell and between the beds of grayish stone, layers having an oölitic structure, nearly pure white in color and much softer than the gray. This "oölite" outcrops at Milltown, Marengo, and numerous other localities in Crawford County; at the Stockslager quarry in Harrison County; in Madison and Posey townships, Washington County, and at numerous places along the French Lick Branch of the Monon Railway west of Paoli, in Orange County. Both it and the more common gray Mitchell limestone comprise the purest forms of carbonate of lime found in the State.

The following table of analyses shows the composition of the Mitchell limestone from four widely separated localities:

ANALYSES OF MITCHELL LIMESTONE FROM SOUTHERN INDIANA.

SOURCE OF SAMPLE.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$).	Insoluble Residue (Silica, etc.).	Total.	Authority.
Oölite from Eichel Quarry, Milltown, Ind	98.91	.63	.15	.48	100.17	W. A. Noyes.
Gray stone from Mitchell Lime Quarry, Mitchell, Ind	96.65	1.20	.27	1.57	99.69	—— ——
Gray stone from South of Harrodsburg, Ind	97.64	....	.32	.82	98.74	T. W. Smith.
Gray stone from land of J. B. Lyne, Monroe County	99.04	....	.09	.80	99.92	T. W. Smith.

The last analysis given is from a ledge of the gray Mitchell limestone on the land of J. B. Lyne, in the southeast quarter of section 32 (8 N., 1 W.), five miles south of Bloomington, Indiana. This showed the highest per cent. of carbonate of lime of any Indiana stone whose analysis has been seen by the writer.

The above analyses show that the Mitchell limestone is a remarkably pure carbonate of lime, in every way suitable for making the purest of quicklime, not only for mortar-making purposes but for chemical and other uses where great purity of the raw ingredient is necessary. Farther analyses of the Mitchell stone will be given in connection with the descriptions of the plants now making lime from it in southern Indiana.

THE BEDFORD OÖLITIC LIMESTONE.—This is the best known limestone in the State, being the formation so extensively quarried for building and ornamental purposes. It is one of the Lower Carboniferous limestones, and forms a portion of the surface rocks in a narrow irregular strip from two to 14 miles in width, extending a distance of 110 miles from near Greencastle, Putnam County, to the Ohio River. Its outcrops occur in Putnam, Owen, Monroe, Lawrence, Washington, Floyd and Harrison counties. Numerous quarries have been opened throughout this area for building stone, and lime has been burned at a number of points, but nowhere on as extensive a scale as at Mitchell and Milltown, where the Mitchell limestone is used. The Bedford oölitic stone ranges from a creamy white to a dark drab in color. It is very uniform in grain and quite soft when first quarried. Under the microscope it is seen to be made up of the globular shells of minute one-celled animals. These are composed of carbonate of lime and are cemented together by the same material, so that the rock is a very pure limestone, ranking close to the Mitchell stone in chemical composition. From a number of analyses of the Bedford stone made by Dr. Noyes for the Twenty-first (1896) Report of this Department the following are taken to show its composition:

ANALYSES OF BEDFORD OÖLITIC LIMESTONE FROM SOUTHERN INDIANA.

Source of Sample.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Ferric Oxide (Fe_2O_3).	Insoluble Residue (Silica, etc.).	Total.
Bedford, Indiana, Stone Quarry, Lawrence County	98.27	.84	.15	.64	99.90
Hunter Bros. Quarry, Monroe County.........	98.11	.92	.16	.86	100.05
Romona Oölitic Stone Company, Owen County	97.90	.65	.18	1.26	99.99
Twin Creek Stone Company, Washington County ..	98.16	.97	.15	.76	100.04

The average of eight analyses of specimens from eight of the leading quarries of Bedford stone showed the following percentage composition: Calcium carbonate, 97.62; magnesium carbonate, .61; iron oxide and alumina, .36; insoluble residue, .91. These analyses show the fitness of the Bedford oölitic stone for making a very pure quicklime; and the practical burning of the lime at Salem, Bedford and other points proves that fitness. For some reason, however, the lime industry in the oölitic stone district is not as flourishing as it should be. Abandoned kilns are found in a number of localities in the area, notably in Monroe County, near the old University building at Bloomington, and at Ellettsville; in Lawrence County, two southwest of Bedford, and three south of the same place along the Monon Railway, and in Owen County at Romona. Prof. T. C. Hopkins, in a chapter on "The Commercial Features of the Bedford Oölitic Limestone," comments on the lack of use of the Bedford stone for lime making, and gives, doubtless, the real reasons for the neglect of the industry in the area. I quote from him as follows:*

"To see the great quantity of waste rock on the dump piles about the oölitic quarries one wonders why more of it is not burnt into lime, and no satisfaction could be obtained to that query when put to the quarrymen. One said it did not make good lime. Another that the lime was too hot, and some had not thought of it, did not know it had ever been tried, or would make lime at all. One only needs to look at the table of analyses of the stone to see that it would make a fat or rich lime, but that should not be a serious objection, as for many purposes a rich lime is preferred to any other. The reason that more of it has not been burnt may be due to a number of causes: 1. Freight rates, the cost of bringing in the coal and shipping the lime. 2. A prejudice in the local markets against rich lime. 3. Want of a large market, as the quarries are situated in the midst of the Mississippi Valley, with large deposits of limestone on all sides. 4. The lack of some enterprising person to push the business into prominence, as all the stone dealers are interested in the sale of building stone and not lime. The last is probably the most important reason."

The Niagara Limestone.—This limestone is the principal formation representing the Upper Silurian Period in Indiana. It forms the surface rocks over a wide area of the eastern and northern portions of the State and also over an irregular narrowing strip, 30 miles to one in width, extending southward from Newcastle, Henry County, through portions of Wayne, Rush, Fayette, Franklin, Decatur, Ripley, Jennings, Jefferson and Clark counties to the Ohio River near Jeffersonville. Through this narrow strip the rock is close to the surface, but in the larger area north of Newcastle it is nearly everywhere covered with deep drift. However, in the valley of the Whitewater and its tributaries in northern Wayne County, at Portland, Jay County, and along the Wabash River in the vicinity of Bluffton, Huntington, Wabash and Logansport it comes to the surface, as also in isolated areas near Delphi, Monon and Kentland. At a number of these localities and also near Utica, Clark County, the Niagara stone has for years been burned into a high grade of lime; and it is probable that at nearly every point where it outcrops it will be found suitable for lime making.

The Niagara limestone ranges from nearly white through buff shaly one in structure. In Decatur, Franklin and Wabash counties it is, in places, especially hard and compact, of even texture and color, and often occurs in thin, easily separated layers, usually from three to 12 inches thick which are largely quarried for flagging, curbing and similar uses. In other places it is known as "cliff rock" owing to the fact that the thick, uppermost layers withstand the action of the weather and form steep cliffs and bluffs along the ravines and lines of outcrop.

The chemical composition of the Niagara limestone varies greatly. In southern Indiana it usually contains only from 6 to 10 per cent. of magnesium carbonate, but the outcrops along the Wabash River contain 40 per cent. or more of this compound. This is especially true of certain outcrops in the vicinity of Huntington, Wabash and Delphi, where the Niagara stone seems to have passed through an upheaval, the strata being tilted in various directions, sometimes at an angle of 45 degrees or more. Near Delphi, Monon, and Kentland, Newton County, the Niagara comes to the surface in isolated islands in which the layers show this same tilted condition. Dr. E. M. Kindle has studied carefully the outcrops and stratigraphy of the Niagara through this region and has an interesting paper concerning it on subsequent pages of the present volume. The following table shows the variability of the Indiana Niagara limestone in chemical composition:

ANALYSES OF INDIANA NIAGARA LIMESTONE.

Source of Sample.	Calcium Carbonate ($CaCO_3$)	Magnesium Carbonate ($MgCO_3$)	Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$)	Insoluble Residue (Silica, etc.)	Sulphuric Anhydride.	Total.	Authority.
Consolidated Lime Company, Huntington	53.22	44.96	.23	.59	.11	99.11	R. E. Lyons.
Harley Bros. Quarry, Delphi, Carroll Co.	54.53	43 92	.51	.19	.18	99.33	R. E. Lyons.
Greensburg Stone Company, St. Paul, Decatur Co.	74.02	10.35	6.20	5.90	.90	97.37	E. T. Cox.
Scanlan's Quarry, Flat Rock Creek, Decatur Co.	83.00	6.3	2.50	5.30	1.00	98.10	E. T. Cox.

The limestones from Huntington and Delphi, whose analyses which those two points are famous. These limes are "cooler" or more "slow-setting" than those from the purer Mitchell and Bedford limestones and for that reason are preferred by many masons and builders. There is little doubt but that as good lime can be made from the Niagara stone at a number of other points along its outcropping horizon in Huntington, Wabash, Miami and Cass counties as at Huntington and Delphi. While analyses are not available, it is believed that the stone at Monon and near Kentland will also make a good grade of lime. The analyses of the Niagara stone in the southern part of its area show that a lime intermediate in character between that made at Delphi and Huntington, and that from Mitchell and Milltown could be produced. Large quantities are at present burned at New Paris, Preble County, Ohio, but six miles east of Richmond, Wayne County, Indiana, and for years kilns were in operation at Cox's Mills, five miles northeast of Richmond, and near Laurel, Franklin County. At these localities the Niagara limestone, similar to that at Decatur and St. Paul is or has been in use. A fine grade of lime has also been manufactured for years from a gray, crystalline, Niagara limestone in the vicinity of Utica, Clark County. Prof. W. W. Borden, in 1873, wrote of the industry in this vicinity as follows:* "The lime burned and sold under the name of the Utica lime has acquired by long use a high reputation, and where known is used in preference to all other brands. J. Speed, Esq., has erected at Utica two of Page's patent kilns, each producing 120 barrels of lime per day. At Robinson's landing, a few miles above Utica, Mr. Jacob Robinson burns of the same stone ten thousand barrels per year. The fuel employed is wood and requires four cords to burn one kiln. The Utica Lime Company use a mixture of wood and coal, and have two kilns, each producing 90 barrels of well burned lime per day. The Louisville Cement and Lime Company, and the Utica Lime Company, and Mr. J. Robinson burn 125,000 barrels of lime per year, employing in the business a large number of hands."

On account of a lack of proper transportation facilities at Utica, where shipment is possible only by boat on the Ohio River, the industry has gradually dwindled to about 8,000 barrels per year.

*5th Ann. Rep. Geol. Surv. of Ind., 1873, p. 145.

Marl as a Source of Lime.—About the existing lakes, and the extinct lakes and marshes of the northern third of Indiana are many extensive deposits of marl or "merl" as it is called in the country. This marl is a soft, earthy material composed principally of an amorphous form of carbonate of lime. Its color varies with the percentage of impurities which it contains, from a milky white to a dark brown when wet; and from a white or cream to a slate color when dry. The grains or particles composing the dry mass cohere very slightly and vary in size from coarsely granular to fine powder. They effervesce very freely and in time wholly disappear in cold muriatic acid, which is the principal test for carbonate of lime. These marls were deposited in the still waters of the lakes of the region, the original source of the marl material being the glacial clay and rock flour which formed a large part of the till or drift of the region surrounding the lakes. Percolating through the deposits of glacial clays and limestone debris, rainwater has, for centuries, dissolved and become saturated with the carbonate of lime. It has then flowed onward underground until it issues forth in the form of a spring, either bubbling up from the bottom or flowing in from the side of the basin in which the lake is located. In the warmer waters of the lake, the carbonate of lime has then been deposited until it has formed the vast beds of so-called marl.*

Several hundred deposits of marl occur in the lake region of the northern part of the State. These vary in size from an area a rod or two square and a foot or two deep, up to hundreds of acres, twenty or thirty feet or even more in depth. In the report cited, are full descriptions of thirty-two deposits which contain a body of marl equal to 160 acres in area and ten feet thick. The following are analyses of average samples of marl from five of these deposits, made by Dr. W. A. Noyes for the 1900 Report. From them one can judge as to the chemical composition of the average deposit in the State:

*For a full account of the Lakes of Indiana and their accompanying marl deposits, as well as for detailed information regarding the formation, deposition, properties and uses of marl, see the paper by Blatchley and Ashley, in the 25th (1900) Report of this Department, pp. 31-321.

ANALYSES OF INDIANA MARLS.

Origin of Sample.	Calcium Carbonate ($CaCO_3$)	Magnesium Carbonate ($MgCO_3$)	Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$)	Insoluble residue (silica, etc.)	Organic matter.	Total.
Lake James, Steuben Co	92.41	2.38	.29	1.16	1.97	98.36
Tippecanoe Lake, Kosciusko Co	90.67	2.42	.32	2.48	2.87	98.76
Manitou Lake, Fulton Co	87.65	2.60	.49	6.39	2.88	100.01
Maxinkuckee Lake, Marshall Co	85.38	3.50	.38	6.40	3.15	98.98
Chain and Bass Lakes, St. Joseph Co	87.92	2.64	.30	3.10	4.18	98.37

In the early settlement of northern Indiana much quicklime was made from these deposits of marl. No one of the counties in which the principal deposits occur has outcrops of limestone, and hence the marl was used, being burned in rude kilns erected for the purpose. Richard Owen, in his report on St. Joseph County, says: "Beneath the swamp-muck beds in the Kankakee marshes near South Bend, a shell marl, three to ten feet thick, is obtained. At many places this is dug and moulded into brick-shaped masses of considerable size, so as to be readily piled in a kiln, burnt and used for all purposes to which lime is usually applied, being of an excellent quality and white color. An extensive manufacture of this kind is also carried on near the fine Catholic College of Notre Dame, beautifully situated a mile or two north of South Bend."*

Other localities where the marl lime was made, were near Rochester, Fulton County; Lime Lake, Steuben County; Albion, Noble County, and Silver Lake, Steuben County. The lime from the marl was snow-white in color, and very perishable owing to its fine mechanical condition. As much of the mortar made from the burned marl did not endure exposure to the weather (probably on account of too small an amount of sand being used in its composition), the use of marl as a lime material was discontinued when railways were constructed which brought in from Wabash, Delphi and Huntington a superior lime. The manufacture of quicklime from the marl for use in mortar will, however, probably never be renewed, as the quality of the lime produced at the lime burning

*Report of a Geological Reconnaissance of Indiana, 1859, p. 200.

cities along the Wabash, taken in connection with the present cheap and rapid means of transportation, will not justify its renewal.

The Burning of Lime.

As has been stated, quicklime is produced from limestone by calcining or roasting the latter. In this process the carbon dioxide gas is expelled, and the solid quicklime of commerce remains. This burning, roasting or calcining is effected in kilns of various kinds. The kilns used at local points for burning lime for neighborhood use are or were intermittent kilns of stone. In them the fire was allowed to go out after each burning, to be started again after the kiln was recharged with stone. These cheaper, temporary or "ground-hog" kilns were rudely constructed of stone,

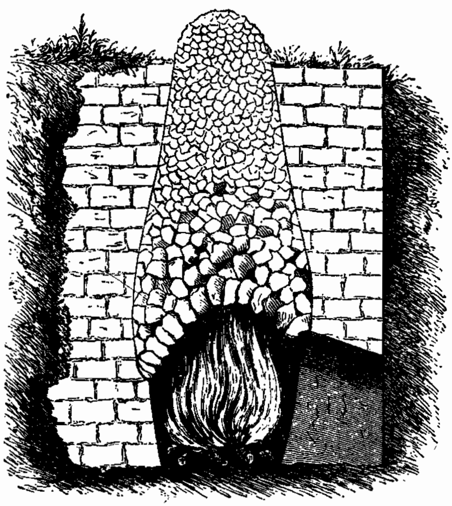


Fig. 1. Old-fashioned "ground-hog" or temporary lime-kiln.

and were located on the side of a hill, so that the top was easily accessible for charging the kiln with stone, and the bottom for supplying fuel and drawing out the lime. In charging, the largest pieces of limestone were first selected and formed into a rough, dome-like arch with large open joints springing from the bottom of the kiln to a height of five or six feet. Above this arch the kiln was filled with fragments of limestone from the top, the larger pieces being used in the lower layers, these being topped off with those that were smaller. A fire of wood was then started under the dome, the heat being raised gradually to the required degree in order to prevent a sudden expansion and consequent rupture of the stone forming the dome. Should this happen, a downfall of the entire mass above would take place, thus putting out the fire and causing a total loss of the contents of the kiln. After a bright heat was once reached through the mass of stone, it was maintained for three or four days to the end of the burning. This was indicated by a large shrinkage in the volume of the contents, the choking up of the spaces between the fragments and the ease with which an iron rod could be forced down from the top. The fire was then allowed to die out and the lime was gradually removed from the bottom. It was in this manner that all the lime used in Indiana for many years was burned, and in some localities these temporary intermittent kilns are still in operation. The process of burning is simple and cheap, the only expense being for blasting the stone and preparing the fuel. Possibly but one or two kilns were necessary to supply a neighborhood for a year. These were burned in a week or two when required, the kiln remaining idle for the remainder of the time.

As the population increased, the demand for lime became greater, and in many places permanent kilns lined with fire brick were erected. These were the old fashioned stone "pot kilns" of a quarter of a century ago. On the inside they were usually circular in horizontal section, tapering slightly, by a curve both up and down from the circle of largest diameter, which was from four to six feet above the bottom. A kiln 10 to 11 feet in greatest diameter, was 25 to 28 feet high, five to six feet in diameter at the top and seven to eight feet at the bottom. There was an arched opening on one side at the bottom, five to six feet high, through which the wood was introduced and the burnt lime removed. A horizontal grating on which the fire was built was usually placed one or two feet above the bottom. In all these intermittent kilns there was an enormous loss of heat at each burning, for the quantity of fuel, necessary to raise the contents of the kiln and the thick stone and brick walls to the degree of heat necessary to form the lime, had to be repeated each time the kiln was charged. Moreover, the stone nearest the dome-arch in the kiln was liable to become injured by over-burning before the top portions were thoroughly calcined.

As wood became scarcer and the demand for lime increased, these intermittent kilns gave way to continuous or perpetual burning kilns, usually of stone, in which the lime was burned by coal without intermission in the fires. In the first styles of these, some of which are still in use, the kiln was filled with alternate layers of coal and limestone and then fired from below with light wood. As the burning was completed in the lower portion of the kiln the finished lime was drawn out from time to time, usually twice each 24 hours, allowing the entire mass above to settle down. New layers of fuel and stone were then added at the top.

These old style perpetual kilns have mostly been replaced by cylindrical steel kilns, 35 to 40 feet in height and six to eight feet in inside diameter. These kilns have two (sometimes four) furnaces, one on either side, situated at about one-third of the height from the bottom. In these the fires are kept perpetually burning, wood, coal, oil or gas being used as fuel. The limestone is elevated in steel cars by means of a tramway to the tops of the kilns and dumped into them until they are full. The flame and heat from the fires in the furnaces pass up through the limestone and thoroughly roast it, so that by the time it has descended to near the level of the furnaces, it has been deprived of all its carbon dioxide gas and converted into lime. The latter is then drawn out at the bottom, the drawing taking place about once every six hours. The limestone for burning should be broken into pieces not exceeding four to six inches in diameter, else the inside of them is liable to remain unburned. More or less trouble is experienced at all kilns with these "cores" or unburned centers, as the pieces of lime containing them have to be sorted from the shipment.

The steel perpetual kilns are a great improvement over the old stone ones in which the coal was mixed with the fuel, as the resulting lime is cheaper and purer, and much less fuel is necessary. All modern lime-making plants are equipped with them, most of those in Indiana being of the Monitor pattern, costing about $1,500 each.

THE MANUFACTURE OF LIME IN INDIANA.

At Delphi, Carroll County.

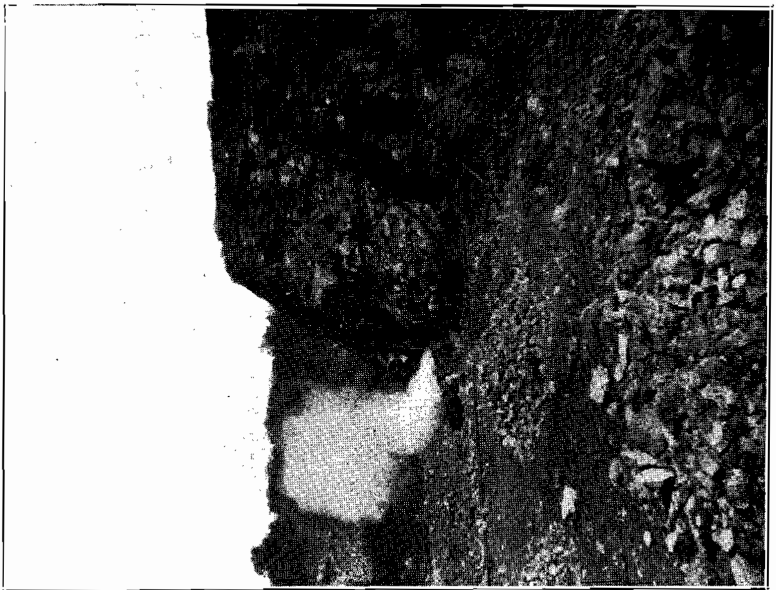
Delphi, the county seat of Carroll County, is a city of 2,500 population, located at the junction of the C. I. & L. (Monon) and Wabash railways, 72 miles northwest of Indianapolis and 112 miles southeast of Chicago. The city is picturesquely located on the high banks of Deer Creek, near the junction of that stream and the Wabash River.

The lime industry in the vicinity of Delphi has been an important one for many years; the "Delphi lime" having a wide reputation for the excellence of its quality. The first kilns, as in other localities, were of a very crude, temporary nature, in which only lime sufficient was burned to supply the local demand. However, the quality of the lime began to attract attention in other places and in 1858 the firm of E. W. Hubbard & Co., composed of E. W. Hubbard, E. R. Harley and Robert Mitchell, was organized for burning lime for shipment. Their principal outlet was along the old Wabash and Erie Canal, as long as that waterway was in operation. The larger part of the output was shipped to Covington, Ind., and from there hauled in wagons to points in Illinois and western Indiana. The old-fashioned intermittent stone "pot kilns" were used until 1870. These held from 1,000 to 1,200 bushels of lime. They were filled one day, burned two and a half to three days, and emptied in a day or two. There was much waste of fuel, due to the necessary cooling at the end of each burning. About 20 of these kilns were operated by the company.

By 1870 several other firms had started in the business. In that year there was a combination of all of these and the pioneer company under the name of "The Delphi Lime Company." The old stone intermittent "pot kilns" were soon replaced by more modern steel ones in which the burning was continuous. The old company operated the plant until 1891, when it was sold to a Mr. Cartwright, who controlled it until 1902. For a year after his death the plant was closed, but a new company was organized under the old name, and the plant was again opened in September, 1903.

PLATE III.

KILNS OF DELPHI LIME CO., DELPHI, IND.



QUARRY OF DELPHI LIME CO., DELPHI, IND

THE DELPHI LIME COMPANY.—The present location of the Delphi Lime Company's kilns is about one mile north of the city limits of Delphi. No railway switch is connected with their plant, the lime being hauled in wagons to the city and there loaded on cars. The company owns twenty acres of limestone land, about half of which has been quarried out to a depth of 15 to 25 feet. In one place a pond, whose water is 12 to 15 feet in depth, fills an abandoned quarry several acres in area. The stone used is of the same character and quality as that burned by the other lime companies at Delphi, being a Niagara limestone, rich in magnesia. It is part of an island or uplift of rock, which was forced above the sea toward the close of the Niagara period. This island is remote from outcrops of the main body of Niagara limestone in the State, and forms the surface of an area of about 600 acres north and northwest of Delphi. As in other isolated deposits of Niagara in this portion of the State, the strata are much tilted, the main dip being 20° to 30° towards the northeast. The stone is, in places, very much shattered, and presents other evidences of a true upheaval.*

The kilns of the Delphi Lime Company are of the Monitor pattern and four in number, one large one being eight feet, the others six feet, in inside diameter. But one of these was in operation at the time of my visit, October 3, 1903. These kilns were among the first of their kind erected in the State, and differ from most others in having at the base four arches or furnaces instead of two. These are about ten feet above the bottoms of the coolers or pits to which the lime passes when thoroughly burned. Each of the smaller kilns produces about 200 bushels and the larger one 240 bushels of lime in 24 hours. Wood, costing $2.50 per cord, was being used for fuel, but on account of its scarcity it will soon be changed to coal. The superintendent claims that with wood, a fourth more lime can be gotten from the same amount of stone, than with coal, and that it can be burned in less time. The trade of the Delphi Lime Company had been largely lost by their year's shutdown, but it was hoped that it would soon be regained. The lime produced is similar to that of the Harley Bros. Lime Company, described later, brings the same price and is sold mainly for builders' use and for paper manufacture.

*See the paper by E. M. Kindle in another part of the present volume for further in-

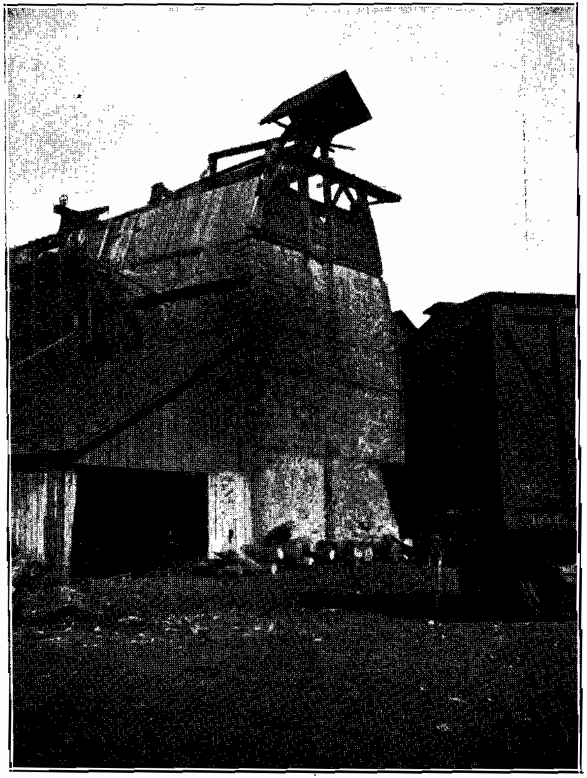
Harley Bros. Lime Company.—The Harley Bros. Lime Company, composed of C. and G. P. Harley, began the burning of lime at Delphi in 1875. Their first kilns were located on a small tract of Niagara limestone land near the northern limits of the present city, but in 1891, having secured possession of a larger tract of stone land, they moved to their present location, one-eighth of a mile farther north. A switch from the Monon Railway runs to their plant. About $10,000 is invested, exclusive of the stone land, and their output of lime is the largest of the three plants located at Delphi. The three kilns operated by the company are of stone and are seven feet in inside diameter, with an output of 225 bushels each per day. The burning is by the continuous process, coal and a small amount of wood being used as fuel. The plant is operated the entire year, with the exception of a few weeks of the coldest weather—May, September and October being the months in which there is greatest demand for the product. In these months 35 men are employed in quarrying stone and operating the plant. Ordinary laborers and quarrymen receive from $1.50 to $1.60 per day; while burners, of which there are two to each kiln, receive $12.25 each for seven days' work.

Harley Bros. own 40 acres of stone land suitable for the burning of lime, their quarry being located just north of the kilns. From 12 to 18 inches of stripping is removed and the stone is then used to a depth of 16 feet. When exposed, the stone in many places is found to be very much broken, the fragments being often raised up in small dome-like arches. The appearance of one of these, in the words of one of the owners, is like that of a pot of hot mush which has been suddenly cooled off. Where layers of any area are found in this particular quarry, they dip 10° to 15° to the southeast. An analysis of this stone, made by Prof. R. E. Lyons for this paper, shows its composition to be as follows:

ANALYSIS OF STONE FROM HARLEY BROS.' QUARRY, DELPHI, IND.

Calcium carbonate ($CaCO_3$)	54.53
Magnesium carbonate ($MgCO_3$)	43.92
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	.51
Insoluble residue (silica)	0.19
Sulphuric anhydride (SO_4)	.18

PLATE IV.



HARLEY BROS. KILNS, DELPHI, IND.

HARLEY BROS. QUARRY, DELPHI, IND.

The analysis shows the stone to be very rich in magnesia. The sum of the magnesium and calcium carbonates, both of which go to form lime, is 98.45 per cent., so that the amount of impurities is very small.

When blasted and broken to the proper size, the stone is loaded into steel cars holding one and a quarter yards, and hauled up a tramway to a point above the kilns where, by an ingenious arrangement, the cars are automatically dumped. A load of stone, so dumped, is converted into lime in about 36 hours. From 50 to 60 bushels of lime are drawn from the bottom of each kiln every six hours.

The Delphi lime, when fresh, is of a dirty brownish color, but when slacked bleaches out as white as any other. It is a "cool" lime which sets slowly. For this reason a much larger amount can be strewn with the trowel along a row of brick; whereas with a "hot" lime but enough can be scattered to lay three or four brick before it begins to set. It is on account of this property that it is so highly esteemed by masons. It is also claimed for it that it has better cementing qualities than a "hot" lime, requiring more sand to form a perfect combination and forming in time a very hard mortar joint. For paper manufacture Delphi lime is said to be superior to a pure calcium lime, as it does not clog the cloth or "felt" as rapidly as does the purer lime, hence the labor of cleaning the "felt" is lessened.

An analysis of the lime burned by Harley Bros. was made for the firm by Dr. J. N. Hurty, of Indianapolis, who reported its composition to be as follows:

ANALYSIS OF HARLEY BROS.' DELPHI LIME.

Calcium oxide	38.59
Magnesium oxide	31.76
Clay	26.63
Silica	.14
Loss	2.88
Total	100.00

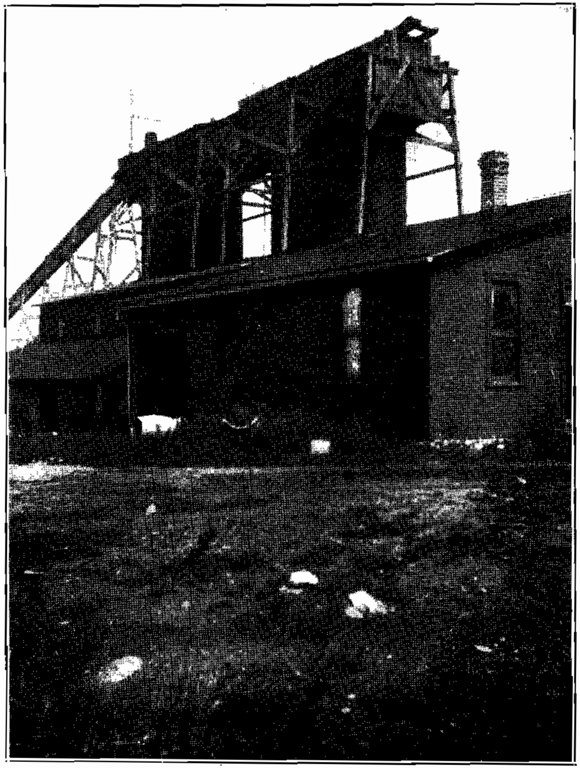
In October, 1903, the Delphi lime was bringing 13 cents per bushel of 70 pounds, or 60 cents per barrel, in car load lots, f. o. b.

ufacture is said to be about $7\frac{1}{2}$ cents per bushel. That made by Harley Bros. is sold mainly for building purposes, though quite a quantity goes to paper factories. The most of it is used in Indiana and northern Illinois. About ten per cent. is shipped in barrels, the remainder in bulk. On account of the great increase, in recent years, in the cost of barrel making materials, most lime manufacturers are trying to reduce the barrel shipments to a minimum. Each lime plant of any size has its own cooper shop. The cost of a barrel at the Delphi plants, in October, 1903, ranged from 23 to 26 cents, of which amount four or five cents went to the cooper, the rest for material. Indiana bituminous "mine run" coal is used for fuel and was being laid down at the plants for $2.40 to $2.70 per ton. Care must be taken to secure a coal as free from sulphur as possible, else a brownish crust will be formed on the lime during burning which will prevent it from properly water slacking.

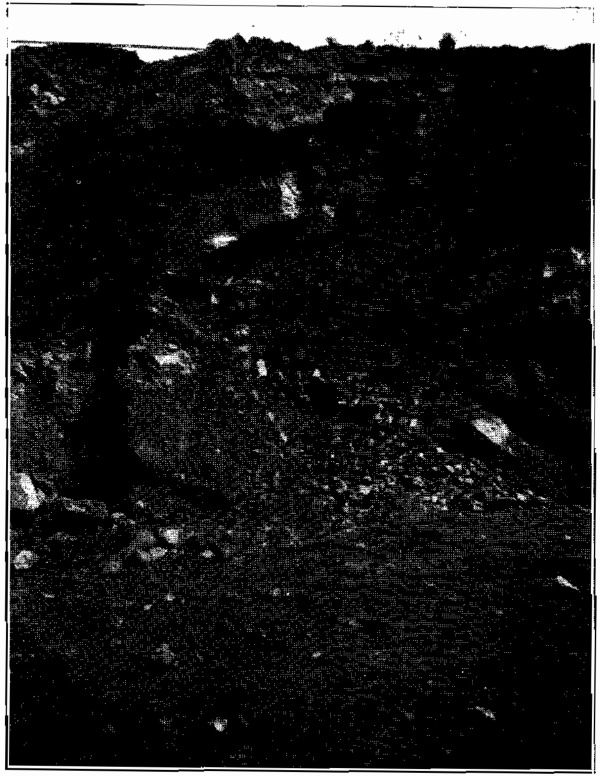
THE COBLE LIME COMPANY.—In 1902 a number of Delphi and Frankfort citizens organized a new company for the purpose of burning lime at Delphi, and incorporated under the name of the Coble Lime Co. During the first year they burnt quite a quantity of lime in old-fashioned pot kilns, but in the spring of 1903, an up-to-date plant was erected at a cost of $12,000, about one mile north and a little east of the courthouse, and about half way between the two plants already described. Here the company owns $22\frac{1}{2}$ acres of excellent stone land, which cost them $7,500. Four steel kilns were erected, each having a capacity of about 200 bushels daily. The kilns are a little smaller than the average, in order to burn the lime thoroughly with coal. A 20-horsepower gasoline engine furnishes power for hoisting stone and compressing air for drilling in the quarry. The kilns are filled twice each day, and the lime is drawn at intervals of six hours. Eighteen men were employed at the time of my visit, the average wages paid being $1.50 per day. The company had found a ready market for all the lime burned since June 5th, when the plant was first opened for business.

In the quarry just north of the kilns the stone is in places broken and upheaved, as in the other quarries in the vicinity. The dip of the strata in place is to the north. The lime produced is similar

PLATE V.



KILNS AND STOREHOUSE OF COBLE LIME CO., DELPHI, IND.



QUARRY OF COBLE LIME CO., DELPHI, IND.

analysis of a freshly burned sample, made for the company by T. W. Smith of Indianapolis, showed its chemical composition to be as follows:

ANALYSIS OF LIME FROM COBLE LIME CO , DELPHI, IND.

Calcium oxide (CaO)	90.20
Magnesium oxide (MgO)	6.08
Iron and aluminum oxides ($Fe_2O_3+Al_2O_3$)	1.70
Potassium and sodium (K_2O+Na_2O)	1.54
Silicon oxide (SiO_2)	.15
Moisture	0.30
Total	99.97

In October, 1903, no switch was as yet completed to the plant of the Coble Co., though a line for one had been surveyed. When it is finished the company will have every facility for producing lime at a minimum cost, as the plant was arranged with an especial view to convenience and economy. With a constantly growing demand for good lime and with the widely known reputation of the Delphi product behind it, there is every reason to believe that a profitable business will soon be established.

At Huntington, Huntington County.

Huntington, the county seat of the county of the same name, is a city of 10,000 population, located at the junction of the Wabash and Chicago & Erie railways, 142 miles east of Chicago and 12 miles southwest of Fort Wayne. Huntington has, for more than a half century, ranked as the principal lime producing center in Indiana. There, as elsewhere, the first kilns were temporary ones of the ground-hog pattern. In 1845, or thereabouts, the first permanent kilns were erected by Louis Gephardt about one mile east of the city. Other intermittent burning kilns of the same kind were from time to time built by other parties, both east and west of the city, at points indicated by the abandoned quarries on the accompanying map. A number of these quarries furnished stone for much of the lime shipped for years on the old Wabash & Erie Canal. Those west of town were located along its margin, and are almost continuous, the separating strips being no more than 15 or 20 feet across.

About 1868, when the first perpetual burning kilns came into use, several larger companies were organized and the industry rapidly grew in importance. In 1875 Prof. E. T. Cox visited the county and made a brief report upon its general geology. In this he wrote of the lime industry as follows: "The greatest development of the Niagara limestone is seen along the banks of Little River above and below Huntington. The most easterly outcrop is on John McCarty's land on section 18, township 28, range 10, about three and a half miles from Huntington. Lime kilns have been established all along the outcrop and the burning of lime constitutes one of the chief industries of the county. Thirty-one kilns were in active operation making caustic lime at the time of my visit. Eight of the number are perpetual kilns, the remainder are occasional kilns which require to be completely discharged and cooled before refilling.

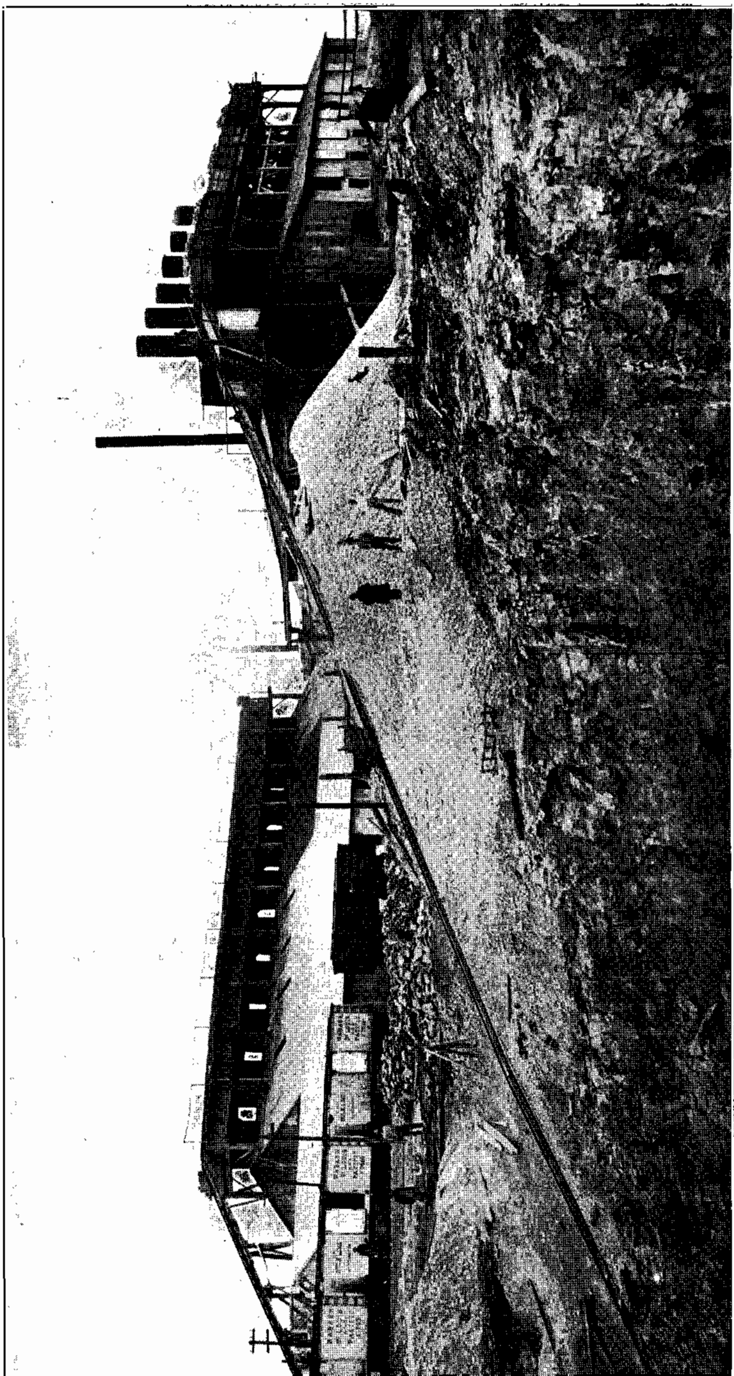
"The annual make of lime amounts to about 617,000 bushels, and the consumption of wood to 12,260 cords; being an average of nearly 400 cords of wood and 20,000 bushels of lime per kiln, and an average of 50 bushels of lime for each cord of wood consumed. This lime is held in high estimation and meets with a ready market, not only in Indiana, but in Ohio and Illinois as well."*

The companies then in operation were gradually combined until in time but three remained. These were the Baltes & Martin Company; the Huntington White Lime Company, and the Beck and Purviance Company. They operated individual plants until 1887, when their interests were pooled under the name of the Western Lime Company.

THE WESTERN LIME COMPANY.—This is the largest lime producing company in the State. It owns four large plants in the vicinity of Huntington, three of which were in operation in October, 1903. As shown on the accompanying map, these are located on switches of the Wabash Railway, about one and a quarter miles east of Huntington, in the northwest quarter of section 13 and the southwest quarter of section 12 (28 N., 9 E.). The closed plant (No. 4) is located about a third of a mile farther east, by the side of the main line of the Wabash Railway. It is the one formerly operated by the "Huntington White Lime Company,"

*7th Ann. Rep. Geol. Surv. of Ind., 1875, p. 131.

PLATE VI.



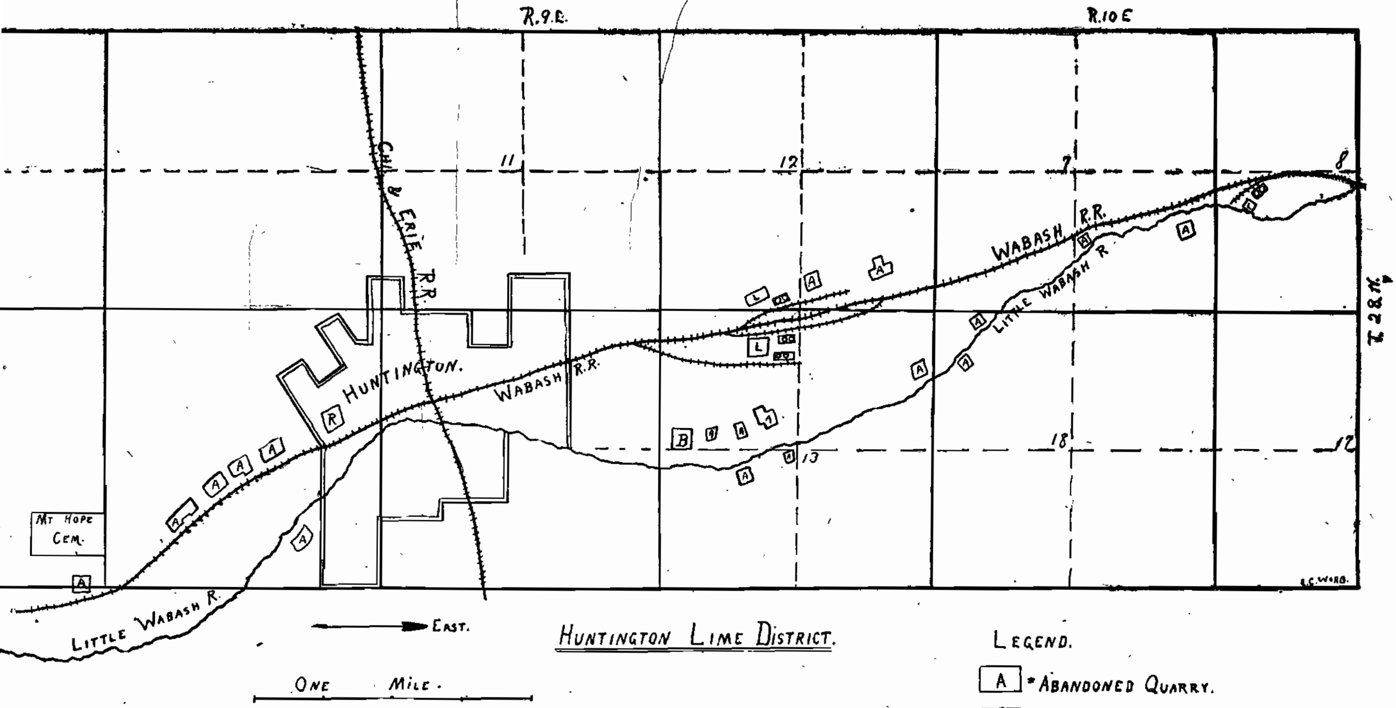
No. 2. Plant of Western Lime Co., Huntington, Ind.

and has eight kilns, six of steel and two of stone. It has not been operated for several years. One reason given for its closing was that the thick ledge near the top of the quarry from which stone was obtained was not so good as the underlying ledges, being shelly and fossiliferous. A mixed grade of lime was the result unless the stone was sorted. Another reason was that the output of the other three plants nearer town equaled the demand, and in closing one of the plants the one farthest distant was selected.

The active plants are equipped with 24 steel kilns, 20 of which were burning lime on the date mentioned. These steel kilns are of the Monitor continuous burning pattern, about 11 feet in outside diameter and 40 feet in height. Their output is about 200 bushels each per day. On account of greatly decreased demand for lime in the winter months but six to eight kilns are operated during that season. From 140 to 200 hands are employed from April 1st to November, the wages paid grading from $1.40 to $2.00 per day. For a number of years all the lime produced was burned with natural gas, but on account of the greatly decreased supply of that fuel it is now only used in part of the kilns during the summer months, and is then supplemented by wood. Hocking Valley, Ohio, coal is the principal fuel used in the winter and spring.

The rock used in making lime in the vicinity of Huntington is a magnesian Niagara limestone, very similar in appearance and chemical composition to that used at Delphi. In regard to the dip of the stone, Mr. L. C. Ward, who prepared for me the accompanying map of the Huntington Lime District, writes: "As to the dip of the rock in the different quarries, nothing definite in the way of figures can be given. Even in the same hole, the dip may vary widely in pitch and in direction. All those west of town dip toward the south and southeast, the pitch varying between 3° and 30°. The latter number is for the quarry marked R, within the city limits. For the neighboring quarries, 3° to 15° are the prevailing dips.

"In the quarries east of town, a greater degree of regularity is noticeable. The quarry marked B has level strata, the dip being considerably less than 1°. All the other quarries in sections 13, 12 and 7 have their strata dipping to the northwest, or north-



HUNTINGTON LIME DISTRICT.

LEGEND.

- A = ABANDONED QUARRY.
- L = LIME QUARRY
- R = ROAD-MATERIAL QUARRY
- B = BUILDING-STONE
- OOO = ACTIVE KILN.

and rarely drops to 10°. In the large quarry marked L, section 13, the dip in the northern part of the hole is 15° to the northwest; in the southern part, 12° to the southwest. In section 8, the strata in the quarry marked L have a dip of 10° to the north and northeast. These great variations in dip point to a greatly complicated set of folds or faults, or both. The overlying mantle of drift, however, precludes any closer study of the strata relations underneath."

In the main quarry, L. (n. w. quarter section 13) used by the Western Lime Company, about 36 inches of stripping is removed and the stone then quarried to a depth of 53 feet. There is no waste except some fine material which accumulates on the bottom and which would choke the kilns if used. The quarry covers several acres and the stone, after being blasted and broken to the required size, is loaded into cars and then hauled by horse-power along temporary tramways to the foot of an incline from which it is raised by steam-power to a platform above the kilns. The cars hold 30 cubic feet of stone, and 26 of them are required to make 450 bushels of lime.

The lime made by the Western Lime Company is a magnesian lime, much the same in character as that burned at Delphi. For mortar making it is "cool" and slow-setting, and where used in paper factories it is claimed that it does not gum the cylinders as does a lime made from pure calcium carbonate. For that reason it is sold to a number of the larger paper and strawboard factories of Indiana and adjoining states. About 35 per cent. is shipped in barrels, the remainder in bulk. The price at the kilns in October, 1903, was 13 cents per bushel or 60 cents per barrel; in car-load lots it brought about two cents less per bushel. An analysis of the lime made for the company in March, 1897, by T. W. Smith of Indianapolis, showed its chemical composition to be as follows:

ANALYSIS OF LIME FROM THE WESTERN LIME CO., HUNTINGTON, IND.

Calcium oxide (CaO)	63.03
Magnesium oxide (MgO)	34.15
Ferric oxide and alumina (Fe_2O_3+Al_2O_3)	2.62
Silica (SiO_2)	.07
Moisture	.13
Total	100.00

The combined calcium and magnesium oxides, which form the quicklime, show it to be 97.18 per cent. pure lime.

THE CONSOLIDATED LIME COMPANY.—The plant of this company is located on a switch of the Wabash Railway, two and a half miles east of Huntington, in the northwest quarter of the southwest quarter of section 8 (28 N., 10 E.). (See accompanying map.) The first kilns, two in number, were erected in 1893, and two more were built in 1894. These were stone pot kilns. In March, 1903, the company replaced these by three steel kilns of the latest pattern, and in October had the foundations in and the steel ordered for three additional ones. The capacity of the six kilns will be 1,500 bushels each 24 hours. The kilns are 10 feet in outside diameter by 42 feet in hight, 8 feet of the latter dimension being taken up by the cooling and drawing pit. When the new kilns are completed the company will have about $30,000 invested. Twenty men are employed, the burners and drawers receiving $12.00 per week of seven days; the quarrymen, $1.50 per day. "Black Hawk" bituminous coal from southern Indiana is used as fuel. Firing is done every three-quarters of an hour, and the lime is drawn every four hours, 30 to 40 bushels to the kiln, the amount depending upon the draught or indirectly upon the density of the air.

The Consolidated Lime Company owns 24 acres of limestone land in the immediate vicinity of the plant, the quarry being just south of the kilns on the bank of the Little Wabash River. Two or three feet of stripping is removed and all the stone is then used; the quarry being opened to a depth of 18 feet. The strata have a decided dip of 10° or more to the north and northeast. The stone is a grayish to buff magnesian limestone whose chemical composition, according to R. E. Lyons, is as follows:

ANALYSIS OF LIMESTONE FROM QUARRY OF CONSOLIDATED LIME CO., HUNTINGTON, IND.

Calcium carbonate ($CaCO_3$)	53.22
Magnesium carbonate ($MgCO_3$)	44.96
Ferric oxide and alumina (Fe_2O_3+Al_2O_3)	.23
Insoluble residue (silica, etc.)	.59
Sulphuric anhydride (SO_3)	.11
Total	99.11

The stone is hauled up an incline by steam-power and dumped into kilns. It burns into a grayish lime which is said to slack quicker than that produced by the Western Lime Company. In plastering 100 square yards of surface, three barrels of the lime is sufficient.

An analysis of an average sample of this lime, made by Dr. R. E. Lyons, showed its constituents to be as follows:

ANALYSIS OF LIME FROM CONSOLIDATED LIME CO., HUNTINGTON, IND.

Calcium oxide (CaO)	59.20
Magnesium oxide (MgO)	38.38
Ferric acid and alumina ($Fe_2O_3+Al_2O_3$)	.49
Insoluble residue (silica, etc.)	.35
Moisture	1.80
Total	100.22

The combined calcium and magnesium oxides which form the lime show a percentage of 97.58, thus proving the purity and excellent quality of the lime. The latter has, up to the present, been sold for building purposes alone and the demand has exceeded the supply. The price in October, 1903, was 12 cents a bushel, or 58 cents a barrel, f. o. b. the cars at the kiln. The market is at present principally in Indiana, but when the new kilns are in place, the company hopes to extend the trade into adjoining states. The quality of the lime produced will, without doubt, aid them in realizing their expectations.

At Markle Huntington Co., Ind.

Markle is a town of 750 population, located in Rock Creek township, Huntington County, nine miles southeast of Huntington on the Chicago & Erie Railway. The most eastern outcrop of Niagara limestone in Huntington County is just south of Markle, on the Wabash River. It has a blue-green color, is irregular in fracture, and usually occurs in four to six-inch layers. The strata have a local dip of 20° to the southeast. The outcrop may be followed for two or three miles up and down the stream. An analysis of the stone, made by E. T. Cox,* showed its chemical composition to be as follows:

ANALYSIS OF NIAGARA LIMESTONE FROM MARKLE, IND.

Lime	37.56
Magnesia	7.58
Carbonic acid and combined water	48.50
Iron and alumina	2.50
Insoluble matter	2.25
Moisture	.75
Sulphuric acid	.27
Total	99.41

The Markle stone was first used for lime in 1888. The kilns, located just south of the corporate limits, were operated for a few years and then closed down until 1902, when the present proprietor, Mr. E. S. Wheeler of Huntington, assumed control. Three stone pot kilns of the intermittent pattern are used, their capacity being 1,000 bushels each. Wood costing $1.75 per cord is used for fuel, the lime being sold as "Wood-burnt White Lime." The proprietor claims that the lime rock contains less sand than that used at Huntington; that it will yield more lime and that the latter will slack quicker than the Huntington lime. About $3,000 is invested in the plant. In 1903, 35,000 bushels of lime were produced, which sold for 12 cents per bushel, or about $4,000. The plant is operated ten months in the year and employs six men.

At Keesport, Cass County.

Keesport is an abandoned station on the Wabash Railway, four miles east of Logansport, the county seat. Large outcrops of a very pure limestone occur along the Wabash River in the immediate vicinity. The burning of lime from one of these deposits was begun by A. B. Keeport & Co. in 1868, and was continued until 1901, when the industry was abandoned, on account of the deposit of stone owned by the firm becoming exhausted. Four continuous burning stone kilns were in use, the capacity of the plant being 1,000 bushels per day. From 1892 to 1896, 220,000 to 250,000 bushels of lime were burned each year. The output was an excellent quality of white lime, which was sold mainly for building and chemical uses. An analysis of the stone made for the firm by Dr. J. N. Hurty showed its composition to be as follows:

ANALYSIS OF LIMESTONE FORMERLY BURNED INTO LIME AT KEESPORT, CASS COUNTY, INDIANA.

Calcium carbonate ($CaCO_3$)	96.02
Silica (SiO_2)	1.02
Alumina and iron oxide ($Al_2O_3+Fe_2O_3$)	2.00
Magnesium carbonate ($MgCO_3$)	1.04
Total	100.08

Near Ingalls, Madison County, Ind.

Ingalls is a town of 600 population, situated 23 miles northeast of Indianapolis, on the Cleveland Division of the Big Four Railway, in the southeastern corner of Madison County.

Beds of a very pure limestone outcrop at a number of places north and northeast of Ingalls. At a point about three-quarters of a mile north of the town the Ingalls Lime and Stone Company erected two modern steels kilns in 1891 and began the burning of lime, with natural gas as fuel. The industry was discontinued in 1894, as no switch had been put in and the lime had to be hauled to Ingalls in wagons and there loaded into cars. The product was a "short," quick-slacking lime. It was sold to glass and strawboard manufacturers and for building purposes, and gave good satisfaction wherever used.

The company owns 66 acres of land about the quarry from which the stone for lime making purposes was taken. The stone lies within two feet of the surface over most of this tract. It is at present quarried and ground for glass making purposes and for a fertilizer. It is mostly in thin layers, which break into fragments when blasted. An analysis of it made by Dr. W. A. Noyes, shows its composition to be as follows:

ANALYSIS OF LIMESTONE FROM NEAR INGALLS, IND.

Silica (SiO_2)	5.85
Alumina (Al_2O_3)	0.77
Ferric oxide (Fe_2O_3)	0.16
Calcium carbonate ($CaCO_3$)	93.17
Magnesia (MgO)	0.25
Combined water (H_2O)	0.08

On account of the low percentage of magnesia present the stone is very suitable for making Portland cement.

NEAR UTICA, CLARK COUNTY.

Utica is a town of small size located on the Ohio River in the southern part of Clark County six miles above Jeffersonville. Thick outcrops of Niagara limestone occur near the town, and lime was first burned from these in temporary kilns by M. H. Tyler and H. C. Emmericke in 1868. In 1871, J. B. Speed & Co. leased some of the stone land and erected three permanent kilns of 800 bushels capacity. These they have since continued to operate, but at present use only one kiln having 300 bushels daily output. This is located about a quarter of a mile northeast of Utica. The stone used is a very fine magnesian carbonate which burns into a lime of high repute for mortar and plaster. Pittsburgh nut and slack coal is used for fuel. The lime is marketed at Louisville and Ohio River points above Utica. In 1903, 13,385 barrels of 2¼ bushels each were produced, but the average annual output for the last seven years has been but about 8,000 barrels. The Union Lime and Cement Co. also operated several kilns near Utica up to about 1900, when they discontinued, mainly on account of lack of transportation facilities.

AT MILLTOWN, CRAWFORD COUNTY, IND.

Milltown is located 34 miles northwest of Louisville, on the St. Louis Division of the Southern Railway. The town has a population of about 450 and is situated on Blue River, which here forms the line between Harrison and Crawford counties. The river at that point is about 225 feet wide and between there and its mouth at the Ohio River has a fall of 89 feet, or about seven and a half feet to the mile. Many places are available for impounding dams, which could be built from 20 to 40 feet high. The stream thus furnishes one of the best unutilized sources of water-power in southern Indiana.

J. B. SPEED & CO.—This company, whose main office is at Louisville, Kentucky, has been making lime at Milltown since 1887. The plant is located on the west side of Blue River, in

Crawford County, and is operated in connection with a large rock-crushing plant whose output is used for ballast and macadam. In the lime plant, four kilns are in use, two of steel and two of stone, the total capacity of which is 1,500 bushels of lime per day. The burning is by the older style of the continuous process kiln in which both fuel and stone are put into the kiln in alternate layers, from the top. The greatest diameter of the stone kilns is about one-third their height above their base. From this they taper gradually down to the "eye" or draw pit. Their capacity is about 375 bushels per day, that of the steel kilns being a little more. Indiana coal from the Ayrshire mines near Oakland City, is used as fuel. Each draw of stone requires from 36 to 48 hours to convert it into lime.

The stone used is Mitchell limestone from certain beds of the quarry which is operated for crushed stone. A detailed section of this quarry is as follows:

SECTION EXPOSED AT J. B. SPEED QUARRY, MILLTOWN, IND.

		Feet.	Inches.
1.	Buff, weathered limestone	1	8
2.	Coarsely crystalline limestone, with numerous crinoid stems	2	0
3.	Pure white oölitic limestone, with few fossils	4	0
4.	Light buff to drab lithographic limestone	5	0
5.	Greenish shale	0	4
6.	Gray lithographic limestone	0	10
7.	Greenish-gray shale, intercalated with bands of lithographic limestone, two to eight inches thick	0 to 1	6
8.	Gray, lithographic limestone	7	0
9.	Soft, granular, buff magnesian (?) limestone	3 to 4	0
10.	Lead gray, fine-grained, crystalline limestone	3 to 4	0
11.	Pure white oölitic limestone	5	0
12.	Calcareous shale	2 in. to 0	4
13.	Gray oölitic to sub-oölitic limestone	4	6
14.	Limestone with black chert	1 in. to 0	8
15.	Drab colored, impure limestone	4	0
16.	Bluish gray lithographic limestone	0 to 0	10
17.	Dark gray, sub-oölitic to sub-crystalline limestone	8	0
18.	Very soft, drab colored, magnesian limestone	6	0
19.	White oölitic limestone	6	0
20.	Gray limestone	16	0

The beds used for lime are Nos. 3, 11 and 17. Nos. 3 and 11 composed of oölite or oölitic limestone of very great purity.

They correspond to similar beds in the Eichel quarry across the river, a chemical analysis of which showed the presence of 98.91 per cent. carbonate of lime.

The stone, after being blasted and broken to the proper size, is loaded into cars and hauled by steam-power up an incline to the top of the kilns; 26.4 cubic yards constituting what is termed a draw or one day's burning. This produces 375 bushels of lime. On account of the process of burning in use, quite a good deal of trouble is experienced with "cores" or centers of the larger pieces of stone which pass through the kilns unburned. Two men are required to separate these when the product is shipped in bulk.

The lime made from beds Nos. 3 and 11 is very white; that from No. 17 is a darker gray in color. The lime is termed "hot" or quick-setting by masons. An analysis of an average sample, made by Messrs. Burk & Arnold, of Louisville, Ky., showed its composition to be as follows:

ANALYSIS OF LIME FROM J B SPEED & CO., MILLTOWN, IND.

Calcium oxide (CaO)	98.24
Magnesium oxide (MgO)	.56
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	.42
Insoluble residue (silica, etc.)	.30
Moisture	.54
Total	100.06

The lime is sold mainly in southern Indiana, Illinois, Ohio and West Virginia. In September, 1903, it was bringing 12½ cents per bushel, or 60 cents per barrel at retail at the plant. Fifty per cent. was being shipped in barrels, the remainder in bulk in car-load lots. About ten per cent. went to paper manufacturers, the remainder being sold for building purposes. Forty men were employed in the lime industry by the company. Their wages ran from $1.30 per day for the quarrymen to $2.00 per day for experienced burners. The plant is run the year around, but with a decreased output in the winter months. The lime has a wide reputation for purity and, in the region where sold, is preferred to the slower setting limes made from the Niagara limestone.

Besides the ordinary quicklime, the J. B. Speed Company make a hydrated lime of two grades, the best of which is sold under the name of "White Rock Finish." A separate plant a few rods north of their kilns is used in its preparation. The No. 1 grade of hydrated lime is made from ordinary quicklime by first crushing, then grinding to extreme fineness. The ground product is then mixed with a certain quantity of water, after which it is passed through a fine bolting cloth. As it issues from this it resembles a very fine flour, but is much lighter, bulk for bulk. It is sold in sacks of two sizes, either cloth or paper, which hold 40 pounds or 100 pounds.

When mixed with water, this hydrated lime is ready for immediate use, and possesses all the qualities of lime putty. It does not air slack and can be applied to almost any purpose for which lime is commonly used, being especially suitable in those lines of manufacture where a dry, inert, carefully seasoned preparation of lime is required. In its use for mortar making, a saving both of time and of water is effected.

In the making of No. 2 hydrated lime an inferior grade of quicklime is used, the same being air-slacked lime from the kilns and portions which have become fused with cinders while passing through them. The process of manufacture is the same as for the No. 1 grade, except that it is not passed through the bolting cloth. It brings $2.50 per ton and is sold in bulk as a top dressing for soils, mainly to Illinois farmers. It is not used as a fertilizer, but as a material for improving the mechanical condition of soils.* The J. B. Speed Company has the only plant for making hydrated lime in the State, and has made quite a success of the business. Similar plants are said to be in operation in northern Ohio.

Eichel Lime and Stone Co.—The plant of this company is located on the east side of Blue River, in Harrison County, about one-quarter of a mile east of the Speed plant. As with the former, the lime industry is carried on in connection with that of preparing crushed stone. The company began the burning of lime in 1903. Three steel kilns are in operation, each of which is 36 feet in height and 20 feet in outside diameter. The process of burning is the same as that of the Speed Company, the kilns being charged at the top with alternate layers of stone and coal. The latter is shoveled in in such a manner as to spread evenly over the center

*See "Uses of Lime," on p. 216.

of the kiln. The outer edge of the layer of coal should not be nearer than one foot to the inner edge of the kiln; otherwise the latter is apt to become too hot, thus causing the partially burned lime to stick to it. If the coal is heaped in the center of the kiln, it is apt to smother down the fire. Ayrshire coal is used as fuel, it being as free from sulphur as any obtainable along the Southern Railway.

The stone used is of the same nature as that used by the plant across the river, the Eichel Company owning 26 acres of stone land surrounding their quarry. A section down the face of the quarry showed the presence of the following beds:

SECTION AT EICHEL QUARRY ON EAST SIDE OF BLUE RIVER, OPPOSITE MILLTOWN, IND.

		Feet.	Inches.
1.	Light drab and light brown lithographic limestone	7	0
2.	Light and bluish drab calcareous shale	1	3
3.	Light drab, lithographic limestone, slightly cross-bedded, with thin lines of coarse sand grains especially toward the top	12	0
4.	Light gray limestone	9	0
5.	White to dark gray oölitic limestone, oölitic structure not distinct	13	0
6.	Hard blue, sub-crystalline, sub-oölitic limestone, (crowfeet)	6	8
7.	Bluish green shale	0	2
8.	Light gray, granular limestone, one notable crowfoot near the middle, accompanied with some green matter	5	0
9.	Shale parting	0	1
10.	Interlayered gray crystalline and oölitic limestone	3	9
11.	Lithographic limestone in thin layers, with shale partings	2	0
12.	Drab lithographic limestone, with calcareous bands and nodules	3	6
13.	Gray crystalline limestone	0	2-6
14.	Lithographic limestone, with numerous flint bands and nodules	7	0
15.	To river, about	10	0

The main bed used for lime is No. 5 of the above section. With it is combined portions of Nos. 3, 6, 8 and 10 of the section; in all about 38 feet. An analysis of the oölite from bed 5, made for this Department by Dr. W. A. Noyes, showed its chemical composition to be as follows:

ANALYSIS OF OÖLITE USED IN LIME MAKING AT EICHEL QUARRY, MILLTOWN, IND.

Calcium carbonate ($CaCO_3$)	98.91
Magnesium carbonate ($MgCO_3$)	0.63
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	0.15
Insoluble in hydrochloric acid	0.48
Total	100.17

Another analysis showing the average composition of six limestone beds of the quarry, including the oölite bed, resulted as follows:

ANALYSIS OF AVERAGE SAMPLES FROM SIX BEDS OF EICHEL'S QUARRY.

Calcium carbonate ($CaCO_3$)	96.87
Magnesium carbonate ($MgCO_3$)	1.19
Silica (SiO_2)	.51
Alumina (Al_2O_3)	.37
Total	98.94

The stone is loaded at the quarry into steel cars, which are drawn up an incline to the top of the kilns, where they are dumped automatically. About 20 cubic yards are used for a draw of 360 bushels. Each draw is about four days in passing through the kiln, but is in actual contact with the fire about 36 hours. The oölite stone loses fully half its weight while being changed into lime.

The Eichel lime, like that from the Speed kilns, is a hot lime, which slacks very quickly. It is also termed a "strong" lime; i. e., a bushel of it will, it is claimed, make more mortar than that produced farther north. About eight per cent. is sold to paper manufacturers, and quite a quantity is ground and goes to glass works, especially to bottle glass factories. The greater quantity is sold for mortar and plaster; the principal markets being in Indiana, Illinois, Kentucky and Missouri. The retail price is the same as at Speed's kilns, the wholesale price not being given. The plant is operated throughout the year. Twenty hands are employed in the quarry and at burning, at wages ranging from $1.30 to $2.00 per day. Besides these, five coopers are engaged in making barrels, for which they receive four cents apiece; an average of 50 being completed in a day by each man.

At Salem, Washington County.

Salem, the county seat of Washington County, is a town of 2,000 population, located on the C., I. & L. (Monon) Railway, 41 miles northwest of Louisville, Kentucky. The quarries of Bedford oölitic limestone near which the limekilns are situated, are in the northwest quarter of section 19 (2 N., 4 E.) one mile west and a little south from the courthouse. They were first operated under the name of the "Salem Stone & Lime Co.," and then for a time under that of "The Salem-Bedford Stone Company." In 1896 Mr. Hopkins wrote of them as follows: "These quarries were for many years worked quite extensively and produced some excellent building stone which went into fine buildings. The Georgia statehouse is constructed of this stone, as is the Salem courthouse, one of the neatest courthouses in western Indiana. There are a half dozen different but closely adjoining openings along the bluff running south from the railway on the west side of the branch road made by the company. The bottom of the stone is concealed either by water or debris at present, so that the total thickness of the stone is not shown. The walls show from three to five channel cuts, or from 20 to 30 feet, with three to 20 feet of rock and soil stripping. The stone has a medium fine grain; no large fossils were observed. The greater part of the stone is buff, yet in a few places a little blue stone occurs. There is a large stone mill and a number of limekilns at the quarry, but the mill is now idle. Most of the channelers have been removed and there appears to be very little dimension stone being quarried.

"A unique feature of this quarry is the absence of the large dump piles of waste stone, the universal accompaniment of the quarries elsewhere. The explanation of this is found in the limekilns at the quarry, where all the waste stone is burned to quicklime and marketed in that form. The only stone that is being quarried at present (July, 1896) is the broken stone for lime burning."*

The Union Cement and Lime Co.—The first lime was burned from the Bedford oölitic stone at the Salem quarries about 1884.

*"The Bedford Oölitic Limestone of Indiana," in 21st Ann. Rep. Ind. Dept. Geol. and Nat. Res., 1896, p. 394.

In 1898 the property passed into the control of the Union Cement and Lime Company, whose main offices are at Louisville, Kentucky. This company at present controls 50 acres of stone land in the immediate vicinity of their plant. The latter is located on a spur of the Monon Railway, a dummy engine, owned by the company, doing the switching.

Five continuous process kilns are used in burning the lime, three of which were in operation in October, 1903. Four of the kilns are of stone; the other of steel. The dimensions of the stone kilns are, base, 22 feet square; top, 18 feet square; height, 38 feet above the drawpit. The stone kilns have a capacity of 250 bushels each and the steel kilns 175 bushels, per day. Wood, oil and coal have all been used as fuel, the use of the first two having been abandoned on account of increase in cost. The coal used in 1903 was nut and slack from Wolfman's mine near Huntingburg, Dubois County, and cost $1.40 per ton, delivered at the plant. The firing is done in furnaces located at the base of the kilns, above the drawpit. Blowers are used in all furnaces to increase the draught.

The quarry from which the stone is at present obtained is located just back of the lime plant, and disclosed the following section:

SECTION OF QUARRY NEAR KILNS OF UNION CEMENT AND LIME CO., SALEM, IND.

1.	Soil, surface clay and weathered stone (stripped)...	5 feet
2.	Buff to gray oölitic limestone......................	8 feet
3.	Bastard oölitic stone..............................	10 feet
4.	Buff to blue oölitic limestone (massive)............	30 feet

The stone used in making lime is from beds 2 and 4 of the section. The bastard stone, bed 3, burns into a yellow lime, which makes a tough putty-like plaster, hence the whole ledge has to be discarded and hauled to one side thus increasing the cost of the lime produced. The stone is first blasted and then broken by sledge or squib blast into small pieces. That from ledge No. 2 is hauled up an incline to the top of the kilns, while that from the deeper ledge, No. 4, is raised by derricks. The latter will be abandoned as soon as room enough is afforded for an incline to the bottom of the quarry. No analysis of the stone used for lime was available, but it is very similar in composition to that from the Twin Creek quarries, about seven miles northwest, whose analysis showed the presence of 98.16 per cent. of carbonate of lime, .97 per cent. of carbonate of magnesia, and only .91 per cent. of impurities. The kilns are filled by day and topped up for night burning. Bins at the top hold stone enough for two or three days' burning when severe weather is experienced. The plant is operated all the year, except for two or three weeks in midwinter. But little trouble is experienced with "cores."

The lime is drawn every eight hours, the output for the three kilns in operation at the time of my visit being 750 bushels daily. It is at first rather dark in color, but becomes pure white when slacked. It is a "hot" lime, which slacks quickly and is evidently very pure in composition. It is used mainly for mortar and plaster, though large quantities are sold to tanneries and paper mills. It is shipped wholly in bulk, and goes mainly to Louisville, from which point it is distributed by the company. At Salem, where there is no competition, it is retailed at 20 cents per bushel. The cost of production is estimated at about 9½ cents on board cars. The company refused to give information regarding the wholesale selling price, or to furnish analysis of either lime or stone, but an analysis of the lime made by Chauvenet & Bro., of St. Louis, showed its constituents to be:

Calcium oxide (CaO)	96.93
Magnesium oxide (MgO)	.85
Silica (SiO_2)	2.22
Total	100.00

Twenty men are employed in and about the plant, their wages ranging from $1.25 for quarrymen to $1.60 per day for foremen and chief burners.

AT MITCHELL, LAWRENCE COUNTY.

Mitchell, a town of 2,500 population, is located in the southern part of Lawrence County at the junction of the C., I. & L. (Monon) and B. & O. S. W. railways, 67 miles northwest of Louisville, and 127 miles west of Cincinnati. The Mitchell limestone, of which mention has been made a number of times in this paper, takes its name from the town, which is located on this stone.

Lime has long been burned from the Mitchell limestone in the vicinity of the town. The first kilns were of the temporary ground-hog pattern. They were in time replaced by the more permanent intermittent burning stone pot kilns. One of the first men in the region of Mitchell to make the burning of lime his principal industry was Asa Erwin, who operated several of these pot kilns 40 or more years ago. John Collett, in his report on the Geology of Lawrence County, published in 1873, makes mention of Erwin and his industry as follows: "Mitchell lime is favorably known to the trade. Asa Erwin, on a branch of Rock Lick Creek, N. E. quarter section 24 (4 N., 1 W.), uses a common kiln, capable of burning one thousand bushels at a time. His annual product is seventeen thousand five hundred bushels, which sells at twenty cents per bushel delivered on the cars. The product is a white lime, which works 'hot,' and is found to be nearly equal to cement for foundations. He makes use of the *Vermicular* stratum, a bluish gray limestone, massive, but traversed in every direction irregularly by tubular canals, from one-eighth to one-half inch in diameter. The stone, on account of its porous nature, is found to burn and slack with great certainty. The waste lime from this kiln has been used with remarkable profit as a manure, and the result invites further experiment."*

The Big Four Lime Company, also operated for a number of years, six or more pot kilns on the main fork of Rock Lick Creek in the northwest quarter of section 30 (4 N., 1 E.), about two miles southeast of Erwin's location. In 1895 the Mitchell Lime Company was organized and by purchase or lease secured possession of both the plants then in operation and all the adjacent stone land suitable for making lime.

THE MITCHELL LIME COMPANY.—This company now owns two large plants on or near the sites of the older pot kilns above mentioned. The larger one of these is the Monon or Rabbitville plant, located on a spur of the Monon Railway, two and a half miles north of Mitchell. The company owns 178 acres of stone land immediately surrounding the plant. On a portion of this the town of Rabbitville, consisting of about 20 neat frame houses and a good brick schoolhouse, is situated. In them live the workmen em-

*5th Ann. Rep. Geol. Surv. of Ind., 1873, p. 302.

ployed about the kilns and quarry. Six modern steel kilns, of 250 bushels capacity each are in use at this plant. The actual output of each kiln averages 200 bushels daily. Both wood and coal are used for fuel. The coal usually comes from Greene and Daviess counties, Indiana. In October, 1903, however, only Daviess County coal was being used, and it was being hauled by wagon from cars at Mitchell and cost about $2.00 a ton laid down at the plant, as against $1.70 for the same coal delivered at the other plant, the difference in cost being due to switching charges by the Monon Railway.

The quarry of Mitchell limestone, from which the stone for burning is obtained, is located just southeast of the kilns. After one to five feet of stripping, composed of soil and bluish outcropping stone, is removed, the face of this quarry discloses nine ledges of stone which are used for lime. These ledges vary in thickness from 10 inches to five feet, and comprise a total thickness of 26 feet. Below the lowermost of these and between it and the Bedford oölitic stone is a ledge 16 feet thick, which is composed of about 80 per cent. lime and 14 per cent. silica. The top of this ledge forms the floor of the quarry and is kept clean of all rubbish and broken stone by the superintendent in charge. All the strata in the quarry dip to the southwest at the rate of one foot to 100 feet, or 52 feet to the mile.

The company has had made an analysis of each of the nine ledges used for lime making. These analyses show a very close uniformity in composition, the carbonate of lime ranging only from 95.73 to 97.51 per cent. An average of the nine analyses was as follows:

AVERAGE ANALYSIS OF NINE LEDGES OF STONE USED FOR LIME MAKING AT THE MONON PLANT OF THE MITCHELL LIME CO.

Calcium carbonate ($CaCO_3$)	96.65
Magnesium carbonate ($MgCO_3$)	1.20
Ferric oxide and alumina (Fe_2O_3+Al_2O_3)	.27
Insoluble residue (silica, etc.)	1.57
Total	99.69

On the eastern side of the quarry, a ledge eight feet from the top, and the fourth in serial order, is more of a bluish hue than the others. It is 30 inches in thickness and is burned separately, the resulting lime being sold for chemical uses only. The analysis of this particular ledge showed its composition to be:

ANALYSIS OF LEDGE NO. 4, AT QUARRY OF MONON PLANT OF MITCHELL LIME CO.

Calcium carbonate ($CaCO_3$)	96.46
Magnesium carbonate ($MgCO_3$)	0.00
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	0.16
Insoluble residue (silica, etc.)	2.46
Total	99.70

The stone from the quarry is raised by an inclined tramway and dumped into bins at the top of the kilns. From these bins it gradually finds its way down through the kilns, about four days elapsing before it is drawn out as lime. The drawing takes place every four hours. The pieces of lime produced are larger than the average, but contain few cores. The waste is said not to exceed five bushels to the car load.

The second or "Rock Lick Plant" of the Mitchell Lime Company, is located about one mile northeast of Mitchell, near the sites of the former kilns of the Big Four Lime Company, and on a switch of the B. & O. S. W. Railway. A rock-crushing plant is operated in connection with the lime making industry, the two being carried on in separate buildings, but a few feet apart and alongside the same switch. The company owns 149 acres of stone land in the near vicinity. Five steel kilns of the same size and pattern as those at the Monon plant are in use for burning lime.

The quarry from which the stone is obtained is opened to a depth of 30 feet, the upper 14 feet being used for lime, the lower 16 feet for crushed and ground stone. The stone used for lime contains a little more silica than that burned at the Monon plant, but otherwise is quite similar.

The lime made at Mitchell has a wide reputation for strength and purity. It is claimed by the company to be "the strongest white lime on the market." It is said to be a quick slacking, and cool working lime which, when slacked, increases largely in bulk, so that 100 pounds will make mortar enough to lay 1,000 brick.

An analysis of a freshly burned sample of the lime from the Monon plant, made by E. F. Buchanan, the chemist of the Colonial Salt Company, of Akron, Ohio, showed its composition to be as follows:

ANALYSIS OF MITCHELL LIME FROM MONON PLANT.

Calcium oxide (CaO)	97.712
Magnesium oxide (MgO)	1.150
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	.328
Insoluble residue (silica, etc.)	.418
Carbonic oxide (CO)	.319
Undetermined	.073
Total	100.00

On account of its purity, a large amount of the lime is sold in Chicago and Cincinnati for chemical use, caustic and soap manufacture, etc. Quite a quantity goes to paper factories, and the remainder for mortar and plaster. About 20 per cent. is shipped in barrels. The cost of barrels made at the plants was 28 cents apiece, of which amount the coopers received 3½ cents. The principal markets for the lime are in Indiana, Ohio, Michigan and Illinois. In October, 1903, the price at the kilns was 13 cents per bushel, or 60 cents per barrel of 185 pounds. In carload lots it brought about two cents less per bushel.

The Mitchell Lime Company is incorporated for $50,000, and has about $30,000 invested in the lime industry. Seventy-five men are employed, most of whom do piece-work. The wages of the burners and drawers average $14.00 per week of seven days. Quarrymen receive $1.25 to $1.50 per day, and common laborers 13 cents per hour. Five cars of lime and 10 to 12 cars of crushed and ground stone were being shipped each day from the two plants of the company in October, 1903. The plants are operated the year around, but with a decreased output in the colder months.

NEAR BEDFORD, LAWRENCE COUNTY.

Bedford, the county seat of Lawrence County, is a city of 7,000 population, situated on the C., I. & L. (Monon), Southern Indiana, and a branch of the B. & O. S. W. railways, 77 miles northwest of Louisville. It has long been the center of the Oölitic Stone Industry of the State, the largest and oldest worked quarries being in its immediate vicinity. Lime has been burned from the oölitic stone at a number of localities about Bedford, but not in recent years; the burning having been done in temporary kilns for local use in the days when transportation facilities were meager. About every oölitic quarry of any size in Lawrence and Monroe counties there are dump or "grout" piles containing thousands of cubic yards of refuse stone. This stone is as pure chemically as any sold for building purposes but on account of some flaw, such as a small crack or "crowfoot," is unsalable.

THE HORSESHOE LIME AND CEMENT COMPANY.—In 1902, the Horseshoe Lime and Cement Company was organized for the purpose of utilizing by burning into lime the spalls and waste stone which had accumulated for years at the P. M. & B. quarry, about five miles northwest of Bedford. This quarry is located on a spur of the Monon Railway in the southwest quarter of the northeast quarter of section 33 (6 N., 1 W.). The spur leading to it leaves the main line of the Monon a short distance north of the famous horseshoe curve or bend, hence the name adopted by the company. The quarry was first opened in 1889, and, having been continuously operated, the grout pile is therefore a very large one.

The kilns of the lime company, three in number, of the continuous burning pattern, are located near the center of the excavated portion of the quarry. They are of stone and are 18 feet square at the base, 4 feet at the top, and 40 feet in height. The capacity of each kiln is 250 bushels per 24 hours. The furnaces are especially arranged for burning slack coal, being enclosed like a regular boiler front. The Dorrance shaking grate, having 66 per cent. air space, is used in the furnace, and the slack coal is burned successfully without artificial draught of any kind. The fire is kept low, being not over six inches high at any time and the grate can be cleaned in a minute or two. The furnace is at no point within three feet of the body or center of the kiln, there being a four-foot arch leading back from the fire box to the kiln. The coal used comes from Linton, Indiana, and costs $1.75 per ton, laid down at the mine. This is a high price for "slack," but it is said that the freight rate on coal from Linton to Bedford, a distance of 49 miles, is the same as from Linton to Chicago, 213 miles. It is thus that the railways foster the infant industries which spring up along their lines.

The spalls or refuse stone used for lime by the Horseshoe Company are in large pieces, some of them containing 200 cubic feet. These are blasted to the required size and hauled up an incline plane to bins or cribs six feet high on the top of the kilns. From here the stone gradually descends through the kiln, taking on an average two and a half days before issuing as lime.

Being burned from stone wholly free from dirt, and in kilns whose construction keeps it separated from all cinders, the lime made by the Horseshoe Lime Company is noted for its purity. On this account it is sold mainly to the chemical trade. It is shipped wholly in bulk in carload lots, and goes to Indianapolis, Chicago and points north and northeast. Quite a quantity is furnished to a large paper mill at Lafayette and to the Illinois Steel Company for use in the manufacture of steel Puzzolana cement. This cement is a mechanical mixture of blast furnace slag and lime slacked with a solution of soda.

Except while undergoing repairs the three kilns have been continuously in use since they were built and the demand for the lime is said to have exceeded the supply. A new kiln of the same capacity as those existing will be erected in 1904. Two analyses of the lime, made for the company, No. 1 by Chauvenet & Bro., of St. Louis, and No. 2 by T. W. Smith, of Indianapolis, showed its chemical composition to be as follows:

ANALYSES OF LIME FROM THE HORSESHOE LIME AND CEMENT CO., BEDFORD, IND

	No. 1.	*No. 2.*
Calcium oxide (CaO)	98.40	97.80
Magnesium oxide (MgO)	.10	.18
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	.52	.62
Insoluble residue (silica, etc.)	.78	1.38
Total	99.80	99.98

For building purposes the Horseshoe lime is a "hot," strong lime, which combines with a large amount of sand in making mortar and plaster. It slacks out very fine and makes an excellent skim coat.

The fact that the Bedford oölitic limestone has long been used in lime making at Salem, coupled with the recent success of the Horseshoe Company at Bedford, should be sufficient proof of the fitness of that stone for a high grade, chemically pure lime. Immense quantities of spalls, already quarried, free from dirt and other foreign matter, exist about all the larger quarries of the region. As the demand for a pure lime increases, there is little doubt but that much of this refuse stone will be used for lime making in kilns which will be hereafter erected.

Near Laurel, Franklin County.

Laurel is a town of 650 population, situated in the northern part of Franklin County, on the Whitewater Division of the Big Four Railway, 54 miles northwest of Cincinnati, Ohio. The town is located near the eastern horizon of the Niagara limestone, and the stone from the vicinity has long been quarried for curbing, flagging, foundations, abutments and similar purposes.

Between 1870 and 1885 lime was burned quite extensively in the vicinity of Laurel for the Wawasee Paper Mill, which was then located on the Whitewater River, three miles above Laurel. Many farmers in the vicinity added not a little to their income by burning lime in temporary kilns for the use of the mill. When, about 1885, the latter burned, the industry was discontinued. A number of local kilns were also from time to time burned about three miles east of Laurel, but for a number of years the lime used at Laurel, Brookville and neighboring towns has been shipped in from New Paris and Springfield, Ohio, where extensive kilns are in operation.

In 1903, the Laurel Steam Stone Company, which controls the output of a large quarry near Derbyshire Falls, in section 20 (12 E., 12 N.), erected near the quarry a temporary kiln and burned two kilns, or 5,000 bushels of lime. According to John O'Hair, the president of the company, the stone used is a ledge immediately underlying the Clinton limestone, and contains 93 per cent. of carbonate of lime. The burning was done more as an experiment to determine the fitness of the lime for use in the large paper mill at Brookville, ten miles below Laurel. The lime was burned with wood, in 72 hours' time, and gave excellent satisfaction at the mill, where it was all sold. This mill uses from three to five carloads a week, and has heretofore been getting it in Ohio and northern Indiana at a cost of 13 cents or more per bushel. The Laurel Steam Stone Company say they can burn it for seven cents or less, and expect to put in a modern plant in 1904 for that purpose. Several good gas wells are located in the near vicinity, and gas will be used for fuel as long as it lasts.

REPORT OF STATE INSPECTOR OF MINES.

OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, IND., February 15, 1904.

Prof. W. S. Blatchley, State Geologist:

Dear Sir—I have the honor to submit to you herewith my fifth annual report as Inspector of Mines, covering the calendar year of 1903, and being the Twenty-fifth Annual Report of this Department, and the thirteenth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

CONTENTS.

INTRODUCTION.

The subject matter of this report is treated under the several captions—

Review of coal trade.
Labor conditions.
Mine casualties..
Statistical.

In the review of coal trade, all of the mining conditions existing in 1903, including the railroad service, is treated as fully as possible.

Under the head of labor conditions we include strikes, Terre Haute and Brazil agreements, and other conditions pertaining to labor. Under mine casualties, various tables are given, exhibiting the cause, number and frequency of accidents to mine employes, also accidents to mine property.

The statistical part of the report gives tables showing the production of coal, number of mine employes, number of mining machines in use, number of mules, number of kegs of powder, tables of averages and comparative tables. These same subjects have all been treated in our former reports. However, by referring to the table of contents, it will be found that we have given some additional information which will be of interest and value to the general public. The production of coal and its distribution and the wages paid to employes have been treated in the same general manner as in our former reports. Mine accidents have been put in more complete form, in tables showing the age and nationality of persons killed and the number of dependents left at each death.

There has also been included the following additional tables, viz: a table showing the number of kegs of powder used in the mines during the year 1903, the price paid per keg and the number of tons of coal produced per keg; a table of mine haulage showing the number and kind of motors in use, and the number of mines at which rope haulage is used (the same table shows the number of steam boilers, number of dynamos, and the number of compressers in use at Indiana mines), and a table showing by counties the name of mines using box car loaders; a table giving the average price per ton for machine and pick mining from 1900 to 1903, inclusive; also the percentage of gain over 1900.

Assistant Inspector of Mines, Charles Long, resigned September 15, and Jonathan Thomas, of Carbon, was appointed to fill the vacancy. His work in inspections and reports has been eminently satisfactory.

TABLE,

Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1903 at Mines Employing More Than Ten Men.

MONTHS.	CLAY COUNTY.		DAVIESS COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	148,913	$137,440 40	21,265	$19,280 91
February	129,257	123,294 13	17,772	16,778 13
March	105,127	111,976 05	12,125	11,584 95
April	61,505	88,794 64	11,712	12,082 71
May	72,630	94,035 42	17,663	18,079 84
June	82,746	107,215 42	17,818	17,788 82
July	82,746	104,695 42	14,543	14,662 65
August	91,740	110,283 65	3,380	3,388 20
September	110,666	131,249 92	15,388	15,930 13
October	125,242	147,322 89	21,286	23,120 50
November	101,901	124,878 07	16,748	19,561 19
December	109,958	134,322 05	21,459	23,184 09
Total	1,222,431	$1,415,508 06	191,159	$195,442 12

	FOUNTAIN COUNTY.		GIBSON COUNTY.	
January	....	....	8,196	$3,976 83
February	....	....	6,111	5,510 79
March	....	....	6,615	5,708 96
April	....	....	4,440	4,456 36
May	....	....	1,260	1,419 55
June	207	$379 50	2,050	3,172 58
July	3,717	3,194 40	2,320	4,674 08
August	2,329	2,048 29	2,896	4,921 19
September	2,395	1,742 00	3,967	5,330 38
October	2,411	1 993 00	1,099	2,988 93
November	2,728	1,927 00	3,378	4,234 57
December	2,748	2,052 00	4,368	4,838 84
Total	16,635	$13,336 19	46,700	$51,233 06

	GREENE COUNTY.		KNOX COUNTY.	
January	207,263	$177,988 94	14,902	$12,706 01
February	176,073	113,136 58	11,922	10,096 65
March	213,253	155,856 36	12,316	9,693 43
April	132,928	119,388 85	8,372	6,937 11
May	143,737	132,801 63	8,811	7,059 96
June	149,310	136,216 21	9,457	8,115 18
July	167,108	152,163 39	7,144	6,565 66
August	166,061	145,150 04	7,783	6,224 38
September	191,480	169,861 38	10,956	15,014 20
October	226,350	198,018 03	13,689	12,517 42
November	225,026	195,092 70	16,549	13,482 27
December	228,202	192,371 33	16,048	14,179 24
Total	2,226,789	$1,888,045 39	137,949	122,591 61

MONTHS.	PARKE COUNTY.		PERRY COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	66,766	$98,818 93	1,419	$1,436 04
February	82,339	85,746 06	1,164	856 35
March	96,457	87,297 64	1,200	1,027 11
April	41,905	53,864 03	1,124	1,070 49
May	50,218	65,015 92	799	785 50
June	56,282	74,067 83	1,016	962 01
July	66,948	82,959 70	1,106	1,115 35
August	79,058	99,452 89	615	649 25
September	85,019	104,850 54	591	669 03
October	99,995	118,260 48	849	947 83
November	84,052	104,298 52	786	969 77
December	113,955	113,871 72	451	626 62
Total	922,994	$1,088,504 26	11,120	$11,115 35

	PIKE COUNTY.		SULLIVAN COUNTY.	
January	58,638	$48,542 56	157,521	$104,955 00
February	46,231	38,300 06	122,053	93,230 36
March	52,274	43,478 35	129,168	96,240 74
April	26,807	27,144 71	100,227	82,658 38
May	27,868	28,825 00	104,804	84,547 27
June	28,883	28,422 16	117,979	97,825 52
July	27,203	30,552 88	120,818	101,758 77
August	34,612	33,305 64	140,739	117,939 01
September	44,843	42,419 56	142,610	123,671 07
October	54,404	50,062 51	142,075	113,602 97
November	39,449	37,912 65	133,776	125,746 77
December	43,016	40,965 91	141,568	122,261 13
Total	484,258	$449,931 99	1,553,338	$1,264,436 99

	VANDERBURGH COUNTY.		VERMILLION COUNTY.	
January	28,035	$18,645 59	74,010	$53,347 68
February	22,661	16,198 87	81,861	60,535 37
March	13,278	11,954 71	84,634	62,306 03
April	9,896	9,988 06	49,138	31,095 39
May	11,439	11,413 49	63,280	51,952 75
June	9,600	10,172 17	76,445	61,036 12
July	12,607	12,812 71	84,433	68,105 28
August	13,791	14,335 96	82,472	67,183 38
September	18,465	19,254 98	80,170	64,747 20
October	23,690	25,442 16	77,424	67,233 01
November	20,356	21,347 83	94,146	80,642 67
December	20,830	21,169 25	94,152	80,462 87
Total	204,648	192,735 78	942,165	$748,447 77

	VIGO COUNTY.		WARRICK COUNTY.	
January	166,397	$144,136 62	30,886	$19,063 73
February	138,269	122,125 61	25,199	15,163 95
March	128,887	105,251 85	25,481	18,308 34
April	205,625	86,076 80	20,661	15,191 91
May	106,326	105,933 90	15,572	12,953 22
June	116,111	102,767 32	21,444	14,707 26
July	137,471	121,859 55	19,967	12,974 32
August	137,318	128,638 43	25,554	18,022 16
September	141,329	134,227 00	24,744	18,463 02
October	146,334	154,937 15	31,701	22,679 58
November	139,077	136,766 54	37,047	25,201 21
December	153,582	151,041 03	37,385	21,753 05
Total	1,716,726	1,493,761 80	315,641	$214,481 75

REVIEW OF COAL TRADE.

The year just ended has been one of the most remarkable in the history of the mining industry of the State, more mines having been opened, more coal produced and more wages paid to employes. The total production, which reached 9,992,553 gross tons, shows a net increase of 1,229,356 tons, or nearly fourteen and one-fourth per cent. over 1902. This large increase is mainly attributable to the new mines opened, thirty-seven in number, yet as large as was the increase in production, it would have been very much greater had it not been for the shortage in railroad cars and lack of transportation facilities. This is especially true of the mines along the Southern Indiana Railroad. One mine on this road, viz: the Black Creek Mine, one of the largest producers in Greene County, fell short of the 1902 production something over thirty thousand tons. The Southern Indiana Railroad, however, was amply able to furnish both cars and transportation to the mines along its line had it not been for the numerous embargoes laid on the coal from their road by other railroads on which they were dependent for an outlet. To the general public, it would seem that the fault for this condition of affairs, attached to the railroads, yet, before placing the blame, it would be well to recall the following factors which should be taken into consideration, viz: the number of new mines that have been opened within the year, the number of railroad cars required to operate a fully developed mine, at say two-thirds time, and the interval from date of shipment of loaded cars and the returning of them to the mine, as well as the excessively heavy freight traffic of all kinds. A close railroad estimate gives thirteen days as the time required to ship a car of coal from the Linton field to Chicago and return the empty. Owing to transfers and other delays, it is presumed that the same would hold good for Indianapolis, while at some points in the gas belt it would require even a greater lapse of time. We must also bear in mind the additional fact that the majority of mines opened recently to operate at full capacity, require from twenty to fifty cars per day. From this it will be seen that the new mines have been opened so rapidly that the consequent demand for railroad cars and motive power could not be furnished to meet the increased requirements.

The market price of coal, while not as high as it was at times in 1902, on the whole has been very good, ranging from $1.15 to $1.45 per ton, mine-run, and mines have undoubtedly been operated at a profit.

The aggregate wages paid in 1903 amounted to $9,149,572.12, an increase over 1902 of $2,070,659.00, or nearly twenty and nine-tenths per cent., while the total number of mine employes was 15,128, an increase of 1,989, or a fraction over fifteen and one-tenth per cent. over 1902. The average wages paid to mine employes in 1902 was five hundred and thirty-eight dollars and seventy-seven cents per employe. In 1903 it was six hundred and four dollars and fourteen cents, an increase over 1902 of sixty-five dollars and thirty-seven cents per mine employe.

Considering the time lost at the different mines the above figures speak well as to the condition of miners and others employed about the mines.

NEW INVESTMENTS.

New investments within the year embrace mainly the opening of new mines, as reported before, thirty-seven in number, nearly all of which are equipped with up-to-date machinery, and will be classed among the largest producers.

IMPROVEMENTS, AND CHANGES IN OWNERSHIP OF MINING PROPERTIES.

One hundred and sixty-eight thousand seventy-one dollars and ninety-six cents was reported to this office as having been spent on improvements of various kinds at Indiana mines, during the year 1903. Owing to the large increase of new mines, and the fact that the purpose for which the money was used was not always reported, it is presumed that a part of that sum was expended in equipping the new mines.

The following will show the changes in ownership and some of the most important improvements that have been made:

The Rebstock, a new block coal mine, in Clay County, was opened during the summer by the I. McIntosh Coal Company, changed ownership in November, and is now owned and operated by the Crawford Coal Company, who classes it as their No. 9 Mine.

The Rob Roy, also a block mine, located near Brazil, owned by the Andrews Coal and Mining Company, was purchased during the summer by the United Coal Company, who operated it a short time before abandoning.

The Otter Creek Coal Company have equipped their Mary Mine, in Parke County, with six electric chain machines.

The Petersburg Mine, in Pike County, owned by the J. Wooley Coal Company, of Evansville, was purchased during the month of June by the Muncie Coal and Mining Company. They have made extensive improvements with a view of increasing the capacity of the mine.

The S. H. Wulfman Coal Company, Pike County, have expended several thousand dollars in improving their Hartwell Mine, building a new tipple, equipped with shaker screens, installing electric motor haulage, which should give the mine a capacity equal to any mine in the southern part of the State.

The Rainbow Coal and Mining Company, Sullivan County, made some very extensive improvements at their Caledona Mine, equipping the hoisting shaft, remodeling the tipple, head frame, etc. They equipped the mine with electric mining machines and motor haulage, in addition to having sunk a new air shaft at the head of the workings, equipping it with a high-speed electric fan, from which excellent results have been obtained in the way of ventilation.

The Mildred Mine, in Sullivan County, is a new mine opened late in the fall by the Busron Coal Company. The J. Wooley Coal Company purchased this mine about the time the mine was completed and ready to ship coal.

The Brazil Mining Company and the Miami Coal Company, in Vigo County, formed a consolidation in November, and are now operating under the name of the latter company.

The Big Four Mine, Warrick County, located at Boonville, and the DeForest Mine, located at DeForest, both of which were formerly ventilated by furnace, have been equipped with fans, and in both instances excellent results have been obtained.

The Victoria Mine, located near Linton, Greene County, formerly owned by the Victoria Coal Company, was purchased early in the year by L. T. Dickason. This mine is operated under the original name.

The Island Coal Company, Greene County, have replaced the rope haulage in their No. 2 Mine, with electric motor haulage.

The Greene Valley Coal Company, Greene County, have installed a box car loader at their Greene Valley Mine, which proved of great value during the busy season when cars were scarce.

The Lattas Creek Coal Company, Greene County, and the Northwest Coal Company, have installed box car loaders.

The Lynn Coal Company, Knox County, was reorganized during the year, and their mine, which was formerly operated as a wagon mine, supplying the town of Bicknell and the adjacent country, now has a mine switch from the main line of the I. & V. Railroad. The mine has also been thoroughly equipped with up-to-date machinery, including shaker screens. At present it has a capacity of about five hundred tons per day, employing seventy-five miners.

O'Cara King & Company purchased the Lyford Mine, in Parke County, in April. The Wabash Valley Coal Company formerly owned this mine. The present Company equipped the mine with electric chain mining machines and other modern improvements.

NEW MINES.

Thirty-four bituminous and three block coal mines have gone into operation within the past year, distributed in the different counties as follows:

Clay County, six; Daviess County, two; Fountain County, one; Greene County, six; Knox County, one; Parke County, three; Sullivan County, ten; Vermillion County, two; Vigo County, five, and Warrick County, one. Twenty-three of these, as shown by the following table, are hand or pick mines, while of the remaining fourteen there are three compressed air puncher machines, and eleven electric chain machine mines, which with few exceptions are equipped with the latest improved mining machinery of all kinds, such as self-dumping cages, shaker screens, box car loaders, first motion hoisting engines, etc., incident to handling a large output of coal and preparing it to suit the various market demands.

In the following table will be found the names of the companies owning and operating these new mines, the names of the mines, the railroad on which they are located, the geological number and thickness of coal seams, the depth and size of shaft, the kind of mines, the kind of machines used, when mines were commenced and when first shipment of coal was made.

TABLE OF NEW MINES.

BLOCK MINES.

CLAY COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
Continental Clay Works	Continental	C. & E. I.	III	4′	65	8 x 20	Pick	....	10-1, '02	7, '03
Crawford Coal Company	Rebstock	C. & E. I.	III	3′ 3″	85	7 x 14	Pick	....	7, '03	11-21, '03
Brazil Block Coal No. 7	Brazil Block No. 7	Vandalia	III	4′	105	8 x 17	Pick	....	'02	2-1, '03

BITUMINOUS MINES.

CLAY COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
Indiana Bituminous Coal Co	Fair View	Vandalia	VI	7′ 6″	80	9 x 19	Pick	....	8-1, '03	10-1, '03
Lewis Coal and Mining Co	Lewis	Southern Ind	V	9′	77	8 x 15	Pick	....	8-26, '03	7-1, '03
Zellar McClellan & Company	Cleverland No. 2	Vandalia	VI	7′	90	8 x 21	Pick	....	8-26, '03	10, '03

DAVIESS COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
Washington-Wheatland Coal Co	Wheatland	B. & O. S. W.	IV	5′	100	8 x 17	Pick	....	11-1, '02	7-20, '03
Mandabach Bros	Mandabach	E. & I.	V	6′	56	6 x 12	Pick	....	....	7-1, '03

FOUNTAIN COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
Silverwood Coal Co	Silverwood	Cloverleaf	V	....	......	....	Pick	....	....	12-1, '03

GREENE COUNTY.

oosier Coal Co..................	Hoosier No. 2	Southern Ind.....	V	7′	46	9 x 17	Machine..	Elec. chain.	....	11, '03
orth Western Coal Co............	North Western No. 3.	Southern Ind.....	IV	5′	75	9 x 16	Machine..	Elec. chain.	8, '02	2, '03
ohnson Coal and M. Co	Atlas No. 2	I. & V...........	IV	5′	128	9 x 16	Machine..	Elec chain.	12, '02	8, '03
ıland Coal Co	Island No. 5...........	Southern Ind.....	IV	5′	55	8 x 19	Pick......	....	7, '03	8, '03
etsinger Coal Co.................	Letsinger............	Southern Ind.....	III	7′ 6″	......	....	Machine..	Comp. air..	'02	2, '03
oal Bluff Mining Co	Twin	I. & V...........	IV	....	......	....	Machine..	....	....	10, '03

KNOX COUNTY.

nterprise........................	....	....	....	....	......	....	....	....	....	....

PARKE COUNTY.

arke County Coal Co.............	Parke No. 11.........	T. H. & L.........	VI	6′ 6″	102	8 x 16	Machine..	Comp. air..	7-1, '03	1, '03
Iinshall Vein Coal Co.............	Minshall No. 2.......	T. H. & L., Vandalia, Logansport	V	5′	107	9 x 18	Pick......	....	....	11-20, '03
accoon Valley Coal Co	Briar Hill............	T. H. & L....	VI	5′	Drift	Compa	ny bought	mine in Dec.	1902.	1, '03
Iecca Coal and Mining Co	Mecca No. 4..........	....	....	....	......	....	....	....	....	....

SULLIVAN COUNTY.

Iammoth Vein Coal Co...........	Mammoth Vein	E. & T. H	VI	6′	173	9 x 15	Machine..	Elec. chain	Spring, '03	12, '03
ittle Giant Coal Co...............	Little Giant	Monon	VI	5′ 6″	......	9 x 16	Machine..	Elec. chain.	Fall, '02	7, '03
ndiana Hocking Coal Co.	Lablanch	E. & T. H	VII VI	4′ 5′ 6″	221	9 x 19	Machine..	Elec. chain.	8, '03	12, '03
ruilettes Creek Coal Co..........	Bruilette's Cr'k No. 6	E. & T. H	VII	5′ 6″	80	9 x 16	Machine..	Elec. chain.	Fall, '03	12, '03
. Woolley Coal Co	Mildred..............	E. & T. H	VI	5′	144	8 x 17	Machine..	Elec. chain.	5-10, '03	12, '03
sland Coal Company.............	Island No. 4..........	I. & V............	IV	5′	260	9 x 17	Pick......	....	3, '03	11, '03
ummins Coal Co.................	Cummins	E. & T. H	VII	5′	Slope	....	Machine..	Comp. air..	Fall, '02	8, '03
itizens Coal Co.	Citizens..............	Local	VI	5′	165	8 x 16	Pick......	....	6, '03	10, '03
oal Bluff Mining Co..............	Superior No. 1	E. & T. H	VII	5′ 6″	112	9 x 18	Pick......	....	4, '03	11, '03
orth Jackson Hill Coal Co.......	St. Clair.............	Southern Ind	VI	5′ 6″	197	9 x 18	Machine..	Electric	6, '03	11, '03

TABLE OF NEW MINES—Continued.

BITUMINOUS MINES—Continued.

VERMILLION COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
Clinton Coal Company	Crown Hill No. 2	C. & E. I.	VII	5′	151	8 x 16	Pick		5-1, '03	7-14, '03
Brazil Block Coal Co	Rhoades	C. & E. I.	VII	5′ 6″	100	8 x 17	Pick		Fall, '03	10-1, '03

VIGO COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
Miami Coal Co.	Miami No. 2	C. & E. I.	VI	6′ 6″	50	8 x 16	Pick		Spring, '03	5-1, '03
Deep Vein Coal Co.	Deep Vein	Vandalia	VI	6′	170	8 x 10	Pick		Spring, '03	9-1, '03
Sugar Creek Coal Co.	Sugar Creek	Vandalia	V	6′	105	10 x 20	Pick			10-20, '03
Lost Creek Coal Co	Lost Creek No. 1	Vandalia	VI	6′	120	9 x 16	Pick		12, '02	9-1, '03

WARRICK COUNTY.

COMPANY.	MINE.	Railroad.	Geological Number of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Beginning of Operation.	First Shipment.
T. D. Scales Coal Co.	Scales	Southern Ind	V	7′	30	9 x 18	Machine	Comp. air	Fall, '02	6-1, '03

NOTE.—There are two seams opened at the Twin Mine, viz., No. IV and No. V. No. IV is found at a depth of one hundred and fifty feet from the surface, carrying four feet in thickness. No. V lies at a depth of fifty-six feet from the surface, six feet thick, and is opened by a double shaft nine by thirty feet in size, the coal from both being hoisted from the same opening. The steam boilers, hoisting engines, dynamos and other machinery are concentrated into one power plant, thereby causing a considerable saving in steam and electric power, labor and fuel, which are necessary to generate such power and operate the machinery, as well as labor in many other departments in and about a mine. There is also a saving in mine buildings, as one blacksmith shop, one carpenter shop, one powder magazine, one fan and fan house, one mule barn, etc., will answer for the two mines.

In addition to the above, the No. IV mine has been equipped with a system of light motor haulage with which it is the purpose to gather the coal direct from the working faces. If successful (there being no good reason why it should not) this will result in an immense saving in the cost of brushing the roadways for height, which on account of the thinness of the coal seam, would be necessary if mule haulage were used.

The sinking and equipping of a mine in this manner, with the existing conditions, is the first attempt of the kind in the State, and results are being very closely watched by those interested in mines and mining. The success of the motor haulage is especially interesting to the general public, as a problem will then perhaps have been solved which will place some of our thin coal seams on a better competitive basis with the thicker ones, and in many instances making it possible to operate mines at a profit in certain coal fields which are now considered worthless on account of such conditions as referred to above, thereby enhancing the value of such lands, also adding greatly to the value of workable coal in the State, the latter being a factor which at some future day will become an important one in connection with our fuel supply.

ABANDONED MINES.

Table Showing Names of Mines, Company and Month of Abandonment.

Name of Mine.	Company.	County.	Month.
Brazil Block No. 11	Brazil Block Coal Company	Clay	November.
Gart No. 5	Brazil Block Coal Company	Clay	March.
Briar Hill	Clay City Coal Company	Clay	March.
Eureka No. 2	Eureka Block Coal Company	Clay	January.
Pratt	Coal Bluff Mining Company	Clay	July.
Silverwood No. 3	Indiana Bituminous Coal Company	Clay	October.
Silverwood No. 2	Indiana Bituminous Coal Company	Fountain	February.
Bruilette's Creek No. 4	Bruilette's Creek Coal Company	Vermillion	January.
Brick Works	Terre Haute Brick and Pipe Co.	Vigo	June.
Nickel Plate	Brazil Mining Company	Vigo	September.
Ray	Seeleyville Mining Company	Vigo	February.

Labor conditions, as a whole, have been very satisfactory during the year, there having been but few strikes, other than local, and these usually lasted but a few days. The strike at the Black Creek Mine, during the summer, originating over the discharge of a driver for beating a mule, was of longer duration than any other. It was in effect some three weeks. We give herewith the Terre Haute and Brazil Agreements.

TERRE HAUTE AGREEMENT.

April 1, 1903, to March 31, 1904.

Pursuant to an agreement made between the Coal Operators and United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, Ind., February 7, 1903, the price of mining for bituminous coal in the State of Indiana shall be 90 cents per ton of 2,000 pounds for screened lump coal, made over a standard screen, and 55 cents per ton of 2,000 pounds for run-of-mine. That further details in scale of prices for pick and machine mining in the State of Indiana for one year, beginning April 1, 1903, shall be as follows:

The standard height of coal in Indiana shall be 3 feet 6 inches, excepting in mines already opened, where the standard height shall be 3 feet 3 inches. All coal less than 3 feet 3 inches in thickness and over 2 feet 9 inches, the price shall be 98 cents per ton for screened lump coal, and 64 cents per ton for mine-run coal. All coal less than 2 feet 9 inches and down to 2 feet 6 inches, the price shall be 106 cents per ton for screened lump coal and 65 cents per ton for mine-run coal.

Narrow entries 7 to 9 feet wide, \$1.86¾ per yard.

Wide entries 12 feet wide, \$1.16½ per yard.

Wide entries shall not be more than 13 feet nor less than 11 feet. In the event of a 10 or 11 feet entry being demanded by the operator, narrow entry prices shall be paid, if 14, 15, 16 or 17 feet entries are demanded the wide price shall be paid.

The right of the operators to drive an 18 foot room when necessary shall not be questioned.

Break Throughs.

Break throughs between entries shall be paid for at entry prices.

Break throughs between rooms, when sheared or blocked, shall be paid for at entry prices, but no break throughs shall be driven without consent of the operators. Nothing herein shall interfere with the law governing break throughs.

Room Turning.

Room turning	$4 50

Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by the operator. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, the price shall be ⅝ of regular price, or $2.81¼.

Machine Mining.

In entries 7 to 9 feet wide	$1 34

In entries 12 feet wide, ⅝ of price for narrow entries, or 83¼. Narrow work after punching machines shall be sheared when demanded by the operator. Narrow work after the chain machine must be done in a workmanlike manner.

Break Throughs.

Break throughs between entries, same as entry prices. Break throughs between rooms shall be paid for at same price when similarly driven.

Room Turning—$3.37½.

Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by the operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, price shall be ⅝ of regular price, or $2.10.

Day Work for Punching Machine.

Machine work, when paid for by the day, shall be for:

Machine runner	$3 17
Helper	2 56

Day Work, Chain or Cutter Bar Machine.

When paid for by the day, shall be for:

Machine runner	$3 01
Helper	3 01

Day work by machines shall apply only to opening new mines and defective work, such as horsebacks, etc.

Price Per Ton for Machine Mining for Punching Machine.

Vandalia track and north thereof:

Screened lump.—Runner, 11½ cents; helper, 10½ cents; loading, shooting and timbering, 50 cents. Total, 72 cents.

Run-of-Mine.—Runner, 7½ cents; helper, 7 cents; loading, shooting and timbering, 30½ cents. Total, 45 cents.

South of Vandalia track:

Screened Lump.—Runner, 10½ cents; helper, 9 and 3-10 cents; loading, shooting and timbering, 52 and 2-10 cents. Total, 72 cents.

Run-of-Mine.—Runner, 6 and 6-10 cents; helper, 6 and 6-10 cents; loading, shooting and timbering, 32 and 3-10 cents. Total, 45 cents.

For Chain Machine

Screened Lump.—Runner, 6¼ cents; helper, 6¼ cents; loading, shooting and timbering, 56 cents. Total, 68½ cents.

Run-of-Mine.—Runner, 4 cents; helper, 4 cents; loading, shooting and timbering, 34½ cents. Total, 42½ cents.

Machine shovels shall be furnished by the operators, but when replaced the old shovels must be returned, and in case of careless breaking or destruction, the helper shall pay for the shovel so destroyed.

Blacksmithing.

Price of blacksmithing shall be 1¼ cents on the dollar.

Sharpening shall be done in a workmanlike manner, and men shall not have to wait for their tools.

Day Labor.

Inside day labor shall not be less than $2.56 per day of eight hours, when men are employed. And for outside day labor on and north of the B. & O. S. W., the minimum price shall be $2.02½ per day.

South of the B. & O. S. W., the price shall be 20¼ cents per hour.

All outside day laborers working at the mines, excepting weighmasters, flat trimmer and dumper, who shall be regarded strictly as company men, shall be recognized as members of the United Mine Workers of America, and present conditions and hours of labor shall prevail during the existence of this contract; and, provided further, that in emergencies or in the absence of any regular employe the right of the operator to employ men not members of the United Mine Workers of America for outside day labor, shall not be questioned.

Any and all flat trimmers shall dock for dirty coal.

Dead Work.

1. It is agreed that the companies shall have the working places as dry as local conditions will permit, and said working places shall be in working condition at time of starting work in the morning. If any companies shall fail to have said working places dry or reasonably so one hour after starting time two successive days, the company shall, if said failure is traceable to neglect or carelessness of the company's agent,

give miner or miners so affected other work or pay him or them for time so lost.

2. The question of slate in or over the coal shall be and is regarded a local question to be taken up and adjusted by the methods provided in the annual Terre Haute agreement for the settlement of disputes. Provided, however, that established usages and prevailing conditions shall not be changed except in new mines where they have not been considered and adjusted.

3. Where bottom coal is excessively hard to take up, the operator shall have the option. If he demands that it be taken up he shall pay extra therefor. Provided, that where coal so left shall exceed 4 inches in thickness it shall be taken up by the loaders and paid for by the machine men, but this shall not apply when caused by sulphur boulders, rock or any unusual condition. And whenever there shall arise a dispute between any loader and boss, or committee and boss, as to whether the bottom coal in any room is "excessively hard," the company interested shall select a man who shall take up one-third of such bottom coal, and if by such test it requires more than forty minutes to take up all the bottom coal in such room, then the loader shall be paid at the rate of 30 cents per hour for such time so required in excess of forty minutes. This is to apply to the No. 4 vein of Linton coal.

General.

1. When the coal is paid for mine-run, it shall be mined in as good condition as when paid for on the screened lump basis, and, when loaded on the miner's car, it shall, as nearly as possible, be free from slate, bone coal, or other impurities, and, if it can be shown that any miner persistently violates the letter or spirit of this clause, he shall be discharged. Persistently, as used in this clause, means three cars the first week and two cars in any succeeding week. Nor shall he load an undue proportion of fine coal in any one car, but shall see that the fine coal is mixed with the large coal in such a way as to make a fair quality of mine-run coal. This provision for cleaning coal and penalty for failure also applies to screened lump coal.

2. The semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme courts of Indiana and of the United States.

3. The time for beginning work in the morning and the length of intermission at noon shall be considered a local question.

4. That the above scale is based upon an eight-hour work day; that it is definitely understood that this shall mean eight hours' work at the face, exclusive of the noon time, six days in the week or 48 hours in the week, and that no local ruling shall in any way deviate from this agreement, or impose conditions affecting the same, but any class of day labor may be paid at the option of the operator for the number of hours and fraction thereof actually worked at the hour rate, based on one-eighth of the scale rate per day. Provided, that when men go into the mine in the morning, they shall be entitled to two hours' pay whether the mine works or not, excepting in event of a mine being closed down by action of any member or members of the U. M. W. of A., the two hours' pay shall be forfeited.

Regarding Drivers.

They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the change at which they receive empty cars, but in no case shall a driver's time be docked while he is waiting for such cars at the point named.

5. Inside day work may be done upon idle days, and in case of emergency on overtime.

6. It is agreed that if any difference arises between the operators and the miners at any time, a settlement shall be arrived at without stopping the work. If the parties immediately affected can not reach an agreement themselves, the question shall be referred without delay to a board of arbitration consisting of two operators, selected by the operator interested, and two miners, selected by the local union of the United Mine Workers of America involved. In the event of these four being unable to reach a decision, they shall select a fifth man, and the decision of the board so constituted shall be final, but no miner or operator directly interested in the differences shall be a member of such board.

Nothing in the above shall be construed as excluding officers of the miners' or operators' associations, nor mine superintendents.

7. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines, except as hereinafter set forth in Article No. 16. In case they fail to agree, they shall proceed to adjust the trouble by the selection of an arbitration board as provided in Article 6 of this agreement. The mine committee shall have no other authority, nor exercise any other control, nor in any way interfere with the operation of the mine, and, for violation of this agreement, the committee or any member thereof or mine boss or superintendent shall be discharged.

8. That under no circumstances will the operator recognize or treat with a mine committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

9. The operator shall have the privilege of working a night shift for cutting coal with machine. All men so employed shall be paid 28 cents extra for each hours' work at night, in addition to the scale price per ton.

10. Work on driving entries and drawing pillars may be by double shift, at the option of the operator.

11. This contract shall in no case be set aside because of any rules of any local union of the U. M. W. of A. Nor shall there be any rules made controlling or affecting the operations of the mines nor shall any change be made in accepted rules without the operators and miners first consulting and agreeing thereto.

12. Coal may be dumped as slowly as the operator may find necessary to thoroughly screen it, even if the car is brought to a stop, but it shall not be dumped in such a way as to throw the coal over the car door or unnecessarily break it.

13. Any miner knowing his place to be unsafe, shall protect same without delay and shall go into the mine for that purpose outside of regular hours and on idle days.

14. No restrictions shall be placed on the amount of coal which machines may mine, nor on the number of cars that any miner may load in any specified time.

Men shall work double in wide entries at option of operator in developing the mine or for running entries for purpose of increasing production.

Enough extra loaders shall be employed in each mine so that the full complement of loaders agreed upon to follow each machine shall be at work every day that the mine hoists coal.

Where three places are now given to two loaders the custom shall continue.

No more than three places for two men nor two places for one man shall be allowed. In mines where the coal averages 6 feet high or over, rooms 30 feet wide or over equipped with two tracks shall be considered double places, and two loaders may be limited to two such places.

In Sullivan county where men work double in two rooms 25 to 30 feet wide with track up the center, the custom shall continue.

Whenever a new mine is opened it shall be governed by the same rules existing in other contiguous mines in the same vein of coal.

15. The price of powder per keg shall be $1.75. The miners agree to purchase the powder from their operators, provided, it is furnished of standard grade and quality, that to be determined by the operators and expert miners jointly where there is a difference.

16. Engineers shall be paid the present rate of wages, thus 12½ per cent. advance. Eight hours shall constitute a day's work. But the engineers shall outside of regular hours, hoist and lower the men, and in addition shall perform all the duties which necessarily and usually pertain and belong to an engineer's position, and shall not receive any extra pay therefor. It is agreed further that no hoisting engineer shall be subjected to the interference or dictates of the mine committee nor the local unions, but all the differences between the engineer and his employer shall be adjusted by the officers of the U. M. W. of A. and employer interested.

17. The prices now paid firemen and blacksmiths, together with present condition of employment and hours of labor, shall continue during the existence of this contract, plus 12½ per cent. advance.

18. It is further agreed that the operators shall offer no objection to the check-off for the check-weighman and for dues for the U. M. W. of A., provided that no check-off shall be made against any person until he shall have first given his consent in writing to his employer. This applies to all day work as well as miners.

SHOT FIRERS.

Present conditions as to shot firers shall continue until a commission composed of one miner, to be selected by the United Mine Workers of America of District No. 11, one operator, to be selected by the Bituminous Coal Operators' Association of Indiana, and Professor Robert Thurston of Cornell College, an expert engineer, shall be appointed.

Such commission shall, as soon as possible, examine the so-called dangerous pick mines in the state of Indiana and decide whether or not it is necessary to employ shot firers in any of said mines on account of gas, dust or other causes beyond the control of either miners or operators, the present methods of mining not to be considered as being beyond control.

If a majority of such commission shall decide that it is necessary that shot firers be employed in any mine and shall sign a report to that effect, then shot firers may be employed by the miners in such mine, who shall pay them for their services, and such shot firers shall be wholly in the employ of the miners and in no manner whatever to be the agents, servants or employes of the owners, operators or managers of the mine.

The owner or operator of any mine where the commission decides that it is necessary that shot firers be employed and where they are so employed by the miners, shall pay to the local union an amount of money equivalent to one-fourth cent (¼ cent) per ton of mine-run or two-fifths (⅖ cents) per ton of screened lump of the output of said mine.

It being agreed and understood that such payment to the local union shall not directly or indirectly be considered as or construed to be a payment by the owner or operator of any part or portion of the services rendered by shot firers for the miners.

It being further expressly agreed and understood that in any mine where shot firers are employed that the relation of master and servant shall exist wholly between the miners and the shot firers and that such relation shall not obtain as between the owner or operator of the mine and the shot firers.

The expenses of such commission shall be borne equally by the United Mine Workers of America of District No. 11, and the Bituminous Coal Operators' Association of Indiana, except that the Operators' Association shall alone bear the expenses occasioned by the appointment and services of the expert engineer.

In behalf of the Indiana Bituminous Coal Operators' Association:

J. C. KOLSEM, President.

P. H. PENNA, Secretary.

United Mine Workers of America, District No. 11:

GEO. HARGROVE, President.

J. H. KENNEDY, Secretary.

BRAZIL AGREEMENT.

CONTRACT.

PICK MINING SCALE FOR 1903.

Contract between the Operators, Miners and Day Laborers of the Brazil Block Coal District from April 1st, 1903, to April 1st, 1904:

1. Entered into this first day of April, 1903, between the Operators' Scale Committee of the Block Coal District and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and United Mine Workers of America, of Indiana, Illinois, Ohio and Pennsylvania, made at Indianapolis, Ind., February 7, 1903.

3. The price for mining screened block coal in the Block Coal District of Indiana shall be one ($1) dollar per ton of 2,000 lbs., it being understood also that the price for digging unscreened coal shall be an equivalent of the price paid for screened coal.

4. That further details in the scale of prices for pick mining in the Block Coal district shall be as follows:

5. The payment for low coal shall be upon the following scale:

6. For all coal two feet ten inches and under three feet one inch, one dollar and five ($1.05) cents.

7. For all coal under two feet ten inches one dollar and ten cents ($1.10).

8. The price of yardage shall be as follows:

Single yardage in coal 3 ft. 1 in. or over	$1 00
Double yardage in coal 3 ft. 1 in. or over	2 00
Gob entries in coal 3 ft. 1 in. or over	1 50
Gob entries in coal 3 ft. 1 in. or over, without brushing	50
Single yardage in coal 2 ft. 10 in. and under 3 ft. 1 in.	1 05
Double yardage in coal 2 ft. 10 in. and under 3 ft. 1 in.	2 10
Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in.	1 57½
Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in. without brushing	52½
Single yardage in coal below 2 ft. 10 in.	1 10
Double yardage in coal below 2 ft. 10 in.	2 20
Gob entries in coal below 2 ft. 10 in.	1 65
Gob entries in coal below 2 ft. 10 in. without brushing	55

All entries to be driven when required by the operator, 5½ feet in the clear in height, and the miners agree to gob the dirt, when he is not required to take it more than the distance of six rooms back from the last break through, and when the dirt is hauled by a mule, then the miners agree to unload the same at a distance of not more than eight rooms back from the last break through from the face of the entry. This agreement shall apply to all the block coal mines in the Block Coal District, with the exception of the Present No. 1 and No. 2 Superior mines of the Zeller & McClellan Company, and in these two mines the same conditions shall continue as were in force during the year just ending, viz., The miners shall continue to gob the break throughs. Twenty-five cents per yard shall be paid extra for all double yardage when the same is worked double shift, and 12½ cents per yard for all single yardage when same is worked double shift. Work on driving entries and drawing pillars may be double shift at the option of the operator.

It is further agreed that the McIntosh & Co. mine will submit to an investigation relative to the time that the companies commenced gobbing the dirt, and that said company will abide by the decision of the joint board relative to the operators' right to have the dirt gobbed at these mines.

9. Inside day scale:

Track layers	$2 56
Track layers' helpers	2 56
Trappers	1 13
Bottom cagers	5 26
Drivers	2 56
Trip riders	2 56
Water haulers	2 56
Timbermen, where such are employed	2 56
Pipe men, for compressed air plants	2 50
All other inside day labor	2 56
Blacksmiths	2 85

All outside day labor shall receive 12½ per cent. advance.

10. The firemen and night pumpers shall be paid at the rate of twenty-four (24) cents per hour for their labor. The above wage is based on an eight (8) hour work day, but in the event the operator desires it, the firemen and night pumpers are to work overtime to the extent of not more than two hours in any one day or shift.

However, it is understood that in the event of an emergency, the firemen and night pumpers will not limit their time but continue working until such emergency is past.

11. Where a miner is working a deficient place, and is being paid by the day, his pay shall be $2.60 per day, and if he uses his own tools during such time, he shall be paid 10 cents per day for the use of same. The operator shall have the option of furnishing the tools for any such work.

12. The price of blacksmithing shall be 1½ cents on the dollar.

13. Semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme courts of Indiana and of the United States.

14. The miner shall not be compelled to load his coal more than six feet from the face at beginning time.

15. Inside day work may be done upon idle days, and in case of emergency on overtime.

16. The hour to begin work in the morning shall be seven (7) a. m., with thirty minutes' stop for dinner, and begin shooting at 3:30 o'clock p. m., from April 1, 1903, to October 1, 1903, and from October 1, 1903, to April 1, 1904, the mines shall start at seven-thirty a. m., with thirty minutes' stop for dinner, and begin shooting at 4:00 p. m., and that no shooting shall be done at the mine except by mutual consent between the bank boss and the bank committee, and in the event that the mine is to work

a half day it shall be the duty of the mine boss to notify the bank committee of the fact.

17. That eight hours a day means eight hours' work in the mine at the usual working places for all classes of inside workmen. This shall be exclusive of the time required in reaching said working places in the morning and departing from the same at night.

18. The miners hereby agree to do all the propping in their rooms, except setting of props required to break the bottom in shooting the same, and if any props are loosened or displaced, thereby endangering the safety of the workmen, the miners agree to reset the same.

19. It is also agreed on the part of the operators not to require the miners to put down their own road, and bottom shooters may lay the road in the rooms when required.

20. Also to give each miner as near as possible an equal turn of cars, and not to allow any day hands to load coal on idle days.

21. No miner shall be discharged or discriminated against because of his refusal to do work by the day when called upon by the pit boss.

22. It is also agreed not to require miners to load or clean falls unless they are caused by some fault of the miner not properly timbering his working place, or his having shot or otherwise caused his timber to become insecure, in which case it will be the duty of the miner to put his place in good order again.

23. It is further agreed that if any differences arise between the operator and miner at any pit, settlement shall be arrived at without stopping of work. If the parties immediately affected can not reach an adjustment between themselves, the question shall be referred to the Executive Board of the United Mine Workers of America, representing District No. 8, and an equal number of operators, whose actions shall be final, but no miner nor operator interested in the differences shall be a member of said committee.

24. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines.

25. Regarding drivers: They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor. Their work beginning when they reach the parting at which they receive empty cars, and in no case shall the driver's time be docked while he is waiting for said cars at the point named, but when the men go into the mine in the morning they shall be entitled to two hours' pay, whether or not the mine works the two full hours, but after the first two hours, the men shall be paid for every hour thereafter by the hour, or for each hour's work or fractional part thereof. If for any reason the regular routine of work can not be furnished inside labor for a portion of the first two hours, the operators may furnish other than the regular labor for the unexpired time.

26. That under no circumstances will the operators recognize or treat with a mine committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

27. The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area,

of uniform size, one and one-quarter (1¼) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

28. It is hereby further agreed that track layers may begin work on top before the usual time of hoisting coal in getting track material ready to send down on the cage, and that the time required in doing so shall be a part of the eight hours' work.

29. In case of emergency work, the mine boss shall consult with the mine committee, and if they approve of the work being done on overtime, the men engaged thereon shall not be required to lay off until their time is equalized with the others working in the said mine.

30. The Crawford Coal Company in their mines at Center Point may continue to do the brushing in the entries where the coal is 3 feet 1 inch and under in thickness.

31. This contract is entered into in good faith by both parties, and there is to be no deviation from it by the operators, miners, laborers or any local union.

Committee on behalf of the Operators for the Block Coal District:

JAS. H. McCLELLAND,
WM. M. ZELLER,
W. E. EPPERT,
JAMES T. ANDREW,
A. H. ZIMMERMAN.

Executive Committee District No. 8, United Mine Workers of America, for Block Coal Miners:

JAMES CANTWELL,
WILLIAM HUSTON,
WM. TREAGER,
WILLIAM WILSON.

CONTRACT.

Machine Mining Scale for 1903.

Contract between the Machine Operators of the Block Coal District and the Executive Board District No. 8, United Mine Workers of America, governing prices and conditions of mining in Machine Mines Block Coal District:

1. Entered into this first day of April, 1903, between the Operators' Machine Mines of the Block Coal District, and the Executive Board of the United Mine Workers of America representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, Ind., February 7th, 1903.

3. The price for loading, shooting, timbering, taking care of all draw slate that is four (4) inches and under in thickness, in rooms and entries, shall be fifty-three and one-half (53½) cents per ton.

Price for entry driving, 6 to 9 ft. wide, fifty-three and one-half (53½) cents per yard.

Price for entry driving, 9 to 12 ft. wide, thirty-two and one-half (32½) cents per yard.

The loader agrees to keep the bug dust and draw slate back 14 ft. from the working face.

All entries more than 12 feet in width shall be paid same as rooms.

Machine Runners and Helpers to be paid twenty-five (25) cents per ton, and when working by the day, machine runners to be paid \$3.03¾ per day. Helpers, \$2.70 per day. Motormen receive 12½ per cent. increase on present wages.

Entry driving, 6 to 9 ft. wide, Machine Runner to be paid 25 cents per yard.

Entry driving, 9 to 12 ft. wide, Machine Runner to be paid 16 cents per yard.

It is further agreed that where there is not sufficient room to gob the bug dust and draw slate, the loader will load it in the bank cars and the company will unload it.

It is understood that there shall be nothing paid for room turning or low coal, and there shall be nothing charged for blacksmithing.

There shall be no discrimination against any employes.

That the system of loading coal in machine mines be on the following basis, to wit:

1. That one man shall have the right to two places where he can take care of same.

2. That two men shall have the right to three places where they can take care of same.

3. All others one place.

When a man is off work more than one day, the mine boss shall have the right to put a man in the places if it is necessary, providing the man leaves the places in the same condition as near as possible as he found them.

The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

This agreement to become a part of the agreement entered into on the 1st day of April, 1903, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

On behalf of the Machine Operators of the Block Coal District:

BRAZIL BLOCK COAL CO.,
JAS. H. McCLELLAND, President.
DIAMOND BLOCK COAL CO.,
JAS. H. McCLELLAND, President.

On behalf of the Executive Board District No. 8,
United Mine Workers of America:
JAS. CANTWELL,
WILLIAM HUSTON,
WM. TREAGER,
WILLIAM WILSON,
HARRY WRIGHT,
Members M. E. B.

CONTRACT

Between The National Brotherhood of Coal Hoisting Engineers and Operators of District No. 8, Signed March 21, 1903.

1. On and after April 1, 1903, until April 1, 1904, the scale of Hoisting Engineers throughout the Block Coal District, or District No. 8, shall be as follows: Where one Engineer is employed, the compensation shall be eighty-four dollars and thirty-seven cents ($84.37) per month. Where two Engineers are required, the first Engineer shall receive eighty-four dollars and thirty-seven cents ($84.37) per month, the second seventy-three dollars and twelve cents ($73.12) per month, and when they change week about seventy-eight dollars and seventy-five cents ($78.75) per month.

2. It is agreed on the part of the Engineers to be at their work in time to lower the men and mules, and remain a sufficient time after the regular working hour to hoist the men and mules from the mine. Also to keep up all repairs on the machinery, including pumps in the mine.

3. It is also mutually agreed that a licensed Engineer shall be employed at all times when steam is required at the throttle. Provided, however, that in all cases where the mine is not hoisting coal, or the machines are not operated, then, and in all such cases, the Engineers are required to do their own firing, it being understood that this provision does not apply to any case where the work of the mine may be stopped in the midst of any one shift. Nor does it cover any case where the fireman is required to assist in the washing or cleaning out the boilers on Sunday.

4. It is also fully understood and agreed upon the part of the Brotherhood of Hoisting Engineers that they will not under any circumstances allow affiliation with any other labor organization to interfere with or prevent their being on duty at any and all times required by the operators, and that they will not suspend work in sympathy with any other organization; and further that they will during the continuance of this contract at all times fully protect all the company's property under their care, and that they will operate fans and pumps, and lower and hoist such men or supplies as may be required to protect the company's property, and any and all coal that may be required to keep up the steam at the company's plant. But it is understood that the operators will not ask them during this period to hoist any coal produced by nonunion labor for sale on the market.

5. It is also agreed that only members of the National Brotherhood of Coal Hoisting Engineers shall be employed in the capacity of hoisting engineers during the continuance of this agreement, when such members, competent to fill the position, can be obtained.

6. No Engineer shall lay off or exchange shifts without the consent of the operators.

7. It is also agreed that in case of sickness or unexpected absence of the engineer any other engineer or engineers shall perform his duty; and if desired by them his wages for time so absent shall revert to the engineer performing such duty.

8. It is also agreed that in case of dispute or trouble arising between any Engineer and the Operator by whom he is employed, work shall not be suspended, but the grievance shall be taken up by the proper officials.

9. It is also agreed upon the part of the operators that they will enforce a rule forbidding the entering of the engine-room by loafers and disinterested parties and that they will have cards printed and placed in conspicuous places to this effect.

Signed and agreed to by Operators' Committee:

JAS. H. McCLELLAND,
WM. M. ZELLER,
A. H. ZIMMERMAN,
M. H. JOHNSON.

Engineers' Committee:

LUTHER PULLEN,
ALBERT HIXON,
T. E. JENKINS,
D. H. COLLIER,
W. C. BIGGINS,
FRANK YOCKUM.

TABLE

Showing by Counties the Name of Mine, Number of Tons Screened, Slack and Nut and Mine Run Coal, Total Tons of All Grades of Coal Produced, and the Distribution Thereof; the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand Mined Coal.

BLOCK COAL MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine-Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine-Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 1	10,079	2,015	....	12,094	12,764	2,555	....	15,319	15,886	11,527	$21,171 39	$19,924 53	$7,283 74	$48,379 66
Brazil Block No. 8	29,260	5,850	....	35,110	9,203	1,850	....	11,053	4,377	41,786	31,891 60	29,603 81	9,731 96	71,227 37
Brazil Block No. 10	22,872	4,575	....	27,447	11,794	2,370	....	14,164	4,902	36,709	31,510 27	16,954 78	6,999 04	55,464 09
Brazil Block No. 11	1,393	280	....	1,673	12,580	2,505	....	15,085	1,801	14,957	14,546 73	6,881 84	3,607 05	25,035 62
Diamond No. 5.....	36,604	7,405	....	44,009	9,068	1,865	....	10,933	11,346	43,596	41,459 74	23,313 57	8,812 27	73,585 58
Rob Roy	Not re	ported.	....	....	....	....	....	....	....	....	....	....	....	....
Total...........	100,208	20,125	....	120,333	55,409	11,145	....	66,554	38,312	148,575	$140,579 73	$96,678 53	$36,434 06	$273,692 32

PARKE COUNTY.

NAME OF MINE.	Machine Mined: Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine-Run.	Total Tons of all Kinds of Coal Produced.	Pick Mined: Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine-Run.	Total Tons of all Kinds of Coal Produced.	Distribution: Indiana.	Other States.	Wages Paid: To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 12	46,115	9,760	....	55,875	9,965	2,274	....	12,239	9,179	58,935	$46,279 21	$40,430 62	$11,308 99	$98,018 82
Mary...............	10,082	1,140	....	11,222	26,062	5,405	....	31,467	2,944	39,745	39,589 80	14,941 82	8,062 21	62,593 83
Total...........	56,197	10,900	....	67,097	36,027	7,679	....	43,706	12,123	98,680	$85,869 01	$55,372 44	$19,371 20	$160,612 65
Total Machine Block	156,405	31,025	....	187,430	91,436	18,824	....	110,260	50,435	247,255	$226,448 74	$152,050 97	$55,805 26	$434,304 97

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

Gifford No. 1	18,483	9,475	....	27,958	17,682	3,450	....	21,132	14,884	34,206	$29,471 56	$17,347 10	$6,788 33	$53,606 99
Gifford No. 2	32,157	2,915	....	35,072	61,528	28,268	....	89,796	35,072	89,796	82,115 27	42,607 14	10,126 32	134,848 73
Total	50,640	12,390	....	63,030	79,210	31,718	....	110,928	49,956	124,002	$111,586 83	$59,954 24	$16,914 65	$188,455 72

GREENE COUNTY.

Black Creek	32,855	18,226	29,030	80,111	29,478	16,036	26,496	72,010	75,116	76,905	$80,168 03	$30,372 10	$9,113 00	$119,653 13
Island City No. 1	....	....	67,149	67,149	....	....	48,228	48,228	48,228	67,149	58,850 96	28,392 31	10,495 13	97,738 40
Island City No. 2	35,375	12,602	62,797	110,774	17,414	6,027	32,142	55,583	55,583	110,774	91,062 50	30,499 74	18,288 36	139,850 60
Gilmour	....	....	136,024	136,024	....	....	....	....	85,403	50,181	72,995 22	23,953 00	8,694 28	105,642 50
Hoosier No. 1	4,487	2,283	14,155	20,925	....	....	....	....	19,402	1,523	7,254 56	9,445 47	2,922 71	19,622 74
Midland	58,246	21,518	20,421	100,185	2,640	837	2,065	5,542	73,613	32,114	42,205 81	12,954 39	19,307 61	81,467 81
Summit No. 2	37,402	9,769	100,460	147,631	....	....	....	....	71,118	76,513	65,355 61	27,949 77	16,754 63	110,060 01
Glenburn	26,816	13,873	58,526	99,215	11,151	6,249	17,165	34,565	107,263	26,517	77,681 73	25,994 07	8,712 04	112,387 84
Antioch	4,020	2,068	25,644	31,732	13,913	6,636	5,284	25,833	41,533	16,032	35,653 77	16,745 25	8,339 99	60,739 01
Tower Hill	31,962	12,913	1,503	46,378	10,108	4,019	704	14,831	37,891	23.318	30,127 95	15,451 81	7.542 73	53,122 49
Green Valley	26,881	24,343	35,162	86,386	....	....	....	....	39,071	47,315	45,154 35	19,877 70	10,205 20	75,237 25
Lattis Creek No. 1	44,609	27,719	36,633	108,961	44	....	13	57	62,323	46,695	60,289 94	28,547 39	16,354 70	105,192 03
Atlas No. 1	8,337	12,815	54,326	75,478	3,873	....	14,214	18,087	76,417	17,148	54,879 32	15,664 50	14.535 33	85,079 15
Letsinger	10,369	4.592	3,364	18,325	....	....	1,646	1,646	12,038	7,933	15,020 72	9,523 17	14,144 40	38,688 29
North Western	3,206	5,173	17,798	26,177	238	741	5,429	6,408	21,694	10,891	14,968 13	11,654 99	7,799 80	34,422 92
Twin	1,253	834	528	2,615	3,092	1,236	402	4,730	4,730	2,615	3,452 65	2,989 50	1,690 65	8,132 80
Atlas No. 2	....	....	4,892	4,892	....	....	115	115	5,007	....	4,057 69	2,572 67	3,809 68	10,440 04
Total	325,818	168,728	668,412	1,162,958	91,951	41,781	153,903	287,635	836,870	613,723	$766,178 94	$312,587 83	$178,710 24	$1,257,477 01

PARKE COUNTY.

Lyford No. 1	7,560	3,138	11,382	22,080	....	....	16,974	16,974	6,492	32,562	$16,355 88	$14,017 64	5,336 76	35,710 28
Parke No. 11	....	....	25,749	25,749	....	....	24,864	24,864	46,399	4,214	27,852 12	7,969 02	4,587 06	40,408 20
Total	7,560	3,138	37,131	47,829	....	....	41,838	41,838	52,891	36,776	$44,208 00	$21,986 66	$9,923 82	$76,118 48

BITUMINOUS MACHINE MINES—Continued.

SULLIVAN COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine-Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine-Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Bunker Hill	17,884	5,960	5,019	28,863	16,912	7,745	1,183	25,840	....	54,703	$34,702 86	$18,918 00	$7,993 68	$61,614 54
Caledonia	21,846	10,768	4,342	36,956	15,691	5,282	7,104	28,077	8,710	56,323	35,502 95	18,434 61	9,867 56	63,805 12
Dugger	27,281	9,429	31,700	68,410	2,336	778	2,575	5,689	19,524	54,575	36,879 80	27,756 73	9,366 32	74,002 85
Green Hill	25,386	11,826	3,034	40,246	1,584	646	....	2,230	520	41,956	20,399 81	17,576 83	6,509 79	44,486 43
Hymera No. 1	60,719	45,082	50,591	156,392	....	....	....	....	41,402	114,990	71,948 53	28,578 04	14.734 34	115,260 91
Jackson Hill No. 2	89,071	64,659	42,685	196,415	....	....	....	....	80,401	116,014	81,851 79	35,046 12	10,932 08	127,829 99
Phoenix No. 3	....	....	128,036	128,036	....	....	....	....	67,470	60,566	65,321 65	24,486 53	12,303 19	102,111 37
Phoenix No. 5	....	....	17,416	17,416	....	....	....	....	9,000	8,416	10,093 00	3,839 00	1,143 00	15,075 00
Shelburn	10,288	5,351	195	15,834	2.054	1,253	27	3,334	9,955	9,213	10,707 82	8,136 30	5,997 35	28,841 47
Star City	62,606	35,167	7,966	105,739	21,877	11,079	2,543	35,499	30,986	110,252	67,618 42	32,231 43	16,391 48	116,241 33
Sun Flower	103,717	34,352	1,763	139,832	....	....	15	15	32,815	107,032	71,233 61	7,143 90	13,518 90	91,896 41
Glendora	76,901	36,901	49,966	163,768	....	....	....	....	58,774	104,994	79,628 44	35,571 10	18,446 95	133,646 49
Hymera No. 2	61,611	56,803	34,356	152,770	....	....	....	....	24,061	128,709	69,301 10	21,928 55	12,470 77	103,700 42
Wilfred No. 1	79,894	34,873	16,079	130,846	....	....	....	....	44,020	86,826	64,755 76	27,576 38	23,329 61	115,661 75
Little Giant	Tonna	ge not	report	ed.	....	....	....	....	....	....	....	....	....	....
Cummins	....	....	2,000	2,000	....	....	1,300	1,300	2,000	1,300	2,500 00	1,500 00	1,045 00	5,045 00
Mildred	....	....	1,745	1,745	....	....	....	....	1,745	....	851 35	1,052 90	1,047 50	2,951 75
West Linton	....	....	280	280	....	....	546	546	826	....	530 51	370 00	986 01	1,886 52
Total	637,204	351,171	397,173	1,385,548	60,454	26,783	15,293	102,530	432,209	1,055,869	$723,827 40	$310,146 42	$166,083 53	$1,200,057 35

VIGO COUNTY.

Atherton	25,776	13,536	401	39,713	12,155	9,217	166	21,538	573	60,678	$30,773 76	$7,115 59	$6,291 57	$44,180 92
Lawton	2,353	1,567	....	3,920	50,925	25,278	21,156	97,359	97,359	3,920	65,561 70	17,471 80	7,588 20	90,621 70
Glen Oak	....	....	165,115	165,115	....	....	4,938	4,938	....	170,053	83,897 72	45,967 59	15,853 31	145,718 62
Parke No. 10	26,308	19,969	100,711	146,988	....	....	....	....	120,865	26,123	70,062 10	25,861 07	12,447 12	108,370 29
Nickel Plate	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Total	54,437	35,072	266,227	355,736	63,080	34,495	26,260	123,835	218,797	260,774	$250,295 28	$96,416 05	$42,180 20	$388,891 53

WARRICK COUNTY.

Big Four	....	....	96,231	96,231	....	....	....	....	50,309	45,922	$42,117 47	$8,256 84	$5,770 27	$56,144 58
Big Vein No. 3	....	....	74,003	74,003	....	....	....	....	74,003	....	36,615 55	6,049 90	5,180 75	47,846 20
Electric	8,005	3,686	19,622	31,313	....	....	....	....	10,160	21,153	13,931 39	4,186 22	2,774 54	20,892 15
Total	8,005	3,686	189,856	201,547	....	....	....	....	134,472	67,075	$92,664 41	$18,492 96	$13,725 56	$124,882 93
Total Bituminous Machine Mined Coal	1,083,664	574,185	1,558,799	3,216,648	294,695	134,777	237,294	666,766	1,725,195	2,158,219	$1,988,760 86	$819,584 16	$427,538 00	$3,235,883 02
Total Machine Mined Block Coal	156,405	31,025	....	187,430	91,436	18,824	....	110,260	50,435	247,255	226,448 74	152,050 97	55,805 26	434,304 97
Total Machine Mined	1,240,069	605,210	1,558,799	3,404,078	386,131	153,601	237,294	777,026	1,775,630	2,405,474	$2,215,209 60	$971,635 13	$483,343 26	$3,670,187 99

BLOCK COAL—HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Continental No. 1	6 957	1,685	....	8,642	....	8,642	$9,402 57	$3,609 03	$2,018 99	$15,030 59
Gart No. 5	3,754	745	....	4,499	2,794	1,705	3,915 25	887 67	909 76	5,712 68
Gart No. 7	28,075	5,630	....	33,705	19,581	14,124	38,425 40	13,019 03	6,916 68	58,361 11
Rebstock	2,065	500	....	2,565	740	1,825	3,006 64	1,016 99	1,204 52	5,228 15
Lawrence No. 6	45,563	10,700	....	56,263	32,222	24,041	46,835 91	9,422 13	5,894 36	62,152 40
Lawrence No. 7	46,759	11,768	1,421	59,948	34,130	25,818	58,431 66	18,986 08	10,511 53	87,929 27
Cornwell	31,614	6,136	....	37,750	37,750	....	33,219 43	10,549 91	4,442 27	48,211 61
Crawford No. 2	29,491	8,095	765	38,351	18,645	19,706	30,674 59	7,008 83	4,732 97	42,416 39
Crawford No. 3	13,478	2,430	....	15,908	6,240	9,668	13,122 18	2,752 05	1,895 84	17,770 07
Crawford No. 6	20,571	6,445	263	27,279	13,453	13,826	25,148 99	5,896 25	3,688 81	34,734 05
Crawford No. 7	33,389	7,919	....	41,308	22,171	19,137	35,388 02	10,623 59	5,912 39	51,924 00
Eureka No. 2	857	100	....	957	275	682	887 05	609 55	525 25	2,021 85
Eureka No. 3	13,475	1,477	601	15,553	4,752	10,801	12,715 90	6,414 15	5,309 25	24,439 30
Pratt	6,991	1,515	672	9,178	9,107	71	7,084 30	3,065 45	1,532 60	11,682 35
Monarch	....	....	9,244	9,244	9,244	....	See note	13,262 29	2,168 35	15,430 64
Rob Roy	Not rep	orted	....	....	....	....	....	....	....	....
Crawford No. 5	22,648	6,384	9,312	38,344	20,210	18,134	34,524 37	9,071 98	5,086 38	48,682 73
Total	305,687	71,529	22,278	399,494	231,314	168,180	$352,782 26	$116,194 98	$62,749 95	$531,727 19

PARKE COUNTY.

Crawford No. 10	13,368	1,985	....	15,353	994	14,359	$13,055 52	$4,138 91	$2,235 23	$19,429 66
Superior No. 1	69,295	16,930	160	86,385	21,330	65,055	74,317 47	18,214 79	10,396 46	102,928 72
Superior No. 2	48,917	11,980	773	61,670	25,130	36,540	52,403 98	21,063 31	11,596 45	85,063 74
Superior No. 3	35,158	8,605	....	43,763	12,178	31,585	43,922 53	10,281 84	5,757 91	59,962 28
Pan American	68,807	10,545	933	75,285	24,850	50,435	73,506 30	21,936 20	7,614 20	103,056 70
Brazil Block No. 9	38,580	7,720	....	46,300	5,267	41,033	44,243 04	15,512 39	6,707 30	66,462 73
Total	269,125	57,765	1,866	328,756	89,749	239,007	$301,448 84	$91,147 44	$44,307 55	$436,903 83
Total Pick Mined	574,812	129,294	24,144	728,250	321,063	407,187	$654,231 10	$207,342 42	$107,057 50	$968,631 02

BITUMINOUS PICK MINES.

CLAY COUNTY.

Cloverland No 1	91,546	33,015	33,480	158,041	85,613	72,428	$104,755 58	$26,313 30	$13,334 88	$144,403 76
Fair View	1,626	1,549	....	3,175	1,707	1,468	2,223 16	1,033 65	1,062 45	4,319 26
Fortner	15,652	6,725	5,762	28,139	21,253	6,886	18,583 46	4,224 10	1,961 57	24,769 13
Klondyke	40,221	19,852	18,069	78,142	72,968	5,174	45,660 45	12,317 97	5,790 58	63,769 00
Glen	46,183	12,805	....	58,988	21,050	37,938	47,381 75	9,355 35	4,600 50	61,337 60
Pearl	58,471	36,269	2,122	96,862	57.832	39,030	56,745 24	13,796 20	6,251 55	76,792 99
Silverwood	16,149	9,910	....	26,059	14,499	11,560	16,645 60	6,362 70	4,125 70	27,134 00
Cloverland No 2	7,743	2,540	....	10,283	1,700	8,583	11,659 00	2,754 58	1,216 71	15,630 29
Lewis	....	....	2,446	2,446	312	2,134	1,100 00	921 19	1,455 61	3,476 80
Total	277,591	122,665	61,879	462,135	276,934	185,201	$304,754 24	$77,079 04	$39,799 55	$421,632 83

DAVIESS COUNTY.

Cabel No. 4	2,892	1,205	....	4,097	4,097	....	$2,978 77	$854 10	$916 75	$4,749 62
Cabel No. 9	7,147	3,754	18,523	29,424	22,277	7,147	16,918 80	8,554 40	3,909 95	29,383 15
Montgomery Nos. 2 and 3	93,008	13,319	9,942	116,269	75,996	40,273	83,383 20	25,268 00	11,986 64	120,637 84
Mutual	12,985	1,750	12,137	26,872	14,850	12,022	19,776 90	5,000 50	3,055 00	27,832 40
Union	....	....	8,494	8,494	8,494	....	5,319 18	1,590 04	787 53	7,696 75
Mandabach	175	110	3,250	3,535	3,535	....	1,636 20	212 34	185 20	2,033 74
Wheatland	187	150	2,131	2,468	2,363	105	1,400 00	1,023 75	684 87	3,108 62
Total	116,394	20,288	54,477	1911 59	131,612	59,547	$131,413 05	$42,503 13	$21,525 94	$195,442 12

BITIUMINOUS PICK MINES—Continued.

FOUNTAIN COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Diamond	349	90	208	647	622	25	$367 33	$285 47	$156 10	$808 90
Rush	4,070	1,460	9,933	15,463	15,463	....	8,661 00	1,461 00	1,294 00	11,416 00
Silverwood	245	90	175	510	450	60	....	784 90	326 39	1,111 29
Total	4,664	1,640	10,316	16,620	16,535	85	$9,028 33	$2,531 37	$1,776 49	$13,336 19

GIBSON COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Oswald	13,005	13,261	20,434	46,700	40,866	5,834	$24,854 19	$15,609 54	$10,769 33	$51,233 06
Total	13,005	13,261	20,434	46,700	40,866	5,834	$24,854 19	$15,609 54	$10,769 33	$51,233 06

GREENE COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Island No. 3	....	....	92,574	92,574	7,574	85,000	$54,252 86	$18,100 55	$8,432 24	$80,785 65
Island Valley No. 3	42,528	21,754	63,306	127,588	81,873	45,715	74,244 34	19,845 46	8,100 13	102,189 93
Island Valley No. 2	21,634	14,264	....	35,898	21,686	14,212	19,600 80	8,910 92	4,850 59	33,362 31
South Linton	33,505	18,556	102,712	154,773	93,763	61,010	93,616 87	23,512 01	7,786 47	124,915 35
Vulcan	2,756	1,116	4,280	8,152	201	7,951	5,009 33	1,033 50	1,511 57	7,554 40
Templeton	9,933	4,410	99,897	114,240	114,240	....	65,984 80	17,100 55	8,256 05	91,341 40

Victoria	27,810	25,422	169,838	223,070	210,616	12,454	132,104 88	19,921 67	10,564 60	162,591 15
Fry	....	....	14,464	14,464	14,464	....	12,785 82	4,540 53	2,033 35	19,359 70
Island No. 5	....	....	5,439	5,439	5,439	....	4,741 10	2,213 45	1,513 94	8,468 49
Total	138,166	85,522	552,510	776,198	549,856	226,342	$462,340 80	$115,178 64	$53,048 94	$630,568 38

KNOX COUNTY.

Bicknell	20,222	17,421	20,838	58,481	57,706	775	$29,846 92	$8,530 96	$6,009 66	$44,387 54
Edwardsport	22	75	6,707	6,804	6,804	....	4,256 94	1,171 95	797 65	6,226 54
Knox	16,637	13,435	20,827	50,899	42,590	8,309	25,447 49	12,352 05	5,381 85	43,181 39
Lynn	....	....	12,486	12,486	11,467	1,019	7,825 60	1,556 47	1,570 93	10,953 00
Prospect Hill	3,694	2,581	3,004	9,279	9,279	....	11,419 97	4,506 99	1,916 18	17,843 14
Enterprise	No report	....	....	....	....	....	....	....	....	....
Total	40,575	33,512	63,862	137,949	127,846	10,103	$78,796 92	$28,118 42	$15,676 27	$122,591 61

PARKE COUNTY.

C. B. Harrison	395	130	3,971	4,496	4,496	....	$2,323 30	$719 50	$412 00	3,454 80
W. P. Harrison	....	....	10,990	10,990	10,990	....	6,011 50	2,536 40	1,240 00	9,787 90
Cox No. 3	....	....	97,459	97,459	82,769	14,690	58,106 05	27,905 35	10,268 23	96,279 63
Lucia	18,412	7,681	31,050	57,143	37,106	20,037	35,442 72	13,218 73	7,873 39	56,529 84
Mecca No. 1	21,882	11,411	2,350	35,643	8,154	27,489	22,700 20	11,473 69	6,073 86	40,247 75
New Century	18,768	9,990	7,885	36,643	11,995	24,648	23,053 41	8,429 62	4,740 37	36,223 40
Minshal No. 1	90,298	18,056	19,930	128,284	128,284	....	102,016 28	28,212 82	11,830 18	141,559 28
Briar Hill	....	....	22,162	22,162	22,162	....	18,194 04	7,002 48	3,716 41	28,912 93
Minshal No. 2	656	189	103	948	143	805	528 42	874 18	471 17	1,873 77
Total	150,411	47,457	195,900	393,768	306,099	87,669	$268,375 92	$100,367 77	$46,125 61	$414,869 30

PERRY COUNTY.

Troy	....	....	10,630	10,630	10,630	....	$7,139 99	$1,914 69	$1,632 92	$10,587 60
Cannelton	273	84	133	490	490	....	272 75	155 00	100 00	527 75
Total	273	84	10,763	11,120	11,120	....	$7,412 74	$2,069 69	$1,632 92	$11,115 35

BITUMINOUS PICK MINES—Continued.

PIKE COUNTY.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Massey	4,179	2,910	10,590	17,679	16,501	1,178	$13,687 03	$4,508 04	$2,590 49	$20,785 56
Aberdeen	2,984	2,450	14,756	20,190	5,853	14,337	11,719 07	4,138 41	2,575 81	18,433 29
Ayrshire No. 3	26,158	16,407	10,609	53,174	35,518	17,656	27,854 36	14,079 17	7,186 80	49,120 33
Ayrshire No. 4	31,241	11,873	47,260	90,374	53,428	36,946	55,862 34	15,243 60	7,641 25	78,747 19
Ayrshire No. 5	179	192	5,050	5,421	4,176	1,245	2,848 23	1,053 22	790 82	4,692 27
Ayrshire No. 6	No re	port.	....	....	....	....	....	....	....	....
Blackburn	629	791	31,248	32,668	30,382	2,286	18,316 04	7,078 81	3,768 75	29,163 60
Hartwell	3,117	1,911	45,479	50,507	42,025	8,482	33,016 31	12,414 63	8,035 44	53,466 38
Little's	33,252	45,472	22,335	101,059	81,936	19,123	58.344 09	17,294 22	6,782 80	82,421 11
Rogers	....	....	2,670	2,670	2,670	....	1,375 65	636 03	158 36	2,170 04
Petersburg	....	....	36,150	36,150	33,486	2,664	22,754 69	7,176 90	3,235 75	33,167 34
Carbon	2,114	1,833	8,274	12,221	7,917	4,304	7,542 54	4,035 43	1,939 88	13,517 85
Winslow	22,353	16,743	23,019	62,115	62,115	....	38,724 96	18,048 21	7,473 86	64,247 03
Total	126,206	100,582	257,440	484,228	376,007	108,221	$292,045 31	$105,706 67	$52,180 01	$449,931 99

SULLIVAN COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
White Ash	3,640	1,605	41,232	46,477	30,887	15,590	$28,411 83	$8,756 49	$4,874 97	$42,043 29
Freeman	8,342	3,640	1,955	13,937	4,390	9,547	10,799 49	2,805 65	2,996 72	16,601 86
Island No. 4	Not rep	orted ...	....	....	....	....	....	....	....	....
Lablanze	....	....	2,259	2,259	2,259	....	400 00	205 00	1,336 00	1,941 00
Citizens	470	450	350	1,270	1,270	....	1,054 44	243 20	247 70	1,545 34
Bruilettes No. 6	....	....	1,317	1,317	....	1,317	2,248 15	....	....	2,248 15
Total	12,452	5,695	47,113	65,260	38,806	26,454	$42.913 91	$12,010 34	$9,455 39	$64,379 64

VANDERBURGH COUNTY.

Diamond	13,872	8,908	10,066	32,846	31,435	1,411	$20,740 27	$4,556 34	$3,800 53	$29,097 14
First Avenue	3,236	2,487	1,944	7,667	6,989	678	5,390 25	1,380 25	1,255 90	8,026 40
Ingleside	Not rep	orted	....	....	....	....	....	....	....	....
Sunny Side	9,006	16,823	27,828	53,657	27,076	26,581	29,335 06	15,279 49	7,085 09	51,699 64
Union	10,409	5,216	10,409	26,034	26,034	....	20,226 60	4,454 55	3,510 40	28,191 55
Unity	21,451	1,000	61,993	84,444	84,444	....	58,500 10	9,865 05	7,355 90	75,721 05
Total	57,974	34,434	112,240	204,648	175,978	28,670	$134,192 28	$35,535 68	$23,007 82	$192,735 78

VERMILLION COUNTY.

Bruilettes No. 3	5,524	10,003	96,076	111,603	16,238	95,365	$58,952 80	$15,086 25	$10,070 85	$84,109 90
Bruilettes No. 4	502	308	11,848	12,658	3,178	9,480	6,207 35	1,989 55	685 30	8,882 20
Bruilettes No. 5	52,455	30,323	86,712	169,490	25,593	143,897	99,973 92	21,306 15	8,736 20	130,016 27
Buckeye	17,302	9,572	16,698	43,572	....	43,572	25,311 16	10,021 37	6,639 50	41,972 03
Eureka	....	....	10,007	10,007	10,007	....	7,200 74	3,489 66	1,854 39	12,544 79
Crown Hill No. 1	65,956	32,087	59,454	157,497	12,498	145,000	89,346 11	17,182 00	6,188 00	112,716 11
Crown Hill No. 2	....	....	5,425	5,425	1,515	3,910	2,200 00	2,925 33	1,308 87	6,434 20
Oak Hill	36,143	21,050	80,364	137,557	....	137,557	79,739 82	22,839 97	11,380 60	113,960 39
Prince	....	....	174,862	174,862	1,354	173,508	97,677 10	27,778 08	9,625 88	135,081 06
Willow Grove	18,319	6,725	81,673	106,717	4,492	102,225	65,161 29	10,049 19	8,695 53	83,906 01
Rhoades	334	160	12,283	12,777	12,283	494	7,058 78	7,403 66	4,362 37	18,824 81
Total	196,535	110,228	635,402	942,165	87,157	855,008	$538,829 07	$140,071 21	$69,547 49	$748,447 77

VIGO COUNTY.

Brick Works	....	....	6,470	6,470	6,470	....	$4,071 67	$1,776 79	$726 92	$6,575 38
Chicago No. 6	24,435	9,762	197	34,394	5,566	28,828	25,528 98	8,123 52	3,561 92	37,214 42
Diamond	54,373	26,080	16,177	96,630	96,630	....	63,327 05	24,607 80	9,567 75	97,502 60
Peerless	35,177	18,965	6,010	60,152	....	60,152	41,428 55	14,183 40	7,089 75	62,701 70
Union	30,935	8,345	41,545	80,825	80,825	....	49,955 15	16,841 90	10,225 30	77,022 35
Ehrlich	14,524	9,236	....	23,760	22,952	808	13,404 47	5,978 10	3,613 70	22,996 27
Grant No. 2	25,680	29,185	48,578	103,443	16,901	86,542	63,496 28	19,899 55	10,366 84	93,762 67
Hector	28,251	20,154	17,409	65,814	57,672	8,142	39,632 83	14,142 58	7,637 34	61,412 75
Klondyke	29,166	23,530	42,744	95,440	6,482	88,958	47,543 15	15,964 05	6,140 10	69,647 30
Miami No 1	114,706	31,360	3,494	149,560	....	149,560	142,253 12	19,324 48	7,293 94	168,871 54
Nickle Plate	11,877	4,140	11,257	27,274	....	27,274	15,374 82	5,600 78	2,560 79	23,536 39

BITUMINOUS PICK MINES—Continued.

VIGO COUNTY—Continued.

NAME OF MINE.	Production.				Distribution.		Wages.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Ray	2,994	2,778	3,101	8,873	2,957	5,916	$4,491 82	$945 18	$485 35	$5,922 35
Redbird	12,455	12,420	25,028	49,903	49,903	....	23,243 98	4,957 32	2,950 16	31,151 46
Rosebud No. 2	85,657	47,533	17,838	151,028	132,801	18,227	92,285 80	23,210 05	8,644 95	124,140 80
Royal No. 1	15,279	8,462	80,501	104,242	101,445	2,797	62,614 37	14,442 38	4,890 15	81,946 90
Larimer	....	....	12,249	12,249	12,249	....	7,005 83	2,594 27	1,643 74	11,243 84
Broadhurst	8,062	8,081	58,659	74,802	45,872	28,930	32,675 63	6,009 01	4,253 43	42,938 07
Miami No. 2	2,044	635	16,205	18,884	....	18,884	14,869 47	2,281 04	2,881 59	20,032 10
Deep Vein	10,353	7,298	10,067	27,718	25,460	2,258	16,502 34	5,053 79	2,743 87	24,300 00
Greenfield No. 1	15,914	10,115	10,186	36,215	36,215	....	22,013 05	4,612 82	3,879 30	30,505 17
Lost Creek	....	....	8,496	8,496	1,290	7,206	5,291 15	2,093 21	1,734 59	9,118 95
Sugar Creek No. 1	619	123	241	983	983	....	1,252 51	546 51	528 24	2,327 26
Total	522,501	278,202	436,452	1,237,155	702,673	534,482	$788,262 02	$213,188 53	$103,419 72	1,104,870 27

WARRICK COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Air Line	9,905	4,635	11,530	26,070	8,530	17,540	$15,896 55	$2,844 50	$1,683 94	$20,424 99
Caledonia	....	....	13,157	13,157	9,232	3,925	6,957 60	1,867 57	1,208 95	10,034 12
Chandler	7,650	3,810	17,315	28,775	7,045	21,730	16,368 25	5,255 45	1,836 45	23,460 15
DeForrest	5,220	3,055	4,540	12,815	12,815	....	7,118 35	1,200 21	791 06	8,109 62
Star No. 1	....	....	33,277	33,277	33,277	....	18,020 97	5,000 97	3,548 00	26,569 94
Total	22,775	11,500	79,819	114,094	70,899	43,195	$64,361 72	$16,168 70	$9,068 40	$89,598 82
Total Hand Bituminous	1,679,522	865,070	2,538,607	5,083,199	2,912,388	2,170,811	$3,147,580 50	$906,138 73	$457,033 88	$4,510,753 11

RECAPITULATION.

Showing Total Production and Wages of Indiana Mines for 1903.

	Machine Mined.				Pick Mined.				Distribution.			Wages.		
	Screened.	Slack and Nut.	Mine-Run.	Total.	Screened.	Slack and Nut.	Mine-Run.	Total.	Indiana.	Other States.	Miners.	Inside Day and Monthly Men.	Outside Day and Monthly Men.	Total.
Total production block machine mines..........	156,405	31,025	....	187,430	91,436	18,824	....	110,260	50,435	247,255	$226,448 74	$152,050 97	$55,805 26	$434,304 97
Total production block pick mines	....	....	....	....	574,812	129,294	24,144	728,250	321,063	407,187	654,231 10	207,342 42	107,057 50	968,631 02
Total block...	156,405	31,025	....	187,430	666,248	148,118	24,144	838,510	371,498	654,442	$880,679 84	$359,393 39	$162,862 76	$1,402,935 99
Total bituminous machine mines.	1,083,664	574,185	1,558,799	3,216,648	294,695	134,777	237,294	666,766	1,725,195	2,158,219	$1,988,760 86	$819,584 16	$427,538 00	$3,235,883 02
Total bituminous pick mines......	....	....	....	....	1,679,522	865,070	2,538,607	5,083,199	2,912,388	2,170,811	3,147,580 50	906,138 73	457,033 88	4,510,753 11
Total bituminous..............	1,083,664	574,185	1,558,799	3,216,648	1,974,217	999,847	2,775,901	5,749,965	4,637,583	4,329,030	$5,136,341 36	$1,725,722 89	$884,571 88	$7,746,636 13
Total machine mined..........	1,240,069	605,210	1,558,799	3,404,078	....	....	....	....	....	....	....	....	....	....
Total pick mined	2,640,465	1,147,965	2,800,045	6,588,475	....	....	....	....	....	....	....	....	....	....
Grand total...	3,880,534	1,753,175	4,358,844	9,992,553	....	....	....	....	....	....	$6,017,021 20	$2,085,116 28	$1,047,434 64	$9,149,572 12

TABLE,

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, and Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties, Expenditure for Improvements and Number of Kegs of Powder Used.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Brazil Block No. 1	23	4	8	20	7	62	288	7	1		1,088
Brazil Block No. 8	17	12	31	34	11	105	261	10			2,597
Diamond No 5	16	10	33	32	12	103	248	12			892
Brazil Block No. 11	20	2	4	10	4	40	124	3			1,120
Continental No. 1	26			8	5	39	147	2		$336 00	
Gart No 5	34			4	5	43	17	6			
Gart No. 7	60			15	9	84	200	7	1	5,035 65	609
Gart No. 10	14	4	15	14	7	54	19	7			1,228
Rebstock	27			3	6	36	24	1			320
Briar Hill	6	8	9	8	6	37	16	5			
Cloverland No. 1	136			45	15	196	163	17			5,050
Fair View	18			9	5	32	50	3			750
Lawrence No. 6	65			8	6	79	188	4			1,222
Lawrence No. 7	84			29	9	122	281	10			3,642
Cornwell	67			11	6	84	228	7	1		1,750
Crawford No. 3	41			6	4	51	130	3			322
Crawford No. 2	53			10	5	63	278	4			1,995
Crawford No. 5	52			11	5	68	255	4			2,420
Crawford No. 6	46			11	5	62	203	3			2,324
Crawford No. 7	60			12	6	78	284	4			1,885
Eureka No. 3	22			6	4	32	217	4			607
Fortner	43			9	4	56	174	5			1,481
Klondyke	90			20	9	119	228	11	1		2,037
Gifford No. 1	40	12	31	25	10	118	169	9		8,313 41	3,050
Gifford No. 2	90	12	33	22	12	169	224	16	1		5,000
Glen	78			10	7	95	216	5			3,565
Pratt	27			7	6	40	105	5			510

Table Showing Number of Miners, Machine Runners and Helpers, etc.—Continued.

CLAY COUNTY—Continued.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Monarch	16	......	......	19	2	37	267	2	......	......	......
Pearl	95	......	......	16	8	119	220	7	......	......	2,713
Lewis	......	4	10	1	4	19	52	1	......	......	125
Silverwood No. 3	32	......	......	12	9	53	183	7	......	......	......
Cloverland No. 2	47	......	......	5	4	56	77	2	......	......	727
Total	1,445	68	174	452	217	2,356	5,536	193	5	$13,685 06	49,029

DAVIESS COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Cabel No. 4	20	......	......	4	6	30	57	3	......	......	......
Cabel No. 9	50	......	......	15	7	72	199	6	......	......	1,534
Hoosier No. 4	12	......	......	3	2	17	30	......	......	......	......
Montgomery No. 2	34	......	......	11	6	51	267	5	......	......	2,224
Montgomery No. 3	123	......	......	28	11	162	256	17	......	......	5,916
Mutual	52	......	......	9	7	68	210	7	1	$1,600 00	2,400
Union	26	......	......	4	3	33	162	2	......	600 00	......
Mandabach	12	......	......	2	3	17	53	2	1	......	300
Total	329	......	......	76	45	450	1,234	42	2	$2,200 00	12,374

FOUNTAIN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Diamond	8	......	......	2	2	12	48	1	......	$30 00	......
Rush	42	......	......	8	6	56	23	2	1	3,100 00	......
Silverwood	16	......	......	1	8	25	26	1	......	......	......
Total	66	......	......	11	16	93	97	4	1	$3,130 00	......

GIBSON COUNTY.

Oswald	54	....	....	30	17	101	140	12	....	$3,554 05	1,599
Total	54	....	....	30	17	101	140	12	....	$3,554 05	1,599

GREENE COUNTY.

Black Creek	65	10	50	30	9	164	153	16	2	....	3,259
Island No. 1	48	14	32	42	13	149	218	16	....	....	2,136
Island No. 2	50	34	50	40	27	201	215	15	....	....	2,280
Island No. 3	83	....	....	23	10	116	216	13	....	....	2,576
Gilmour	15	16	90	42	15	178	208	19	....	....	1,380
Hoosier No. 1	6	4	22	6	5	43	239	3	....	....	514
Island Valley No. 3	120	....	....	32	12	164	182	18	....	....	4,515
Island Valley No. 2	43	....	....	10	8	61	209	5	....	$1,381 29	1,252
South Linton	150	....	....	31	9	190	208	17	....	....	5,456
Midland	12	12	60	25	10	119	190	9	1	....	1,200
Vulcan	17	....	....	3	6	26	81	1	....	310 00	400
Summitt No. 2	18	16	92	54	8	188	190	18	....	....	1,705
Templeton	93	....	....	21	11	125	280	13	1	....	3,600
Victoria	164	....	....	30	13	207	254	11	1	....	8,497
Glenburn	35	14	73	47	14	183	197	20	1	....	2,000
Antioch	78	....	....	36	11	125	288	7	2	12,724 76	2,707
Tower Hill	12	8	32	9	10	71	223	3	....	2,576 55	1,062
Green Valley	....	14	60	21	10	105	182	8	1	....	1,044
Lattis Creek No. 1	....	16	72	38	20	146	216	9	....	600 00	1,600
Atlas No. 1	21	10	45	18	10	104	233	9	....	....	1,444
Fry	25	....	....	6	3	34	....	2	....	2,336 39	1,200
Letsinger	16	8	18	5	9	56	....	3	1	19,500 00	500
North West	10	8	26	21	11	76	172	6	1	3,677 13	840
Twin	....	6	11	3	7	27	70	2	....	....	....
Island No. 5	16	....	....	10	6	32	49	2	....	....	385
Atlas No. 2	15	6	18	7	8	54	39	3	....	....	111
Total	1,112	196	751	610	275	2,944	4,512	248	11	$43,106 12	51,663

Table Showing Number of Miners, Machine Runners and Helpers, etc.—Continued.

KNOX COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Bicknell	45	....	....	12	10	67	202	8	....	....	3,496
Edwardsport	20	....	....	7	5	32	69	4	....	$50 00	....
Knox	51	....	....	13	7	71	172	7	2	....	3,000
Lynn	32	....	....	6	6	44	100	5	....	800 00	840
Prospect Hill	18	....	....	5	3	26	202	3	....	....	500
Total	166	....	....	43	31	240	745	27	2	$850 00	7,836

PARKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
C. B. Harrison	6	....	....	1	1	8	20	2	....	$40 00	232
W. P. Harrison	Not re	ported.	....	....	....	....	....	....	....	800 00	640
Brazil Block No. 12	20	18	50	40	14	142	265	16	....	....	1,492
Cox No. 3	77	....	....	25	14	116	260	10	1	4,896 46	3,065
Lucia	57	....	....	18	7	82	202	12	2	600 00	2,568
Mecca No. 1	32	....	....	17	8	57	202	13	1	....	1,778
New Century	Not re	ported.	....	....	....	....	....	....	....	....	....
Lyford No. 1	....	12	40	31	15	98	175	7	....	15,871 00	1,341
Mary	17	14	45	27	9	112	249	8	1	2,200 53	2,295
McIntosh No. 3	33	....	....	10	5	48	271	3	....	....	....
Superior No. 1	128	....	....	20	8	156	227	9	1	....	4,971
Superior No. 2	83	....	....	25	8	116	277	11	1	....	3,926
Superior No. 3	85	....	....	13	7	105	177	5	1	....	2,502
Minshal No. 1	141	....	....	40	10	191	260	16	....	1,411 68	6,064
Pan American	140	....	....	21	11	172	211	8	....	....	3,443
Brazil Block No. 9	93	....	....	31	9	133	178	9	....	....	1,743
Raccoon	27	....	....	5	5	37	238	3	2	62 28	1,628
Park No. 11	19	12	11	8	7	57	180	3	....	....	1,301
Minshal No. 2	17	....	....	3	4	24	27	1	....	....	41

Crawford No. 10	Not re	ported.	....	....	....	....	....	....	....	....	109
Crawford No. 8	Not re	ported.	....	....	....	....	....	....	....	....	344
Mecca No. 4	....	....	....	....	....	....	....	....	....	....	1,324
Total	975	56	146	335	142	1,654	3,419	136	10	$25,881 95	40,807

PIKE COUNTY.

Massey	28	....	....	5	3	36	195	3	....	$2,243 15	1,200
Aberdeen	30	....	....	8	6	44	204	5	....	1,121 00	1,200
Ayrshire No. 3	61	....	....	21	9	91	156	17	....	....	6,944
Ayrshire No. 4	85	....	....	26	20	131	140	10	....	2,506 60	....
Ayrshire No. 5	Not re	ported.	....	....	....	....	....	....	....	2,250 00	....
Blackburn	48	....	....	12	8	68	123	8	....	....	1,708
Hartwell	90	....	....	14	18	122	178	11	....	3,049 87	2,730
Littles	122	....	....	35	11	168	176	20	1	....	4,220
Rogers	20	....	....	5	1	28	27	2	....	....	106
Petersburg	35	....	....	16	7	58	159	6	....	....	1,549
Carbon	17	....	....	6	4	27	226	8	....	1,650 00	900
Winslow	80	....	....	22	15	117	184	12	....	532 98	....
Total	616	....	....	170	102	888	1,768	97	1	$13,353 69	20,557

PERRY COUNTY.

Troy	20	....	....	3	3	26	205	2	....	$480 00	701
Total	20	....	....	3	3	26	205	2	....	$480 00	701

SULLIVAN COUNTY.

Lablanch	8	....	....	13	19	40	21	1	....	....	....
Bunker Hill	19	4	24	20	10	77	193	12	....	$1,354 00	1,809
Caledonia	....	12	54	33	13	112	227	10	....	18,774 00	2,003
Dugger	10	8	44	35	15	112	213	14	1	....	942
Green Hill	....	8	45	17	9	79	159	8	1	341 71	700
Hymera No. 1	20	12	105	35	25	197	207	15	1	....	2,142
West Linton	Not re	ported.	....	....	....	....	....	....	....	2,800 00	....
Jackson Hill No. 2	....	18	108	48	16	190	233	22	1	....	1,618
Phoenix No. 1	18	16	40	27	17	118	216	10	....	....	....

Table Showing Number of Miners, Machine Runners and Helpers, etc.—Continued.

SULLIVAN COUNTY—Continued.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Phoenix No. 3	15	....	....	4	3	22	203	3	....	....	2,062
Phoenix No. 5	37	6	6	12	9	70	84	6	1	....	....
Shelburn	4	4	14	9	9	40	183	6	1	$3,850 00	....
Star City	....	16	84	52	24	176	212	14	1	....	1,551
White Ash	51	....	....	11	7	69	217	5	....	2,130 93	1,988
Freeman	30	....	....	7	5	42	77	4	....	1,211 00	803
Sun Flower	1	12	73	23	10	119	208	8	....	....	1,200
Glendora	2	16	103	37	19	177	200	10	....	....	2,312
Hymera No. 2	12	12	85	20	15	144	191	11	1	....	2,397
Wilfred No. 1	....	12	70	27	14	123	219	7	....	....	1,618
Little Giant	....	6	28	18	10	62	125	3	....	....	221
Cummins	8	10	17	15	15	65	103	4	....	....	
Citizens	12	....	....	4	5	21	24	2	....	....	....
Mildred	....	4	6	1	4	15	50	1	....	....	100
Island No. 4	20	....	....	2	6	28	22	2	1	....	60
Mammouth Vein	8	2	2	6	4	22	19	1	....	....	....
Total	275	178	908	476	283	2,120	3,606	177	9	$30,461 64	23,526

VANDERBURGH COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Diamond	35	....	....	6	6	47	260	3	....	....	....
First Avenue	22	....	....	5	7	34	92	2	....	....	732
Ingleside	Not re	ported.	....	....	....	....	....	....	....	....	....
Sunnyside	61	....	....	17	10	88	188	11	3	....	2,032
Union	30	....	....	7	7	44	203	4	....	$500 00	144
Unity	74	....	....	12	10	96	278	9	....	....	3,972
Total	222	....	....	47	40	309	1,021	29	3	$500 00	6,880

VERMILLION COUNTY.

Bruilettes Creek No. 3	91			22	8	121	183	13			7,233
Bruilettes Creek No. 5	115			25	10	150	131	16	2		
Buckeye	47			17	18	72	181	7			
Cayuga	15			4	3	22	235	2		$331 60	700
Crown Hill No. 1	133			22	10	165	222	12		11,685 00	7,895
Oak Hill	141			37	11	189	192	16	1	3,072 80	9,301
Prince	155			34	10	199	216	14	1	1,474 56	1,600
Willow Grove	70			10	7	87	172	6		7,344 15	5,796
Crown Hill No. 2	Not re	ported.									271
Total	767			171	67	1,005	1,532	86	4	$23,908 11	32,796

VIGO COUNTY.

Atherton		8	35	8	9	60	258	3			
Rhoades	33			17	8	58	49	3			
Brick Works	12			4	2	18	140	2			600
Chicago No. 6	78			18	8	104	184	9		$250 69	1,200
Diamond	120			40	13	173	178	16			4,000
Peerless	70			20	8	98	29	11			2,575
Lawton	113	4	3	28	11	159	205	11			3,660
Union	73			24	12	109	241	13			2,330
Ehrlich	21			11	5	37	259	3	1		923
Grant No. 2	110			38	11	159	170	18		216 00	4,947
Glen Oak	50	12	67	51	17	137	242	30	1		3,899
Hector	60			18	9	87	248	8		250 00	3,035
Klondyke	93			17	10	120	235	12			3,621
Miami No. 1	157			23	10	190	216	13			4,973
Nickle Plate	40			13	9	62	146	7	1		
Park No. 10	50	30	40	47	17	184	227	15			2,830
Ray	70			13	6	89	42	7			
Redbird	41			7	4	52	283	3			2,145
Rosebud No. 2	128			30	9	167	222	9			4,220
Royal No. 1	95			20	12	127	228	8			4,414
Larimer	22			5	5	32	44	2	1		717
Broadhurst	50			8	7	65	270	4			3,280
Miami No. 2	28			6	4	38	142	2			778
Deep Vein	40			12	6	58	165	3			1,860
Greenfield No. 1	27			5	5	37	203	2			1,925
Lost Creek	36			8	6	50	45	4			625
Sugar Creek	12			7	6	25	24	1			
Total	1,629	54	145	498	229	2,555	4,665	219	4	$585 57	71,669

Table Showing Number of Miners, Machine Runners and Helpers, etc.—Continued.

WARRICK COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.	Number Kegs of Powder.
Air Line	21	....	....	4	8	28	247	3	1	$1,525 00	....
Big Four	....	12	42	15	12	81	244	7	....	2,951 16	1,540
Big Vein No. 3	13	16	39	10	9	87	155	4	1	....	1,238
Caledonia	13	....	....	3	3	19	210	3	....	26 00	610
Chandler	24	....	....	7	3	34	186	3	....	1,645 75	920
DeForrest	17	....	....	3	3	23	127	2	....	227 86	1,025
Star No. 1	44	....	....	9	10	63	130	9	1	....	2,050
Electric	....	8	27	8	9	52	149	4	....	....	1,000
Total	132	36	108	59	52	387	1,448	35	3	$6,375 77	8,383
Grand total	7,808	588	2,232	2,981	1,519	15,128	29,928	1,300	54	$168,071 96	327,820

TABLE.

MACHINE MINES.

Showing by Counties the Name of Mines, Number and Kind of Machines, Tons of Coal Mined, Number Miners Employed, Average Tons per Miner.

CLAY COUNTY BLOCK COAL MINES.

MINE.	Kind of Machines.			Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
	Compressed Air Puncher.	Electric Chain.	Total Number Machines.				
Brazil Block No. 1	......	9	9	12 094	12	1,008	1,344
Brazil Block No. 8	......	6	6	35,110	43	812	58,578
Brazil Block No. 1	......	2	2	1,673	16	105	836
Diamond No. 5	......	·5	5	44,009	43	1,023	8,802
Gart No. 10	......	3	3	27,447	19	1,445	9,149
Total General Average	......	24	24	120,333	133	980	5,013

PARKE COUNTY BLOCK COAL MINES.

MINE.	Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Brazil Block No. 12	......	12	12	55,875	68	821	4,656
Mary	......	7	7	11,222	59	190	1,603
Total General Average	......	19	19	67,097	127	528	3,531

CLAY COUNTY BITUMINOUS MINES.

MINE.	Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Gifford No. 1	......	6	6	27,958	43	650	4,659
Gifford No. 3	......	6	6	35,072	45	779	5,845
Total General Average	......	12	12	63,030	88	716	5,252

GREENE COUNTY BITUMINOUS MINES.

MINE.	Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Black Creek	......	5	5	80,111	60	1,201	16,022
Island No. 1	8	......	8	67,149	46	1,460	8,393
Island No. 2	18	......	18	110.774	84	1,318	6,154
Gilmour	......	8	8	136,024	106	1,283	17,003
Hoosier No. 1	......	2	2	20,925	26	804	10,462
Midland	......	6	6	100,185	72	1,391	16,697
Summit No. 2	......	9	9	147,631	108	1,367	16,403
Glenburn	......	7	7	99,215	87	1,140	14,173
Antioch	......	6	6	31,732	50	634	5,288
Green Valley	......	7	7	86,386	74	1,167	12,340
Lattis Creek	......	8	8	108,961	88	1,238	13,745
Atlas No. 1	......	5	5	75,478	65	1.372	15,095
Letsinger	4	......	4	18,325	26	705	4,581
North West No. 1	......	4	4	26,177	34	770	6,544
Twin	......	3	3	2,615	17	153	871
Atlas No. 2	......	2	2	4,892	34	149	2,446
Tower Hill	......	5	5	46,378	40	1,159	9,275
Total General average	30	77	107	1,162,958	1,007	1,155	11,896

MACHINE MINES—Continued.

PARKE COUNTY BITUMINOUS MINES.

MINE.	Kind of Machines. Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Lyford No. 1	......	6	6	22,080	52	424	3,680
Parke No. 1	6	......	6	25,749	23	1,119	4,291
Total General average	6	6	12	47,829	75	638	3,985

SULLIVAN COUNTY BITUMINOUS MINES.

MINE.	Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Bunker Hill	......	4	4	28,836	28	1,022	7,209
Caledonia	......	8	8	36,956	66	560	4,618
Dugger	......	5	5	68,410	52	1,315	13,682
Green Hill	......	4	4	40,246	53	759	10,061
Hymera No. 1	......	8	8	156,392	117	1,336	19,549
Jackson Hill No. 2	......	9	9	196,415	126	1,559	21,824
Phoenix No. 3	9	......	......	128,036	56	2,286	14,670
Phoenix No. 5	3	......	......	17,416	12	1,451	5,805
Shelburn	......	2	2	15,834	18	879	7,917
Star City	......	8	8	105,739	100	1,057	13,217
Sun Flower	......	6	6	139,832	85	1,527	23,305
Glendora	......	8	8	163,768	119	1,376	20,471
Hymera No. 2	......	8	8	152,770	97	1,575	19,096
Wilfred	......	8	8	130,846	82	1,595	16,355
West Linton	......	1	1	280	10	28	280
Cummins	5	......	5	2,000	27	7	400
Mildred	......	2	2	1,745	10	174	872
Total General Average	17	81	98	1,385.548	1,133	1,222	14,138

VIGO COUNTY BITUMINOUS COAL MINES.

MINE.	Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Atherton	......	4	4	39,713	43	900	9,928
Lawton	......	2	2	3,920	7	531	1,960
Glen Oak	......	6	6	165,715	79	2,090	27 519
Parke No. 10	15	......	15	146,988	70	2,099	9,799
Total General Average	15	12	27	355,736	199	1,285	29,645

WARRICK COUNTY BITUMINOUS MINES.

MINE.	Compressed Air Puncher.	Electric Chain.	Total Number Machines.	Tons Produced.	Number of Miners Employed.	Average Tons per Miner.	Average Tons per Machine.
Electric	......	4	4	31,313	35	894	7,823
Big Four	6	......	6	74,003	54	1,345	12.334
Big Vein	8	......	8	96,231	55	1,749	12,029
Total General Average	14	4	18	201,547	144	1,399	11,141
Grand Total	82	235	317	3,404,078	2,820	1,207	10,738

Note.—Total pick miners, 7,808; total pick mine coal, 6,588,475 tons; average tons per miner, 843.

TABLE,

Showing Number of Miners, Total Wages of Miners and Average Wages Per Miner; Number of Inside Day and Monthly Men, Total Wages of Same, and Average Wages Per Man; Number of Outside Day and Monthly Men, Total Wages of Same, and Average Wages Per Employe, by Counties.

COUNTY.	Number of Miners.	Total Wages of Miners.	Average Earning Per Miner.	Number of Inside Day and Monthly Men.	Total Wages of Inside Day and Monthly Men.	Average Earning Per Inside Day and Monthly Men.	Total Wages of Persons Outside.	Number of Persons Outside.	Average Earning Per Outside Man.
Clay	1,687	$736,361 87	$436 43	452	$315,330 88	$697 63	$137,624 60	217	$634 21
Daviess	329	131,413 05	451 11	76	42,503 13	559 12	21,525 94	45	478 30
Fountain	66	9,028 33	136 79	11	2,531 37	230 12	1,776 49	16	111 03
Gibson	54	24,854 19	460 26	30	15,609 54	520 31	10,769 33	17	633 48
Greene	2,059	1,228,519 74	596 65	610	427,766 47	602 89	231,759 18	275	842 76
Knox	166	78,796 92	474 68	43	28,118 42	654 38	15,676 27	31	505 68
Parke	1,177	699,901 77	593 79	335	268,874 31	802 60	119,728 18	142	843 15
Perry	20	7,412 74	370 63	3	2,069 69	689 89	1,632 92	3	544 30
Pike	616	292,045 31	474 09	170	105,706 67	621 80	52,180 01	102	511 55
Sullivan	1,361	766,741 31	563 36	476	322,156 76	673 79	175,538 92	283	620 31
Vanderburgh	222	134,192 28	604 46	47	35,535 68	756 07	23,007 82	40	575 12
Vermillion	767	538,829 07	702 51	171	140,071 21	819 12	69,547 49	67	1,038 02
Vigo	1,828	1,038,557 30	568 13	498	309,604 58	621 69	145,599 92	229	640 12
Warrick	276	157,026 13	568 58	59	34,661 66	587 60	22,793 96	52	438 30
General Average	10,628	$6,017,021 20	$566 14	2,981	$2,085,116 28	$699 67	$1,047,434 64	1,519	$689 54

NOTE.—Pick miners, machine runners and helpers and loaders are reported as miners.

TABLE,

Showing Price Paid Per Ton for Pick and Machine Mining, Inside Day Labor, Total Number of Employes, Total Production, Total Wages, Wages Per Year Per Employe, and Per Cent. of Gain or Loss Per Ton for Each Year from 1890 to 1903, Inclusive.

Year.	Block Mining.		Bituminous Mining.		Wages Inside Day Labor.	Total Number Employes.	Total Production.	Total Wages.	Wages Per Year Per Employe.	Per Cent. Gain.	Per Cent. Loss.
	Price Pick Mining.	Price Machine Mining.	Price Pick Mining.	Price Machine Mining.							
1890	$0 75	....	$0 70	$0 34½	$1 87½	6,550	3,791,211	Not reported	....	.....	.....
1891	75	....	70	34½	1 87½	6,975	3,819,600	....	....	.....	.....
1892	75	....	70	34½	1 90	7,600	4,408,471	....	....	.....	.....
1893	75	....	70	34½	1 90	7,431	4,358,897	....	....	.....	.....
1894	75	....	65	34½	1 90	Not	reported.	....	....	.....	7½
1895	70	....	60	29½	1 75	7,885	4,202,084	$1,852,500 00	$234 93	.....	$7\frac{9}{13}$
1896	70	....	60	29½	1 75	7,112	4,068,124	1,750,000 00	246 06	.....	.....
1897	61	....	51	27⅜	1 52½	7,984	4,088,100	1,600,000 00	200 40	.....	15
1898	76	$0 57	66	30	1 75	....	5,140,920	1,182,500 00	....	$29\frac{7}{17}$	.....
1899	76	57	66	30	1 75	7,366	5,839,713	3,813,652 39	517 73	.....	.....
1900	90	68½	80	39	2 25	8,858	6,283,063	4,843,343 26	546 77	$21\frac{7}{33}$	.....
1901	90	68½	80	62	2 30	12,096	7,019,203	5,680,539 86	469 62	.....	.....
1902	90	68½	80	62	2 30	13,139	8,763,197	7,078,913 12	538 77	.....	.....
1903	1 00	78½	90	68½	2 56	15,128	9,992,553	9,149,572 12	604 81	12½	.....

Above Percentages are based on Pick Mining.
April 1st, 1900, Miners' Screens were reduced from 1½ inch mesh flat bar to 1¼ inch mesh acron bar, which amounted to 5 cts. advance per ton on mining.
Total reduction in price per ton from 1890 to 1897 amounted to 27½%.
Total gain 1903 over 1890, $35\frac{5}{7}$%.
Total gain 1903 over 1897, 86%.

FATALITIES AND INJURIES.

During the year 1903 there were more accidents to mine employes, fatal, serious and minor, than in any of the previous years in the history of the mining industry of this State.

The monthly reports of mine bosses made to this Office show an aggregate of two hundred and seventy-six (276) accidents, classed as follows: Fatal, fifty-five (55); serious, one hundred and forty-five (145); and minor, seventy-seven (77), the causes of which are shown by the annexed table.

TABLE,

Exhibiting the Number of Casualties Arising from Different Causes, 1903.

CAUSE OF ACCIDENT.	Fatal.	Serious.	Minor.	Total.
Falling slate	17	64	27	108
Falling coal	1	16	5	22
Mine cars	5	40	18	63
Caught by cage	3	3	5	11
Kicked by mule	......	......	2	2
R. R. cars	1	......	2	3
Windy shots	2	5	......	7
Delayed shots	4	1	1	6
Premature shots	5	7	......	12
Smoke explosion	......	10	......	5
Shot blowing through pillar	1	1	1	3
Suffocated	3	......	......	3
Powder explosion	4	2	......	6
Explosion of kerosene	1	......	......	1
Gas explosion	1	3	......	9
Mining machine	......	......	2	2
Fell down shaft	5	......	......	5
Coal falling down shaft	......	1	1	2
Electric shock	1	......	......	1
Miscellaneous causes	......	2	3	5
Total	55	145	77	277

An investigation of each of the above fatalities, as well as a greater part of the serious accidents, was made either by myself or one of my assistants, and, with one or two exceptions, i. e., where persons lived for some time after being injured, the investigation of the fatal accidents was made in conjunction with the coroner of the county in which the accident occurred.

COMMENTS ON ACCIDENTS.

The increased number of casualties in 1903, as indicated by this report, is attributable, in some measure at least, to the number of new mines that have been opened, thus affording more avenues of danger—there being more coal mined, necessitating the employment of a greater number of miners and other mine employes, also the use of more explosives, all of which are important factors in the history of mine accidents. The prime factors, however, is the use, or in a majority of cases the misuse, of these explosives.

In making an inspection of a mine recently, I overheard a miner remark, "that powder was cheaper than muscle." This seems to be the maxim of the average miner today, hence the increase in the number of mine accidents.

In our report for the year 1901, we made the statement that at least fifty per cent. of the mine accidents for that year were due either directly or indirectly to the use of powder; by smoke explosions caused by a number of heavy shots being fired simultaneously; by premature and delayed shots, also by windy or blown-out shots, the latter being caused by shots that were either misplaced or overcharged; all of which is very destructive to the safety of the miners and the property of the mine owners.

It will require but a brief review of the table of causes and the description of casualties occurring in 1903, to substantiate the fact that the above statement will more than hold good for that year.

Of the thirty-four fatalities, as shown by the table, nineteen (19), 35 7-10 per cent., were due directly to the use of powder and other explosives, while seventeen (17), or nearly 31½ per cent., were due to falling slate. Conservatively speaking, at least one-half of the latter number would have been avoided had the most ordinary precaution been taken in examining the roof after shots had been fired, and by resetting props which had been knocked down by coal thrown from such shots. All of such precautions are incumbent upon the miners for their own safety.

While discussing this subject, it will not be amiss to mention two other factors that have played important parts in connection with the fatal and serious accidents that have occurred within the past three years, viz., dynamite and fuse—the former being used in conjunction with blasting powder, resulting in almost every instance in an overcharged shot, while the use of fuse in preference to squibs has been the cause of accidents in many ways, such as delayed or premature shots.

The great danger in this practice is the fact that the shot firer will commence lighting shots at the head of an entry and continue from one room to another as long as there are any shots to light in that part of the mine, and the fuse on which the shots are tamped being cut at different lengths, will occasionally result in a dozen or more exploding simultaneously, causing a severe explosion, or an accident from the extra heavy concussion.

Both of the above practices can not be condemned too severely, and there should be laws enacted prohibiting the use of either dynamite or fuse in blasting coal.

Three of the unfortunates that met their death during the year were not mine employes. One, a boy under fourteen years of age (the minimum age prescribed by law at which boys are allowed to work in the mines of this State), had been sent into the mines by his parents to assist an older brother, who had been working with their father. The father was absent on that day. The other two persons were merely visiting the mine in which they met their death.

A history of each of the other fifteen fatalities not commented on above will be found in the description of fatal accidents given below.

FATAL ACCIDENTS.

Clay County.

January 5th—Goldy Hadley, miner, was almost instantly killed in the Gifford No. 2 Mine. He was working off some loose coal in a break through, and in doing so, uncovered a bad slip in the roof, when at about 10 o'clock, apparently without warning, a large piece of slate fell, striking him on the head, crushing it so badly that he died in twenty minutes.

January 29th—Charles Smith, miner, aged forty-five years, having a wife and two children, was fatally injured by a fall of slate in the Klondyke Mine. He was at work in his room on the morning of above date, mining off some loose coal, when about 9:30 o'clock, apparently without warning, about four tons of slate gave way from a slip which had been exposed in the roof, falling on him and inflicting injuries from which he died at 3 o'clock of same date. His room was well timbered with the exception of this slip, which had been neglected.

April 15—Dora McCullough, driver, age twenty years, married, was fatally injured by being run over with a mine car in the Cornwell Mine. Evidence obtained at the investigation shows that there was a hill some fifty or sixty yards long with about 8 per cent. grade in favor of the loaded cars on the run on which he was driving, requiring two spraggs on one side and three on the opposite side of a trip of two cars. At the time of the accident his trip was found at the bottom of the hill with one spragg in it, and McCullough was sitting up leaning against the car as if he had been squeezed by the mule. He lived about forty minutes and was not able to talk during that time. He leaves a wife and one child.

July 8th—William Buckholz, miner, age twenty-six years, married, was killed by a premature blast in the Brazil Block Coal Company's No. 1 Mine. He and three other miners were employed driving a pair of entries through a rock fault in the above mine. About 3:30 o'clock of the date above named, they had three shots ready to fire in a break through, two sumpers, one located in each corner of the place and one near the roof in the center. The two sumpers were each charged with five sticks of dynamite, tamped on eighteen inches of fuse. The accident was caused in attempting to fire them.

Buckholz lighted one and turned to light the other, when he sank or fell forward on the one he had just lighted and lay there until it had exploded, killing him instantly. The supposition is that he had an attack of heart failure which caused him to fall. He leaves a wife and three children.

November 19—James McGowan, miner, age sixty-four years, married, was fatally injured by falling slate in the Brazil Block Coal Mine No. 1. He and his son were at work in his room in the afternoon, when, apparently without warning, a large piece of slate, 14x12 feet in width and length, fell on him injuring him so that he died three days later. He leaves a dependent wife.

Daviess County.

September 28th—Charles Mandabach, miner, age thirty-four years, married, has three children, was killed by falling down the Mandabach coal shaft, located near Washington. Deceased was one of the owners of the mine, and the morning of above date he was working on the top, dumping coal. There were no gates at the top landing, and in switching an empty car he pushed it into the shaft, himself falling to the bottom, being killed instantly. A compliance with the statute requiring gates at the top of the shaft would have prevented this accident.

Fountain County.

October 14th—Fred Perry, miner, age twenty-six years, single, was fatally injured in the Rush Mine. At firing time on the evening of above date, deceased was standing in the entry when a very heavy shot was fired in a room some fifty feet distant, the force of which knocked him down striking his head against the rail and fracturing his skull. Death resulted a short time after.

Greene County.

January 10th—Scott Padgett, age forty-one years, married, was fatally injured by the railroad cars at the Templeton Mine. He was employed to bring the flats down to the tipple at the mine, and about 10:45 o'clock, of above date, he was riding on the front end of a car which was being pulled down to the tipple by a mule. When some distance from the tipple he jumped off the car for the purpose of making the mule travel faster, and in so doing caught his heel in the switch frog, throwing him down across the rail. The car passed over both legs crushing them so badly that amputation was necessary, death resulting a short time after the operation was performed. He leaves a wife and nine children.

March 10th—C. Shuts, miner, age seventeen years, single, was killed by a blast in the Glenburn Mine. He was working in a room with his father at the time, and on the evening of above date the father had gone home, leaving the son to fire the shots, two in number. At about 3:30 p. m. he attempted to fire one of the shots when it exploded prematurely, either from a defective squib, or by his lighting the squib too close to the powder. He lived two days after the accident.

April 28th—Ross Figgins, machine helper, age thirty years, married, was killed by falling coal in the Midland Mine. On the above date he was at work shoveling slack after a machine. He and his machine runner were making the last cut in the right-hand corner of a room in which a piece of loose coal had been left from the preceding cut. They had the cut nearly finished, when about two and one-half tons of the coal gave way, striking and killing him instantly. He leaves a wife. This accident could have been prevented by a small amount of labor on the part of the loader in working off the loose coal.

July 1st—August Klusmier, miner, age twenty years, married, was instantly killed by falling slate in the Black Creek Mine. This accident was investigated by Mr. Dodds, Assistant Inspector of Mines, who reports that deceased did not have his room properly timbered, as being the prime cause of the accident. He leaves a wife and one child.

August 19th—Edward Culp, driver, age twenty-five years, married, was fatally injured in the Green Valley Mine. On the afternoon of above date, he had gone into an entry after a trip and had instructed another driver to follow him in and pull a car from a room outside of where Culp was going. The driver who followed him in left his empty car stand in the entry while he went into the room after the loaded one. Deceased seemingly had forgotten the instructions he had given the other driver, as he came down the entry at rather a fast rate of speed, standing on the front end of the loaded car, which collided with the empty one, crushing him, inflicting injuries from which he died ten days later. He leaves a wife and one child.

August 27th—Israel Hughes, Jerryman, age thirty years, married, was killed by falling slate in the North West No. 3 Mine. At about 11 o'clock on the above date, he and one other person were at work cleaning up a fall of slate on one of the cross entries when, apparently without warning, a large piece of slate fell on him, killing him instantly. The slate had been examined by himself and the boss in the morning before commencing work, both pronouncing it safe to work under. He leaves a wife.

August 28th—Michael Schafer, miner, age twenty-nine years, single, was fatally burned by a powder explosion in the Antioch Mine. On the afternoon of above date, he had made up his cartridges, and was cleaning a blasting barrel. In order to dry it, he fired a squib through it. The squib, passing through the barrel, struck the face of the coal and bounded back into the loose cartridges, firing them, they in turn exploding the powder in the keg sitting near by, burning him so badly that he died three days later at St. Anthony's Hospital in Terre Haute.

October 15th—Logan Edington, miner, age seventeen years, single, was killed instantly by falling off an ascending cage in the Letsinger shaft. Little could be learned of this accident, other than the fact that the proper signal had been given. The engineer replied at the top of the shaft with the answering signal, after which deceased got on the cage and it was belled away. When the cage reached the surface he had disappeared. The supposition is that he lost his balance and fell off the cage.

December 4th—George Gilman, miner, age twenty years, was fatally injured by a delayed shot in the Black Creek Mine. Little could be learned of this accident other than the deceased had lighted his shot and retired to an adjoining room for safety, and after waiting a while, it is presumed, thinking the squib had gone out, he started back to try another one, but when within a few feet of the shot it exploded, injuring him so that he died on December 6th, at St. Anthony's Hospital, Terre Haute. He leaves a wife.

December 5th—Joseph Maney, age forty years, miner, married, was killed in the Antioch Mine by a piece of coal thrown from a shot. This accident was investigated by Assistant Inspector Mr. Thomas, and from evidence obtained it was learned that there were four shots fired inside of the room in which deceased was working, one of which was in the face of the entry about eighty to one hundred feet distant. Also that the shots in this mine are tamped on fuse. At about 3:20 o'clock the entry man lighted his shot and ran past deceased's room calling him to come. Deceased then lighted his shot and ran out on the entry. Just as he reached his room parting, the shot in the face of the entry exploded, throwing a piece of coal, which struck deceased just behind the left ear, injuring him fatally. When found by parties who returned to look for him he was lying in an adjoining room in an unconscious condition, from which he did not recover. He leaves a dependent wife and two children.

December 17th—Charles Moore, miner, age twenty-three years, single, was killed by a falling slate in the Victory Mine.

Deceased and two other persons were working at night, shooting down slate, for the purpose of making height at a point on the double parting about seventy feet from the shaft bottom in the above mine. At about 10 o'clock p. m. of the date named they had fired two shots in the slate, one on each side of the entry. The shots did not bring the slate down, but left it in such a condition that it was almost ready to fall. For some reason, deceased went in under it, it is thought to get a couple of cap-pieces to be used as wedges, and while under it a large piece of the slate fell on him, inflicting injuries from which he died at 11 o'clock the following day.

Knox County.

July 14th—Walter Welty, aged seventeen years, was killed by falling down the Knox Coal Company's shaft located at Bicknel. Deceased was not an employe of this company, but on this evening was visiting the night engineer. Deceased requested the engineer to let him down the shaft, which he refused to do. The engineer then went into the boiler room, to attend to his fires, and when he returned deceased had disappeared. On investigation he was found at the bottom of the shaft, life extinct. The supposition is that he opened the shaft gate to step on the cage, which he thought was at the ground landing. It being very dark, he did not see that the cage was not there and stepped into the open shaft.

December 14th—Claude Alsman, not an employe, age seventeen years, single, was killed by an ascending cage in the Knox Mine. This accident was investigated by Assistant Inspector Mr. Dodds, and from evidence taken at the inquest it was learned that deceased was not an employe of this company, but had gone down into the mine to visit some friends and look around the mine. When coming up out of the shaft with a number of other persons he lost his balance, presumably caused by the motion of the cage, leaned over and was caught by a buntin, and thrown back down the shaft, a distance of about seventy feet. Life was extinct when he was brought to the surface.

Pike County.

December 19th—Riley Rumble, driver, aged twenty-six years, single, was fatally crushed between a mine car and the entry rib in the Littles Mine. He was standing on the front end of a trip of cars at a double parting. There were four mules standing in the way, and he was waiting for them to move, so that he could start to the shaft bottom with his trip. When his mule started to pull the cars, in leaning over to avoid the other mules, he was caught between the car and the rib and crushed so badly that he died two days later.

Parke County.

January 7th—Peter August Johnson, miner, aged seventy-six years, single, was killed in the Mary Mine. He was at work loading a car of coal on the morning of above date, working some eight feet back from the face of his room, which was well timbered, when a piece of slate, about 250 pounds weight, fell on his back, driving his face to the floor. The supposition is, that the blow stunned him, and that while in this unconscious condition with the rock laying on his head, holding his face to the floor, he was smothered to death.

June 5th—William Daniels, shot firer, aged thirty-nine years, married, met his death by suffocation in the Briar Hill Mine. Deceased and one other miner were employed to fire the shots in the above mine.

It was developed by the investigation that on the evening of the 5th, they had nearly completed their work and a number of very heavy shots had been fired on the first south entry, this being the point where they were then working. The supposition is, that Daniels lost his way in the mine, owing to the powder smoke. When found he was lying near the face of the entry where the first shots were fired life extinct. He leaves a wife and two children. Overcharged shots were largely responsible for this accident.

July 6th—Jesse Perkins, miner, age fifty-two years, married, was killed by a premature shot in the Zeller-McClellan Columbia No. 1 Mine. He had tamped a shot on a fuse on the evening of above date and about 3 o'clock attempted to fire it. The shot exploded while he was still trying to ignite the fuse, pieces of coal striking him and killing him instantly. His nephew, who was waiting to fire a dirt shot at the time, was also seriously injured by flying coal, having his leg fractured and was otherwise cut and bruised. Deceased leaves a wife. Had a squib been used in this instance, the accident might have been avoided.

August 14th—Bass Montgomery, fireman, age twenty-six years, married, was fatally burned by an explosion of coal oil at the Lucia Mine. About 2 o'clock on the night of above day, he was filling his miner's lamp from a coal oil can containing about one-half gallon of oil. While so engaged the oil in the can exploded burning him so badly that he died at 4 o'clock the following afternoon. He leaves a wife and four children.

September 15th—James Rosa, miner, age seventeen years, single, was suffocated by breathing heated powder smoke in the Columbia No. 2 Mine. He had gone into the mine about 7 o'clock p. m. of above date with Vennela Guido, a fellow miner, to assist him in firing a couple of shots, and as they did not come out as soon as expected, a searching party went into the mine after them. Both men were found unconscious in the room where the shots had been fired and deceased never regained consciousness. His companion, however, recovered after being brought to the surface, though suffering from the injuries received. It is presumed, as there was no evidence of their having been injured by coal, slate, or otherwise, that they had gone back into the room after the shots were fired to note results and were overcome by the smoke.

October 31st—Thomas Kerrick, miner, age twenty-eight years, married, was fatally injured by falling slate, in the Briar Hill Mine.

Deceased had gone into a fellow-miner's room to visit, and was standing somewhere near the center of the room when a piece of draw slate three and one-half inches thick, measuring eighteen by twenty-four feet wide, fell on him and so injured him that he died one hour later. He leaves as dependents a wife and two children.

November 30th—Albert E. Snodgrass, trapper, age fifteen years, was fatally injured by falling slate, in the Mecca No.

1 Mine. About 11 o'clock a. m. of above date, he was following his driver from his door out to the double parting when a large piece of slate measuring eleven by eight feet, length and breadth, four inches in thickness fell on him, inflicting injuries from which he died ten hours later

February 28th—Charles Wilden, miner, age forty-nine years, married, was fatally injured in the Cox No. 3 Mine, by being struck with pieces of coal thrown from a delayed shot. He had two shots ready to fire at firing time, 3:30 p. m., on the evening of above date, one of which he had lighted and retired to a place of safety. After waiting awhile, he heard a shot explode, which he thought was in his room. Results, however, proved it to be in an adjoining room. Having heard the explosion, he started back into his room to light what he thought was his remaining shot and when within ten or twelve feet of the face, his first shot exploded, pieces of coal from it striking and injuring him to such an extent that he died the evening of the same day. He leaves a wife and eight children. A compliance with the statute, requiring shots to be fired in rotation would have prevented this accident.

March 2d—Julius Currey, miner, single, age eighteen years, was killed by falling slate in the Lucia Mine. Evidence obtained at the investigation shows that at the time of the accident at 7:30 a. m., he was either setting a prop, or sounding the roof, it could not be determined which. He was found under a piece of slate with a sledge hammer in his hands. The section of slate was twenty-one feet long, seven feet wide and about eight inches thick. There were thirty-eight available props in the room at the time of the accident, and had a part of them been set, the accident could have been prevented.

May 15th—Matthew Barr, miner, age thirteen years, was fatally injured by falling slate in the Columbia No. 2 Mine. This was his first day in the mine and he was working with his father driving a break through off of a double parting. They had finished their day's work about 1:30 o'clock p. m., and the boy was back at the mouth of the break through gathering up some picks, when about one hundred pounds of slate fell on him, injuring him so that he died on the following day.

SULLIVAN COUNTY.

March 5th—Walter Kemp, driver, age twenty-two years, single, was killed in the Hymera No. 2 shaft about 11 o'clock on the morning of above day. Kemp, who was driving a mule on the night shift, got on the cage with his mule preparatory to leaving the mine. The cage was belled away in the usual manner, but when it reached the surface the mule was found standing on the cage, but the driver had disappeared. The alarm was given at once and on investigation, Kemp was found in the sump at the bottom of the shaft. No outcry, that would indicate what caused him to fall off the cage, had been heard.

March 14th—George Bemis (not employed), age fourteen years, was fatally injured by a mine car, in the Phoenix No. 5 Mine. On the morning of above day, he had gone into the mine to help his brother, and was assisting him to load a car of coal. There was considerable loose coal thrown on the roadway by a shot some distance back from the face of the room. The room they were working dips with rather a strong grade toward the face. In cleaning up the roadway, they had used a cap-piece to check the car. Deceased was working in front of the car, attempting to remove the chalk from in front of the car wheel for the purpose of letting the car down nearer the face of the room, when it started and caught him against a prop, crushing him, inflicting injuries from which he died within a few hours.

April 2d—Murry Hunt, driver, age twenty-one years, married, was fatally injured by a gas explosion in the Green Hill Mine. On the morning of above day, Hunt, in company with another laborer and the mine boss, had gone into the mine for the purpose of repairing a dam which had been built to shut off the water in the old workings. The dam had been constructed of three walls of timber, packed between with clay. In order to make the necessary repairs, the greater portion of these timbers had to be torn out.

By 9:30 o'clock a. m. two of the walls had been removed, and the mine boss had picked up a bar and knocked out the wedge over the inner wall and raised his lamp to the opening for the purpose of examining the interior of the dam. Considerable gas had accumulated in the old workings, which found vent through the opening just made and ignited from his lamp, causing an explosion. Hunt, who was standing directly in front of the dam, received the full force of the explosion, and was burned and bruised so badly that he died while being taken home, a distance of two miles. Carelessness on the part of the mine boss was exhibited here, he knowing that the mine generated both black and fire damp and that tearing away the barrier would allow either to flood that part of the workings.

May 11th—Ludwig Hoffman, loader, age twenty-five years, single, was killed by falling slate in the Star City Mine. On the evening of above date, he and another miner, with whom he was working had fired four shots, three in one room and one in the inside adjoining room, firing the one in the inside room last. On their way out of the mine they were crossing the outside room, which was very smoky, and Hoffman was in advance, had gotten about half way across it, when suddenly a large piece of slate gave way, falling on him and killing him instantly.

June 10th—Isaac Prior, timberman, age fifty-nine years, married, having a wife and four children, was fatally injured by falling slate in the Shelburn Mine. About 2:25 p. m. he was standing in the main air course, opposite a break through. The supposition is, that he was examining the roof when a large piece of slate fell on him, injuring him so that he died about 5 o'clock in the afternoon of the same day.

July 3d—Clarence Wharton, age eighteen years, single, was killed by falling slate in the Dugger Mine. This accident occurred at a double parting on one of the cross entries, the parting being a terminal for both mule and motor haulage.

The slate which fell on deceased was located at the inside end of this parting and was known to be loose for several days. Charles Wharton, father of deceased and assistant mine boss, had tried to take it down prior to the accident, but failed. About 10 o'clock on above date, deceased came into the parting with a loaded trip, and having turned his mule was in the act of hitching it to an empty car, when a large piece of slate measuring eight feet in length, three feet wide, and from six to twenty-two inches thick fell on him, killing him instantly. It appears from the foregoing that the proper precaution was not taken in this instance, or the accident might have been prevented. The facts that the loose slate was located at a double parting where the drivers and mules during the day frequently were compelled to pass under it, in going to and from their work, and that the noise made by the tramping of the mules, moving mine cars, motors, etc., would drown any noise made by the slate in cutting, chipping, or other indications that it was about to fall, should have impelled double precautions being taken at points of this kind, in the way of timbering or taking the slate down.

October 8th—J. E. Chapple, miner, age nineteen years, single, was fatally burned by the explosion of a keg of powder in the Jackson Hill No. 2 Mine. A keg of powder which belonged to the deceased had been sent down the mine and was left laying on the roadside until it came his turn for a car. Deceased and a fellow miner were playing with the powder, driving nails into the keg, thus causing a spark which ignited the powder and brought about the explosion with the above results.

October 14th—A. L. Gaston, timberman, age thirty-nine years, married, was killed by falling down the Island Company's shaft No. 4. He was at work on the above date, putting a midwall betwen the hoisting and fan shafts. The midwall had been constructed to a depth of about one hundred and thirty feet, and the fan shaft was four by nine feet in size.

Deceased was lowering his brattice lumber shiplap, six inches by sixteen feet, down the fan shaft in a sinking bucket, the bucket being about two feet ten inches across. About 1:15 p. m. of above date, he had loaded the bucket with fifteen pieces of the shiplap, which were set in loose, the top ends dragging down the side of the shaft. He also got into the bucket himself to descend. Although advised by both the mine boss and the engineer not to do so, he persisted in going down with the lumber, and when about one hundred and thirty feet from the surface, which is about half way down, by some means or other he fell out of the bucket, falling to the bottom of the shaft and was instantly killed. He leaves a wife and six children.

December 8th—Adolph Hellman, loader, age forty years, married, was killed by a shot blowing through a pillar in the Hymera No. 1 Mine. He was working in room No. 30 on the second south entry. The room was only partially turned, being driven in about twenty feet, and is directly opposite a break through which had been driven from the second south to within one foot of being through to inside south entry. This entry had been driven just about to the outside edge of the break through, and the entry man in the first south had drilled a hole in his entry in the rib next to the break through, and judging from the depth of the hole knew that his powder would be bedded somewhere opposite. Also knowing that the pillar was very thin, he warned deceased of the danger of remaining in his room when the shot was fired. About 1:30 o'clock p. m. the entry man lighted his shot and called deceased to come out of his room, he replied all right, but continued at his work until the shot exploded, blowing through the pillar and throwing a large quantity of loose coal into the room neck, striking him and killing him instantly. He leaves a wife and two children.

Vanderburgh County.

The first fatal accident to occur in the mines of Indiana, during the year 1903, was that of Louis Pletcher and Richard Sanders, miners, both of whom were killed by a premature shot in the Sunnyside Mine, at Evansville, about 3 o'clock p. m., January 3d. There was no one present at the time the shot was fired, and as life was extinct in both when they were found, little could be learned as to the exact cause of the accident. On examination of the working place and surroundings, the face of a twelve-foot entry disclosed the fact that there had been two shots prepared, ready to fire, one in each corner of the face, but only one of which had been fired; the squib in the remaining shot showing evidence of having been lighted, as the sulphur on the match was considerably charred. Pletcher and Sanders were working buddies, driving a pair of entries together, and the presumption is that both had gone into the entry where the accident occurred, for the purpose of firing the two shots, each man to light one, and in doing so, the shot which exploded was either lighted too close to the powder, or the squib was defective, and when the shot exploded the concussion extinguished the remaining squib, with the result as above described.

December 2d—Wm. Ray, miner, age fifteen years, was fatally burned by a powder explosion in the Sunnyside Mine. About

10 o'clock a. m. of above date, he was filling a can of powder from a full keg, when his lamp fell into the can, exploding the powder therein as well as the remaining powder in the keg, inflicting burns from which he died during the night following.

Vermillion County.

May 15th—Thomas Durkin, driver, age thirty-five years, married, was fatally injured by mine cars in the Oak Hill Mine. About 11 o'clock a. m. of above date, deceased had come out to the double parting with a loaded trip. The double parting is located at the foot of a hill some two hundred yards in length; the coal being hauled from this point by rope haulage.

A trip of fifteen cars had just reached the top of this hill, which rises with rather a sharp grade, when in some way they became detached from the rope and ran back down the hill into the empty siding, striking the empties between which deceased was standing, injuring him so that he died on the evening of the same day. He leaves a wife and two children.

July 27th—Joseph E. Balcak, car coupler, age twenty-six years, single, was killed by coming in contact with an electric wire, in the Klondyke Mine. About 1 o'clock of above date he was coupling cars on a siding or double parting which forms the east terminal of the motor haulage in the Klondyke Mine. The trolley wire extends in past the siding a short distance, and stands about thirteen inches above the top of the mine cars and about on a line with the outer edge of the car. Deceased had stooped under the wire, reached in between the cars and made his coupling and when rising touched the wire with his left shoulder. He tried to make an outcry and a trapper boy standing nearby seeing his condition ran to him and tried to pull him away from the wire, receiving a shock which knocked him down. The boy then ran for help, but when it had arrived Balcak was dead.

As soon as notified of the accident the engineer examined his voltmeter and found that it was carrying but two hundred and forty-seven volts, two hundred and fifty being the maximum load carried. It is generally considered by electricians and other persons conversant with electric power that two hundred and fifty volts will not kill a human being, and in fact is not considered dangerous unless the contact continues for some length of time. In this connection we may say, there is never a day, in the mines somewhere in the State that some person does not come in contact with a live wire carrying two hundred and fifty volts, with no serious results.

In the above case, however, a combination of circumstances brought about the accident. The floor around the double parting was wet, and deceased was sweating and was resting his hands on the car irons, his left side also touching the irons on the car and his left shoulder the live wire, thus forming a direct circuit through his heart, which may possibly have been weak. The evidence proves conclusively that this death at least was due entirely to an electric shock.

July 20th—Harry Titus, miner, age twenty-five years, was fatally burned by a powder explosion in the Indiana Fuel Coal Company's No. 5 Mine. On the evening of above date he was making up his cartridges preparatory to charging his shots and was pouring the powder into the cartridge from a quart can which he had filled from his full keg, sitting near by. A spark fell from his lamp into the can, firing it, and this in turn exploding the powder in the keg, with above results. Had deceased observed the statute governing the distance a lamp shall be set from the powder when cartridges are being made up, this accident would not have occurred. Titus leaves a dependent wife and three children.

September 29th—Benjamin Bishop, shot firer, age thirty-five years, married, met his death from the effects of a windy or blown-out shot in the Indiana Fuel Coal Company's No. 5 Mine. Deceased and one other miner were employed as shot firers in the above mine. On the evening of the date mentioned they had nearly completed their work, each man working in separate parts of the mine. About 8 o'clock p. m. deceased fired a shot in the face of an entry. This shot was drilled three feet past the cutting or loose end, one foot past the cutting or loose end being the maximum distance. The shot was five and one-half feet thick, five feet being the maximum thickness provided by law.

The shot was fired with eight pounds of black powder and caused a smoke explosion. When found deceased was lying in a room about fifteen feet from the face of the entry, life extinct. He leaves as dependents three children.

Vigo County.

January 26th—John Crabb, miner, age forty-eight years, married, was killed in the Glen Oak Mine. He was at work in his room loading a car, at 7:30 o'clock on the morning of above date, when about two tons of slate fell on him, killing him instantly.

His room was well timbered to within seven feet of the face, a large water slip lay across the face of the room which had been exposed by shots fired the previous evening, and he either did not notice it, or failed to examine the roof, as this was the direct cause of the accident. Deceased leaves a wife and five children.

January 26th—James Wesmer, miner, married, was suffocated by inhaling the smoke and heated air, caused by the burning of the tipple at the Harris and Lankford Mine. Somewhere between the hours of 8 and 10 o'clock on the morning of above date, Archie Ferguson, one of the top men employed about the mine placed a can of black oil or car grease by the side of the stove in the tipple, for the purpose of melting it, after which he resumed his work incident to the care of the pit top. The grease being set so close to the stove, soon became very hot and ignited, setting fire to the tipple, completely destroying it together with the head frame and fan house. There were nineteen persons and two mules in the mine at the time of the fire.

The driver at the bottom of the shaft was notified as soon as the fire was discovered and he gave the alarm to the men inside the mine, after which he returned to the shaft bottom and was hoisted to the surface on the cage. By this time, however, the fire had gained such headway that the cages could not be used, and there being no manway, or second outlet at this mine, the miners with one exception, Virgil Beck, who climbed the buntins, remained in the mine until the tipple had burned and until arrangements could be made for a rescuing party to enter and assist them. When the rescuing party had reached the men, it found Wesmer and four other persons badly overcome by the smoke and heated air. Wesmer died within a few minutes after being brought to the surface. The other four recovered in a very short time with no very serious results. Fortunately none of the other miners were injured. Wesmer leaves a wife.

November 26th—Abel H. Pell, miner, age thirty years, married, was killed at the bottom of the J. Ehrlich coal shaft. He was at work on the above date, with the mine boss and a fellow miner, removing the old guides in the shaft preparatory to replacing them with new ones.

From evidence obtained at the investigation, Pell was working about seven feet up from the bottom of the shaft, standing on a buntin. About 8:30 the cage in the compartment in which they were working was ordered to the top of the shaft for the purpose of sending down a new guide timber, and it is supposed that the cage or water box, while descending in the opposite compartment from where deceased was standing, caught his head against a buntin, crushing it and killing him instantly.

Warrick County.

September 25th—Thomas Robinson, miner, age fifty-five years, was fatally injured by a delayed shot in the John Archibald Coal Company's No. 1 Mine. At firing time, 3.30, on the evening of above date, he was attempting to fire a shot, having lighted the squib and retired to a place of safety. The squib did not fire as quickly as he thought it should and after waiting awhile thinking it had gone out, he went back into his place for the purpose of trying another one. When he had gotten within about eighteen feet of the face, the shot exploded, pieces of coal striking and so injuring him that he died within a few minutes. He leaves a wife and one child dependent.

September 11th—Stigal, miner, age fifty-three years, married, was killed by a premature blast in the Air Line Mine. From evidence obtained at the investigation of this accident it is evident that it was due to one of two causes, viz., a faulty squib, or carelessness in lighting it. An eyewitness who was standing within eighteen feet of deceased when he attempted to fire the shot testifies that the shot exploded almost the instant he touched the squib with his light. He leaves a wife and two children.

September 29th—Henry Shopenhurst, miner, married, was fatally injured by falling slate in the Big Vein No. 3 Mine. At 7:30 a. m. he was at work in his room loading a car of coal, shoveling from in front of the car. Suddenly a large body of coal gave way falling on him and injuring him to such an extent that he died at 11 o'clock a. m. of the same day. He leaves a wife.

A summary of the names of persons, occupation, date and cause of each death, the name of the mine and county in which the fatalities occurred are given in the following table:

TABLE OF FATAL CASUALTIES.

CLAY COUNTY.

DATE.	NAME.	Age.	Dependents.	RESIDENCE.	OCCUPATION.	CAUSE OF ACCIDENT.	MINE.	COMPANY.
January 5	Goldy Hadley	....	....	Brazil	Miner	Falling slate	Gifford No. 2	Collins Coal Co.
January 29	Chas. Smith	45	3	Staunton	Miner	Falling slate	Klondyke	C. Ehrlich Coal Co.
April 15	Dora McCullough	20	2	Cardona	Driver	Mine car	Cornwell	Jackson Coal and Mining Co.
July 8	Wm. Buckholz	30	4	Brazil	Miner	Premature blast	Brazil B No. 1	Brazil Block Coal Co.
November 18	Jas. McGowan	64	1	Knightsville	Miner	Falling slate	Brazil B No. 7	Brazil Block Coal Co.

DAVIESS COUNTY.

DATE.	NAME.	Age.	Dependents.	RESIDENCE.	OCCUPATION.	CAUSE OF ACCIDENT.	MINE.	COMPANY.
September 28	Chas. Mandabach	34	3	Washington	Miner	Fell down shaft	Mandabach	Mandabach Bros.
June 26	Mat Ryan	38	4	Cannelburgh	Driver	Falling slate	Mutual	Mutual Mining Co.

FOUNTAIN COUNTY.

DATE.	NAME.	Age.	Dependents.	RESIDENCE.	OCCUPATION.	CAUSE OF ACCIDENT.	MINE.	COMPANY.
October 14	Fred Perry	26	....	Cates	Miner	Windy shot	Rush	Rush Coal Co.

GREENE COUNTY.

DATE.	NAME.	Age.	Dependents.	RESIDENCE.	OCCUPATION.	CAUSE OF ACCIDENT.	MINE.	COMPANY.
January 10	Scott Padgett	41	10	Linton	Laborer	Run over by cars	Templeton	Western Indiana Coal Co.
March 10	Charles Shute	17	....	Linton	Miner	Premature shot	Glenburn	Dickason Coal Co.
April 28	Ross Figgins	30	1	Midland	Machine hand	Falling coal	Midland	Midland Coal Co.
July 1	August Klusmier	30	2	Linton	Miner	Falling slate	Black Creek	Black Creek Coal Co.
August 19	Edward Culp	25	2	Jasonville	Driver	Mine cars	Green Valley	Green Valley Coal Co.
August 27	I. Hughes	30	1	Jasonville	Laborer	Falling slate	Northwest No. 1	Northwest Coal Co.
August 28	Mike Schafer	29	....	Antioch	Loader	Powder explosion	Antioch	Antioch Coal Co.
October	Logan Edington	18	....	Midland	Miner	Fell off cage	Letsinger	Letsinger Coal Co.
December 4	Geo. Gilman	30	1	Linton	Miner	Delayed shot	Black Creek	Black Creek Coal Co.
December 5	Jos. Maurey	40	3	Antioch	Miner	Coal from shot	Antioch	Antioch Coal Co.
December 17	Chas Moore	23	1	Linton	Laborer	Falling slate	Victoria	Victoria Coal Co.

TABLE OF FATAL CASUALTIES—Continued.

KNOX COUNTY.

Date.	Name.	Age.	Dependents.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
July 14	Walter Welty	17	1	Bicknel	Not employed	Fell down shaft	Knox	Knox Coal Co.
December 14	Claude Alsman	17	....	Bicknel	Not employed	Ascending cage	Knox	Knox Coal Co.

PIKE COUNTY.

Date.	Name.	Age.	Dependents.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
December 19	Riley Rumble	26	....	Littles	Driver	Mine cars	Littles	S. W. Littles Coal Co.

PARKE COUNTY.

Date.	Name.	Age.	Dependents.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
January 7	P. A. Johnson	76	....	Brazil	Miner	Falling slate	Mary	Otter Creek Coal Co
February 28	Chas. Wilden	49	9	Coxville	Miner	Delayed shot	Cox No. 3	Brazil Block Coal Co.
March 2	Julius Currey	18	....	Mecca	Miner	Falling slate	Lucia	Rock Run Coal Co.
May 15	Matthew Barr	13	....	Perth	Miner	Falling slate	Columbia No. 3	Zeller-McClellan Co
June 15	Wm. Daniels	39	2	Coxville	Shot firer	Suffocated	Briar Hill	Raccoon Valley Coal Co.
July 6	Jesse Perkins	52	1		Miner	Premature shot	Columbia No. 1	Zeller-McClellan Co.
August 14	Bass Montgomery	26	5	Mecca	N fireman	Explosion	Lucia	Rock Run Coal Co.
September 15	James Rosa	18	....		Miner	Suffocated	Columbia No. 2	Zeller-McClellan Co.
October 30	Thos. Kerrick	28	3	Coxville	Miner	Falling slate	Briar Hill	Raccoon Valley Coal Co.
November 30	Albert Snodgrass	15	....	Mecca	Trapper	Falling slate	Mecca No. 1	Mecca Coal and Mining Co.

SULLIVAN COUNTY.

Date.	Name.	Age.	Dependents.	Residence.	Occupation.	Cause of Accident.	Mine.	Company.
March 5	Walter Kemp	22	....	Hymera	Driver	Fell off cage	Hymera No. 2	Hymera Coal and Mining Co.
March 14	George Bemis	13	....	Alum Cave	Not employed	Mine car	Phoenix No. 5	N. Pittsburg Coal and Coke Co.
April 2	Murry Hunt	21	2	Sullivan	Driver	Gas explosion	Green Hill	Green Hill Coal Co.
May 11	Ludwig Hoffman	25	....	Star City	Loader	Falling slate	Star City	Harder-Hater Coal Co.
January 10	Isaac Prior	57	6	Shelburn	Timberman	Falling slate	Shelburn	Keystone Coal Co.
July 3	Clarence Wharton	18	....	Dugger	Driver	Falling slate	Dugger	Indiana Chicago Coal Co.
October 8	J. E. Chapple	19	....	Jackson Hill	Miner	Explosion	Jackson Hill No. 2	Jackson Hill Coal and Coke Co.

October 14 ...	A. L. Gaston..........	56	7	Superior	Timberman	Fell down shaft ...	Island No. 4	Island Coal Co.
December 18.	Adolph Hellman	40	3	Hymera........	Loader.........	Shot through pillar	Hymera No. 1 ...	Hymera Coal Co.

VANDERBURGH COUNTY.

January 3 ...	Louis Pletcher	....	....	Evansville	Miner	Premature shot....	Sunnyside	Sunnyside Coal Co.
January 3 ...	Richard Sanders	....	....	Evansville	Miner	Premature shot....	Sunnyside	Sunnyside Coal Co.
December 2..	Wm. Ray	15	....	Evansville	Miner..........	Powder explosion .	Sunnyside	Sunnyside Coal Co.

VERMILLION COUNTY.

May 15.......	Thos. Durkin..........	35	3	Clinton	Driver	Mine car..........	Oak Hill	Oak Hill Coal Co.
July 27.......	Jos. Baloak............	26	....	Clinton	Car coupler	Electric shock.....	Prince	Keller Coal Co.
July 30......	Harry Titus............	25	4	Clinton	Miner...	Powder explosion .	Bruilettes No. 5..	Indiana Fuel Co.
September 29.	Benjamin Bishop......	35	3	Clinton	Shot firer	Windy shot	Bruilettes No. 5..	Indiana Fuel Co.

VIGO COUNTY.

January 6 ...	John Crabb	48	6	Burnett........	Miner..........	Falling slate......	Glen Oak	Glen Oak Coal Co.
January 26 ..	James Wesmer	....	1	W. Terre Haute	Miner..........	Suffocated	Harris-Lankford	Harris & Lankford.
June 2	Joseph Selker	29	....	....	Cager	Descending cage ..	Nickel Plate.....	Brazil Mining Co.
November 26.	Abel H. Pell	30	6	Seeleyville.....	Miner......	Descending cage ..	Ehrlich	J. Ehrlich Coal Co.

WARRICK COUNTY.

September 11.	Wm. Stigal	53	3	Chandler.......	Miner..........	Premature shot....	Air Line	Hall & Marsh.
September 25.	Thos. Robinson........	55	2	Newburg.......	Miner..........	Delayed shot	Star No. 1........	J. Archibald Coal Co.
September 29.	H. Shopenhurst	....	1	Boonville	Miner	Falling coal	Big Vein No. 3...	J. Woolly Coal Co.

TABLE,

Showing by Counties the Names of Mines at Which Box Car Loaders are Used, Also Giving Name and Cost of Loader.

CLAY COUNTY.

Name of Mine.	Name of Loader.	Cost of Loader.
Brazil Block No. 1	Autumwa	$2,500 00
Brazil Block No. 7	Autumwa	2,500 00

GREENE COUNTY.

North West	Autumwa	$2,500 00
Lattis Creek	Autumwa	2,500 00
Green Valley	Autumwa	2,500 00

PARKE COUNTY.

Brazil Block No. 12	Autumwa	$2,500 00

PIKE COUNTY.

Hartwell	Christy	$2,000 00

SULLIVAN COUNTY.

Mammoth Vein	Autumwa	$2,500 00
Wilfred	Autumwa	2,500 00
Glendora	Autumwa	2,500 00
Cummins	Autumwa	2,500 00

VERMILLION COUNTY.

Rhodes	Autumwa	$2,500 00

Total number of Loaders, 12. Total cost, $27,500.00.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

OFFICE OF STATE NATURAL GAS SUPERVISOR,
MARION, IND., January 11, 1904.

Prof. W. S. Blatchley, State Geologist:

Sir—I submit to you herewith my First Annual Report, the same being the twelfth annual report from this office. I began the duties of the office March 16, 1903, which is the time in the year when the field is demanding most attention. Since that time, for reasons fully explained in the body of the report, it has not been possible for me to give much time to either collecting material for a report or compiling it. I have given briefly the transactions of the office for the past year and such data regarding the condition of the field as should be interesting to those interested in the natural gas industry.

Permit me to thank you at this time for the very cordial support that I have received from you at all times.

I respectfully submit this report.

Yours sincerely,
BRYCE A. KINNEY,
State Natural Gas Supervisor.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

In 1891, a little more than four years after natural gas was discovered in this part of Indiana, a law was enacted by the Legislature then in session, creating the office of State Natural Gas Supervisor and defining his duties. As will be noticed below, these are certainly numerous enough to satisfy the most industrious. Of course, the law should not be criticised, because it does not conform to the conditions at present, for when it was enacted the general conditions in the field were not only very different, but the public idea regarding the generation, storage and life of natural gas has suffered a radical change. Former reports from this office have noted the exact conditions in the field from year to year and the changes, and these will not receive more than passing notice here.

Under the law it is the duty of the State Natural Gas Supervisor to make a personal inspection of all the gas wells of the State so far as it is practical and to see that every precaution is taken to insure the health and safety of workmen engaged in opening gas wells and laying mains and pipes, and of those who, in any manner, use natural gas for mechanical, manufacturing, domestic or other purposes. Here have been given probably one-fifth of the duties assigned to the Supervisor, and with the aid of the one assistant allowed him and by working every week in the year he could doubtless do this work. I inspect all the wells possible while attending to more important duties, at least enough in the various sections of the field to give me a correct idea of the condition of the gas supply. As to the looking after the safety of workmen engaged in the gas industry, I have given it no time, because there is no use of it at this time. Contractors, gas companies and manufacturers employ the most skillful workmen possible, men who thoroughly understand the dangers attending the handling of natural gas. These are the conditions now. Doubtless they were different early in the history of the field.

In addition to the above it is the duty of the Natural Gas Supervisor to collect and tabulate in his annual report to the State Geologist the following facts: The number of gas wells in the State, with their location and a record of the geological strata passed through in drilling them; the depth at which salt water is reached in the various wells and the height to which it rises; the volume of gas produced by each well so far as it can be ascertained, and also the rock pressure of the various wells; the increase or decrease in the rock pressure and volume of flow of the various wells of the State; the number of miles of mains laid for the transportation of natural gas and the capacity and cost of the same; the amount of capital invested in the gas industry and the number of persons employed in the same; the cost of natural gas for fuel in the various cities and towns in the gas belt, and in addition, a large amount of data regarding the manufacturing industry in the gas field that alone would require the time of one man to collect and tabulate. Much of the information required above is collected and published by the Bureau of Statistics. Nor is this all; according to law it is the duty of this office to inspect all the pipe-lines in the State once each year or as often as the State Geologist may direct. This is a work that is necessary in part only. Most of the larger gas companies look after their lines very carefully. They have no gas to waste. Men are employed to go over the lines at regular intervals. It is a waste of time for the Supervisor to inspect these lines. Of course, as would be expected, there are a number of gas companies that pay but little attention to their field lines and these should have the attention of the Supervisor frequently.

In addition to the numerous duties enumerated above, the Natural Gas Supervisor must see that all the laws of the State pertaining to the drilling of wells and the piping and consumption of natural gas are enforced. This is the most important duty charged to this office at this time. During the early history of the field, the public in general was opposed to the enforcement of the laws that had been enacted to husband the gas. As has been stated many times in the reports from this office, the majority of the consumers of gas, both in the field and in the pipe line cities, thought, and honestly too, that the supply of gas would last forever, and that no just reason could be given for laws to prevent waste. The conditions have forced a change in public opinion. Questions regarding the generation, storage and pressure of natural gas are given but little attention now. It is admitted everywhere that the supply in this field is about exhausted. What are the most effective measures to adopt to save what is left that it may be utilized as its value warrants? To the minds of most people in the gas field, the only duty of the Natural Gas Supervisor at this time is to enforce the laws regarding the waste of gas.

Comparatively little was known regarding the natural gas industry when the laws to regulate the use of this fuel were enacted. Enough territory had been developed to show the approximate area of the field, though it was some time before the gas area was definitely defined, if it ever has been. To the consumer who knows nothing of gas except what he sees at the point of consumption, the supply seems inexhaustible. It has been a very difficult task to convince the consumers of this fuel that the supply would not last forever.

Regarding the purpose of the annual reports from this office, it is plain that they are to make public the resources and limitations of the gas field. This I shall endeavor to do, though it must not be forgotten that the work of the office has changed as the conditions in the field have. For the first five years of the history of the field there were no laws to enforce, and if there had been it would have been a difficult task, as it always is, to enforce a law against public opinion. At that time, the time of the Supervisor could be given to the statistics required in the report. As the field progressed and evidences of a decline in the supply became plain, laws were enacted to husband it, and as the consumers of this fuel became educated as to the true conditions in the field, more of the Supervisor's time was demanded in the enforcement of the law. Since I have had charge of the office I have devoted all of my time to the enforcement of the law prohibiting the waste of gas. Incidental to the other work I have been able to collect the data and statistics given in this report. The citizens of the gas belt and the consumers of natural gas in general do not seem to be concerned very much at present about the condition of the field. It is understood and acknowledged by all that the supply is fast declining and that the end can not be far off.

The changed fuel conditions in the gas belt and other places in the State where natural gas is used has been accepted in a common-sense way by the average natural gas consumer, and where other fuels have not already been adopted arrangements are being made to change. As I have stated, what is demanded now by those interested in the gas industry as well as the consumer, and that in no uncertain tone, is the strict enforcement of the law prohibiting waste. And, since I have not been able to do all of the work stipulated by law, I have endeavored to do that which seems to me is of most importance to the natural gas interests under present conditions.

THE CONDITION OF THE GAS FIELD.

To make an intelligent report of the condition of this field at this time is indeed a difficult task. It is difficult for any one that has not visited the field to understand the varied conditions that exist at this time. And, not only are they varied but they are constantly changing. During the early history of the field they were fairly uniform. To gain an idea of the condition of the entire field it was but necessary to examine one or two sections. To gain any conception at all of the gas field at this time, and the supply of gas, it is not only necessary to visit and examine every section of the field, but it is equally necessary to understand the general character and location of the gas rock. In this field the Trenton limestone is referred to as the gas rock, but, as a matter of fact, only a small part of the Trenton limestone is gas rock. The gas rock is that part of the Trenton limestone that has the textural condition necessary to a gas reservoir; that is, that is porous. It neither comes to the top nor extends to the bottom of the Trenton formation. It is usually found from one to fifteen feet from the upper surface of the Trenton rock and is from one to fifty feet thick. In a few instances it has been found thicker than this, but there is seldom over fifty feet of continuous gas rock. Both surfaces of this rock are very uneven, as the records of many deep wells testify. At no place has the surface of this rock been found level for any considerable distance, and a relief map of the upper surface would show many hills and valleys, elevations and depressions. As I have stated before, the early history of the field showed similar conditions throughout the entire gas area which remained until the salt water advancing met the lower portions of the overlying strata of hard limestone, completely occupying the gas rock at the lowest points. Thus it is seen how the high places in the gas rock have become sealed one from the other as the stock of gas has been consumed and the salt water has advanced. It is also plain why gas wells on the same farm frequently differ so greatly in rock pressure and volume. Each taps a different reservoir. The conditions stated above are substantially the conditions in this field at this time. Instead of there being one gas reservoir as there was for many years, there are numerous small reservoirs, each completely sealed in by the salt water. The same force that governed the pressure at the beginning governs it now, except that the presence of the salt water did not have to be considered at first as it does at present. The life of the gas in each independent gas-holder depends upon the size of the elevation, the porosity of the gas rock and the consumption as it did with the larger reservoir. It is but reasonable to believe that as the supply of gas diminishes and the salt water advances that the reservoirs from which we are drawing gas now will be divided and subdivided into smaller reservoirs until the supply is entirely exhausted. If the drill strikes the center of one of these small reservoirs or elevations in the gas rock a "gusher" is frequently reported, though it may cease to be a profitable producer in a very short time, and, on the contrary, if the drill strikes a low place in the gas rock the result is evident. From the statements above the reason for the great difference in the life, rock pressure and volume of gas produced by wells located in the same section of the field is plain. Frequently wells located on the same farm vary much in rock pressure and volume of flow. One may continue to produce gas in commercially valuable quantities for a year, while another one-half mile away may succumb to the salt water in one week. There is one element in the gas field with which the gas industry has to contend which has not been mentioned. I have reference to the oil industry. The progress of the same and the part it has played in shaping the history of the gas industry will be noted in another chapter of this report.

In many respects the year just past has been peculiar and much unlike previous years in natural gas history. To understand this a brief reference must be made to the history of the development of the field. For the first three or four years after the field was discovered there was but little systematic drilling. Wells were drilled where they were needed. No heed was paid to waste, and the surplus energy of nearly every city and town in the gas territory was expended in trying to get some one to use the gas. It was not long until pipe-line companies entered the field, and then the drilling and general development of the field by all classes of consumers became somewhat systematic, and remained so until the entire field, north, south, east and west, was tied together with pipe-lines. Pipe-line companies, local gas companies and manufacturers very soon learned the necessity of leasing territory to hold in reserve for future drilling and of planning their field of operations. Sometimes this was a difficult task, as conflicting interests tried to pre-empt the same territory. Plans had to be changed to meet unforeseen conditions. Some of the larger gas companies by extending their lines showed a disposition to control the entire gas area. This was a failure, as the highways can not be pre-empted, and wherever a gas company can obtain a right of way for a pipe-line sufficient well sites can be obtained without serious trouble. However, conflicting interests have usually been adjusted without much difficulty. From the beginning, pipe-lines have been extended year after year toward what was considered the center of the field. Where it was possible wells were usually drilled one-half mile apart, though the distance between wells was never uniform. Frequently small areas contiguous to pipe-lines were left undrilled. This continued until the field was developed, that is, developed according to the plan I have described. When this was done there was nothing left for gas companies to do but to redrill the territory. This is being done. With but few exceptions all the drilling done this year is on locations between old wells, many of which had been abandoned years ago. The average well drilled now would have been considered a failure ten years ago. The per cent. of failures are growing larger each year, and where gas is found the volume of flow is seldom above 500,000 and frequently below this. The drilling this year has been much different from former years because there is absolutely no system in it; that is to say, locations are not drilled in regular order. Gas companies drill in one section of their territory and then another, wherever the indications for gas are best. Wherever the rock is found high the salt water is not liable to be so bothersome. While, as I have said, the wells obtained now are very small they are, nevertheless, profitable. The iron is usually from old wells and the cost is frequently not much more than the drilling. Then, gas is sold for five times what it was ten years ago. Another incentive to continue drilling, though the wells are small, is the oil prospects. Much of the gas territory is showing oil, and where gas is not found in profitable quantities the well is not always a loss.

There has been a very radical change in the method of selling gas throughout the field this year. Within a comparatively short time after gas was discovered every city and town of any consequence was piped for gas. In a few cities "wide open" franchises were granted allowing the gas company to regulate the price for all time. In most cases, however, the danger of this was foreseen, and a limit to the rates to be charged was inserted in the franchise. At first and for a number of years gas was sold at "flat rates" both in the gas territory and in pipe-line cities with one or two exceptions. The price varied from fifty cents to one dollar and fifty cents per stove. The gas companies prospered at these rates for a number of years. As the supply of gas decreased and the wells became less productive; as the rock pressure decreased and the pipe-line had to be extended each year and compressing stations added, the gas companies began to demand higher rates. This was refused at first in most instances, and the result has been numerous controversies between the representatives of the people and the gas companies. In some places the rates have remained the same until this year, and then they were advanced only when the gas company absolutely refused to supply gas longer at the old rate. At present gas is sold in all of the larger pipe-line and gas-belt cities, except Indianapolis, and there is but little sold there, by meter. On account of the scarcity and high price it is not a universal domestic fuel at present, and of course it never will be again. It is generally used as a cooking fuel where the supply is sufficient.

But little new pipe-line has been laid this year. More line was taken out of the ground than was put in it, and especially is this true of the larger lines. The Indianapolis Gas Company and the Manufacturers' Gas Company of Indianapolis, both supplying gas to Indianapolis for domestic and manufacturing purposes, have quit supplying gas to that city and have taken up their lines to the field. A number of smaller lines have been abandoned. A large amount of pipe-line of all sizes belonging to manufacturers who have either left the gas field on account of fuel or have been compelled to change to other fuels is not being used and will probably be taken up soon.

Abandoned Territory.

On account of the scarcity of gas in some sections of the State, wells have been drilled in territory that has been abandoned for a number of years. In a few instances these efforts have been to a certain degree successful. Usually small companies have been organized to supply gas to the stockholders only. In one city of the gas belt at least twenty-five wells have been drilled within the corporate limits of the city within the year just past. About three-fourths of these produced a little gas at first, enough to supply from five to fifteen families. About one-fourth of them are producing a small amount of gas at present. In but few instances have these wells proven to be satisfactory investments. I have never advised drilling in such territory. Wells drilled in territory that was overrun with salt water five or ten years ago are sure to meet an early death. There is no provision for the renewal of the supply of gas, and when the territory is exhausted that is the end. Notwithstanding, however, the discouragements in this territory, it is probable that much of the field will be redrilled. After using gas for fifteen years, the people in the gas belt dislike very much to give it up as a fuel and will exert every effort to prolong the supply. What deceives so many interested in these company wells is the rock pressure. The wells that are drilled now in this territory that was abandoned ten years ago show near the same rock pressure that the territory did when it was abandoned. Those that are interested in these wells judge them by the rock pressure, which is never in any case an index of the capacity of the well. The open flow pressure is an index of the volume of the well and that alone.

NEW TERRITORY.

History shows that the development of the Indiana natural gas field was along natural and rational lines. It is easily understood. Soon after the discovery of gas, pipe-lines from six to twelve inches in diameter, radiating in every direction from the gas reservoir, transported the gas to cities and towns beyond the gas area. Consumers 140 miles from the main gas field were permitted to enjoy this gaseous fuel. Naturally, as the edge of the field where these lines first tapped it began to show signs of exhaustion, the lines were extended toward what was thought to be the center of the field. Seldom was any territory completely developed as fast as the lines were laid. Not only were many well sites left but an occasional area of considerable acreage that seemed comparatively unproductive at that time in the history of the field was passed. By way of explanation it might be said that the productiveness or capacity of a gas well is governed by the porosity of the gas rock. If the rock is very porous and the gas passes rapidly from the gas rock to the well bore, the well will be very productive. On the contrary, if the gas rock is hard and contains but few pores or interstices in which the gas may be held, it will pass very slowly from the surrounding gas rock to the well bore and the well will be less productive. The latter is the condition found in the unproductive area referred to above. It may be said, however, to the credit of this rock, that as a usual thing the wells remain productive longer than they do in the more productive rock. In this connection I will repeat, that this undrilled territory just referred to is supplying most of the well sites this year. Wells are located, if possible, near pipe-lines and as close as possible to the point of consumption, either between wells once productive or in territory that was labeled unproductive years ago. The territory referred to above is usually spoken of as new in the gas field, but it is not so considered in this report. New gas territory is that which has never been drilled or tested in any way until the present time. Such is the territory in the northern part of Grant County and the southern parts of Wabash and Huntington counties. Quite a large area of fairly productive territory has been developed in that section this year. Some of the wells started with a very large production, and a showing of oil is found in some places. Over one hundred wells have been drilled in that section, and three years ago it was considered entirely out of the gas belt. Huntington, Wabash and Marion are supplied largely from this field this year. This new field, though small, is completely separated from the main gas area, either by salt water or a section of hard nonporous rock, probably the latter. The rock pressure varies from 230 to 280 pounds. The gas rock is very irregular in thickness and porosity. A few "dusters" are to its credit. How long it will continue to supply the present draught I can not say, though every indication is that it will be much shorter lived than the field south.

Since gas became so scarce, it is but natural that considerable "wildcatting" around the edge of the field should be done. Cities are piped for natural gas and all of the appliances for regulating and distributing the same are in place. The consumer has the necessary pipes and heating appliances. Even if other fuels were as desirable as gas, a change would mean a large immediate expense. Under these conditions, gas companies can get any reasonable price for the gas as long as it does not cost more than other fuels. A number of fairly productive wells have been drilled near the extreme northwest edge of the field this year, the product of which is being taken to Wabash and Peru. So far as I know all of the gas companies of the State that are pretending to supply gas are doing their best to give good service, though it is true that some have fallen far short this year even with the limited consumption. In some sections gas companies have expended large sums of money in their efforts to secure an adequate supply of gas, and have failed. In most instances discouragements have been met with renewed determination, and because of this more than one city has enjoyed the privilege of using gas one more year.

About seven years ago a strong flow of gas was found near Petersburg, Pike County. The second well was a failure. A second producer has been recently found. Gas has been used in that city for domestic and manufacturing purposes since the first well was drilled. The flow of the wells and the pressure remain strong considering the consumption. The find at Petersburg stimulated the desire to find gas in that section of the State. Much money has been spent and many wells drilled without much success except at Loogootee, Martin County, and Princeton, Gibson County. At the former, gas was found at a depth of about 500 feet, four years ago. Twelve wells have been drilled a short distance west of the city. All are good producers and show a pressure after four years' use of 125 pounds. The field is small and efforts to enlarge it have not been successful. Some oil is found. At Princeton but little gas has been found, not enough to be commercially valuable. The oil prospects are bright at this time.

There has been some drilling for gas in Allen County the past year with a show of success, but not enough gas has been found to attract much attention.

The Consumption of Gas.

The consumption of natural gas both in the field and in pipeline cities has decreased more during the past year than any previous year in the history of the field. To a person who has watched the progress of the field from the beginning it seems that the year 1903 has been a year of changes. More people have changed from natural gas to coal and wood than any previous year, and in the matter of rates the change has been almost universal. Gas is very generally sold in the larger cities by meter measurement, and the change from the flat rate system has, in most cases, been made this year. To benefit by the meter, economical appliances must be used and, since the future of gas is so doubtful, many people have declined to purchase new appliances and are using gas for cooking only. Thus, the use of natural gas for domestic purposes has decreased at least fifty per cent. during the past year.

It is very difficult to say how much gas is used for manufacturing purposes or to compare the amount used now with the amount used when gas was plenty and factories used all they could and wasted nearly as much as they used. Some gas is used by some factories, and none that I know of have enough. One thing is certain, all the gas belt factories are not going to leave this part of the State when the gas is entirely exhausted. The indications now are that but few factories will leave the gas field. Some of the smaller glass factories that have but little invested in buildings and machinery will probably either quit the business or rebuild near a supply of fuel. Some of the largest and most substantial factories in the field have quit using gas and are seemingly doing a profitable business, using coal. Others are shut down a part of the time on account of the shortage of gas, while a majority are supplementing the limited supply of gas with other fuels. Present indications are that but little gas will be used for manufacturing purposes another year. The first city to abandon the use of natural gas entirely is Logansport.

The Waste of Gas.

It is hardly possible to say anything about this subject without rehashing what has been said in former reports, for it has been given more space than any other subject for several years. It has been and is a subject of most vital importance to the gas interests of the State. There never has been a moment since this fuel was discovered that it has not been wasted in various ways in every section of the field. After about five years the Legislature of the State took notice of this waste and enacted laws prohibiting the use of natural gas in flambeau lights and the escape of gas and oil from pipe-lines. Every person at all acquainted with the history of the field knows of the large amount of gas that has been wasted by the use of the large gas torches that were allowed to burn night and day, year in and year out. The enforcement of the law prohibiting these lights encountered much opposition at first which was caused largely by the idea that was generally entertained at that time, that the stock of gas was being renewed daily and could not be exhausted, regardless of the amount used or wasted. Of course, as usual, it was contended that the law was unconstitutional. In 1896, the Supreme Court of the State rendered a decision holding the law constitutional. About this time the gas began to show signs of failure and this, with the decision of the Court, has rendered the work of enforcing the law comparatively easy. The only trouble that I have had is to get the necessary evidence to convict the person who uses or lights the light. My attention is called more often to the lights used by drillers and oil well pumpers than any other class of people. Natural gas makes the most convenient light that either can use, and there would be no objection to its use if it was not wasted. Most of the waste can be charged to carelessness. Imperfect fittings and burners are used and more lights are used than are necessary. I have found the most economical outdoor light to be a jumbo tip enclosed in a perforated iron globe. While these do not, strictly speaking, conform to law, they consume less gas than the lawful light. There have been twenty arrests made by this office during the year for the violation of the flambeau law. Twenty-one affidavits were filed by an officer at Upland not connected with this office against persons using natural gas torches, with four convictions.

Prior to the discovery of oil in the main gas area but little gas was permitted to escape from wells. The amount of gas that has been wasted to test the gas field for oil and to produce oil can not be even estimated. It would probably be a little extravagant to say that as much has been wasted as has been used, but an enormous amount has been wasted, as every person will testify who witnessed the oil excitement in the vicinity of Alexandria, Madison County, in 1897. The records show that over fifty wells, producing from one to five million cubic feet of gas daily, remained open for six months. These wells were closed after the Supreme Court of the United States had declared the law constitutional. From that time until recently there has been a struggle between the oil and gas interests. It has been impossible, even if desirable, to stop the development of the oil industry in the gas field. Oil can not be produced in high-pressure gas territory without wasting some gas. However, the gas pressure has gone to a point now where oil can be produced if the proper precautions are taken, without wasting gas. Most cases of waste that I have found this year could be charged to negligence on the part of the pumper. In fact, in the most productive parts of the oil territory, gas is so scarce that the oil operator is more interested in husbanding it than any one else. There are many places in the oil field where there is not enough gas for fuel for drilling and pumping. While it is not possible for one assistant and myself to be every place at the same time or to visit any one place very often, yet I have learned the sections where the disposition to waste the gas seems most pronounced and have, I think, reduced the amount of wilful waste to a minimum. As the field pressure decreases, the pressure in the lines becomes less, and with a low-line pressure there is absolutely no excuse for wasting gas anywhere in the field. The surplus gas can always be put in a line at a fair compensation.

Where there is any effort made to keep field lines in repair there is but little waste now, and as the line pressure decreases the waste from this source becomes less. Of course, as long as there is any gas in the lines there will be some waste, and it can only be kept at a minimum by constant attention on the part of the owner. I have endeavored to enforce the law prohibiting the waste of gas from pipe-lines, and believe that I have done effective work along this line this year.

Plugging of Abandoned Gas and Oil Wells.

Without criticising my predecessor in office in the least, I can say that previous to this year there was but little done to enforce the law regarding the plugging of abandoned gas and oil wells. Both the condition of the field and the reports of the Natural Gas Supervisor show that the subject has needed attention, and doubtless it would have received it had not the law been defective. Numerous attempts to enforce its provisions proved fruitless. The law stipulated the manner of plugging wells and provided an adequate penalty for its violation, but it did not provide any way of ascertaining when a well was to be plugged and, if so, whether according to law or not. A law was enacted by the last Legislature, the provisions of which are given below, that remedies the weak places in the old law and makes it possible for the Supervisor to know whether abandoned oil and gas wells are plugged as they should be or not. Of course, as far as the gas is concerned, much of the damage is done, but a vigorous enforcement of the law at this late day will do much to protect the oil rock. As far as I have been able to ascertain the provisions of the law have been very generally observed during the past year by both the gas and oil interests. I have numerous requests for copies of the law, and for the benefit of those interested who may read this report I give it in full below.

AN ACT concerning the drilling, operating, maintaining and abandoning gas and oil wells, and prescribing penalties for violations of the same.

and repealing sections two and three of an act entitled "An act concerning the sinking, safety, maintenance, use and operation of natural gas and oil wells, prescribing penalties and declaring an emergency, approved March 4, 1893," and declaring an emergency.

(Approved March 7, 1903.)

Section 1. *Be it enacted by the General Assembly of the State of Indiana,* That before the casing shall be drawn from any well, for the purpose of abandonment thereof, which has been drilled into any gas or oil bearing rock, it shall be the duty of any person, firm or corporation, having the custody or control of such well, at the time of such abandonment, and also the owner or owners of the land wherein such well is situated, to properly and securely stop and plug the same in the following manner: Such hole shall first be solidly filled from the bottom thereof to a point at least twenty-five feet above such gas or oil bearing rock with sand, gravel or pulverized rock, immediately on the top of which filling shall be seated a dry, pine wood plug, not less than two feet in length, having a diameter of not less than one-fourth of an inch less than the inside diameter of the casing in such well; above such wooden plug such well shall be solidly filled for at least twenty-five feet with the above mentioned filling material, immediately above which shall be seated another wood plug of the same kind and size as above provided, and such well shall again be solidly filled for at least twenty-five feet above such plug with such filling material. After the casing has been drawn from such well there shall immediately be seated at the point where such casing was seated a cast iron ball or a tapered wood plug at least two feet in length, the diameter of which ball or the top of which wood plug shall be greater than that of the hole below the point where such casing was seated, and above such ball or plug such well shall be solidly filled with the aforesaid filling material for a distance of at least fifty feet

Sec. 2. The person, firm or corporation owning or having control or custody of any such well or the land in which any such well is situated, shall file or cause to be filed in the office of the Recorder of the county in which any such well is located, within fifteen days after the same has been plugged, as provided in section one, the affidavit of at least two persons who assisted in the plugging of such well, which affidavit shall be recorded in the miscellaneous record books in the office of the recorder of such county, and shall set out in detail the manner in which such well was plugged and the depth of each such wood plugs and iron ball below the surface of the ground, and the record of such affidavit shall be prima facie evidence in any court of a compliance with the provisions of this act.

Sec. 3. It shall be the duty of any person, firm or corporation sinking a well in any oil or gas-bearing rock, or having sunk such well and maintaining the same, to case off and keep cased off all fresh water from such well.

Sec. 4. Any person, firm or corporation that shall, in any manner, fail or refuse to plug a well in the time and manner provided in section one of this act, or shall fail or neglect to secure and file in the proper

Recorder's office the affidavits provided for and required in section two of this act, or shall fail and neglect to properly case off fresh water from such well and keep the same cased off while said well is maintained, as provided in section three of this act, shall be liable to a penalty of two hundred dollars for each any (and) every violation thereof and to the further sum of two hundred dollars for each ten days during which such violation shall continue, and all such penalties shall be recoverable in a civil action brought in any court of competent jurisdiction in any county in which such violation occurred, brought in the name of the State of Indiana on the relation of such county and for the use and benefit of such county, and in all such cases if there be a recovery by the State it shall recover in addition to such penalties a reasonable attorney's fee.

Sec. 5. Sections two and three of an act entitled "An act concerning the sinking, safety, maintenance, use and operation of natural gas and oil wells, prescribing penalties, and declaring an emergency, approved March 4, 1893," are hereby repealed.

Sec. 6. To better enforce the provisions of this act the Natural Gas Supervisor of the State of Indiana is hereby empowered to enter upon any land at any time for the purpose of examining and testing any such well or wells.

Sec. 7. Whereas an emergency exists for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

Compressing Stations.

The annual report of the Natural Gas Supervisor for the year 1901 states that there were 41 compressing stations (usually known as pumping stations) in operation in the gas field at the end of that year. The total number of compressors in use is not stated, but it was not far from 100. The same report says: "With the decrease in the rock pressure in the field came the necessity for using compressors on pipe-lines. The pressure required to transport natural gas depends primarily upon the consumption. With no consumption and the pipe-line perfectly tight, the pressure at the outlet of the line must be the same as at the wells, and with the line wide open at the point of consumption the loss of pressure is at a maximum. The amount of natural gas that can be transported in any pipe-line a given distance depends upon the size of the line and the pressure in the same, the former governing the volume of gas and the latter the velocity. Thus, as the field pressure decreases, the question presented to both gas companies and manufacturers is, whether to build compressing stations or increase their pipe-line capacity. Some have adopted the former, others the latter, while occasionally it has been necessary to resort to both." I agree with this, except that compressing stations were used before the decrease in the rock pressure was sufficient to notice. Where gas was to be transported a long distance, as was the case with the Ohio and Indiana Gas Company and the Indiana Natural Gas and Oil Company, it was necessary to install compressors at the beginning. With the aid of powerful compressors there is hardly a limit to the distance that gas can be transported. For the purpose of protecting the gas territory, the General Assembly that convened in 1891 attempted to regulate the production and transportation of natural gas by enacting a law (Acts 1891, page 89) prohibiting:

1. The transportation of natural gas at a pressure exceeding 300 pounds.

2. The use of any device or artificial process to increase the flow of gas from the wells or for the purpose of increasing the flow of gas through the pipe-lines.

A law enacted by the last General Assembly in substance repeals the act of 1891 except the provision regarding the 300 pounds pressure, and with the present conditions there is little use for it. Though I know it is impossible for any company in the field with the limited supply of gas, to raise the line pressure to the maximum allowed by law, I have tested the pressure in all of the lines transporting gas from the most powerful compressors in the field and have not found the pressure at any place above 200 pounds.

While compressors can be used now without violating any law so long as the pressure is not raised above 300 pounds to the square inch, yet it can not be said that their use is not a detriment to the field. Wherever they are used they have the effect to create a vacuum, not only in the pipes back of the compressor but in the gas rock, and when the pressure is removed from the rock the salt water rushes in and fills the space once occupied by the gas. My observation leads me to believe that where compressors are used in a given territory, the gas rock in the vicinity of the wells under the influence of the compressors soon succumbs to the salt water.

THE STRATIGRAPHY AND PALEONTOLOGY

OF THE

Niagara of Northern Indiana.

BY EDWARD M. KINDLE.

PART I.—STRATIGRAPHY.

PART II.—PALEONTOLOGY.

THE STRATIGRAPHY AND PALEONTOLOGY OF THE NIAGARA OF NORTHERN INDIANA.

By Edward M. Kindle.

PART I.—STRATIGRAPHY.

INTRODUCTION.

The present paper is the outgrowth of field work done during parts of the field seasons of 1899 and 1902. Considerable collections and many notes on Niagara stratigraphy were obtained during the summer of 1899 while studying the Devonian rocks for the Indiana Geological Survey. Through the coöperation of the United States Geological Survey and the Indiana Survey, the writer was able to spend one month during the summer of 1902 in mapping the Niagara outcrops of northern Indiana, and in making collections of their fossils. Prof. George L. Collie accompanied the writer during the summer of 1902, and Mr. V. H. Barnett in 1899, and to these gentlemen we are indebted for much valuable assistance.

Nearly all of the Niagara outcrops in the northern half of the State have been examined. Particular attention has been given to the Niagara dips which have received such widely different explanations from different geologists.

TOPOGRAPHY.

The original topography of northern Indiana is almost entirely masked by the drift. Deep well records indicate considerable topographic relief in preglacial times. The thickness of the drift in the vicinity of some of the outcrops shows some of the preglacial valleys to have had a depth of four hundred feet or more. Previous to the coming of the ice sheet the topography of northern Indiana was of a rather rugged type, which probably did not differ greatly from the topography of southern Indiana. In place of this, we have now a great sheet of glacial till, which has obliterated the ancient valleys, and forms a comparatively level plain. In some sections of the northern and northeastern portions of the State morainal topography varies the general uniformity of level which prevails over much of this plain. In the western part, the gently rolling prairies of Newton and White counties merge into the extensive marshes of the Kankakee.

Randolph County attains the greatest elevation of any part of the area, the highest railroad level being 1,234.4 A. T., which is also the highest recorded elevation in the State. The southern part forms the watershed of eastern Indiana and from it streams flow in every direction. The Wabash, Kankakee and White rivers receive most of the drainage of the Niagara area.

The longer streams have excavated shallow valleys in the glacial till, most of which do not reach down to bedrock. The Wabash Valley, however, cuts through the drift at many localities, and along the upper part of its valley affords many excellent exposures of the Niagara. The Niagara also reaches the surface in Newton and Jasper counties, and in some of the counties to the southeast of the Wabash. In nearly one-half of the counties of northern Indiana, however, the drift is so deep that no outcrops of bedrock occur within them. No outcrops of paleozoic rocks are known in the tier of counties along the Michigan State line.

STRUCTURE AND CORRELATION.

VIEWS OF PREVIOUS WRITERS.

The earlier workers on the geology of Indiana generally believed the geological structure of the State to be much simpler than recent investigations have shown it to be. Their firmly rooted belief in the uniformity of the geological structure of Indiana prevented many of them from ever entertaining any explanation of the Niagara dips which would include deformation. Prof. John Collett, for many years State Geologist, says in describing Niagara beds which show dips: "The uniform undisturbed condition of the strata of this and adjoining States, will not allow the presumption of upheaval and such dislocation of strata as would account for these phenomena."* Starting with the assumption of the "undisturbed condition" of the strata, it is not surprising that Collett was compelled to confess in describing a locality exhibiting tilted beds, that "This quarry is a mystery."**

It will be the purpose of the following pages to show that we have in the Niagara beds of northern Indiana a notable exception to the nearly horizontal and undisturbed condition which generally characterizes most of the other formations of Indiana. A number of theories concerning the structure of the Niagara area and the dips have been advanced, and the more important ones will be briefly reviewed.

Owen.—Richard Owen first directed attention to the tilted Niagara rocks of northern Indiana. Forty years ago Owen wrote that he had found, near Delphi, "A local dip to the southeast amounting to 40°."† He mentioned also the sharp dips at Wabash and Huntington.

Cox.—Ten years later E. T. Cox, then State Geologist, gave a brief description of these localities, but ascribed the inclined beds to false bedding.‡

Oblique or false bedding on a large scale is an unusual phenomenon in limestones. The seas in which they are deposited are seldom sufficiently shallow to permit the action of currents strong enough to produce oblique bedding. As a possible explanation of the dip, however, the hypothesis of oblique bedding proposed by Cox requires an examination. The history of the discussions concerning the Le Claire limestone of Iowa illustrates the difficulty sometimes met with in discovering positive evidence as to the character of the bedding. Even where true bedding seems obvious, it is not always easy to discover in the strata intrinsic evidence which will entirely eliminate the possibility of false bedding being the cause of the inclined strata.

At a number of localities highly inclined beds, richly fossiliferous, have been observed in contact with barren or nearly barren beds where the evidence of tilting seemed so clear as to require no special comment but for the fact that the oppo-

* Twelfth Ann. Rep. Ind. Geol. Surv., p. 59.
**Twelfth Ann. Rep. Ind. Geol. Surv., p. 59.
†Ind. Geol. Surv. 1859-60, p. 98, 1862.
‡Rep. Ind. Geol. Surv., 1872, p. 307.

site opinion has been held regarding them. The final test of the false bedding hypothesis comes in applying it to particular cases. Does it afford a satisfactory explanation of such examples as the following? Near Delphi a bed fifteen feet or more in thickness occurs, composed almost entirely of the shells of *Conchidium laqueatum,* one to three inches in length, which is inclined at an angle of 20°. While it is, perhaps, not impossible that such a bed should occur in false-bedded strata, it appears to the writer highly improbable. In the case, however, of strata having a dip of 70° or more, as shown in Fig. 1, oblique bedding can not be considered even as a possible explanation. The materials composing the beds, if piled in layers inclined at such a high angle, could not possibly retain their position. Deformation alone offers a satisfactory explanation for such dips.

Gorby.—In 1886, S. S. Gorby* described a considerable number of outcrops showing tilted strata, and announced that they indicated a great anticlinal, "extending entirely across the State," which he called the "Wabash Arch." Many of the dips recorded by the author of this hypothetical arch afford evidence against it. About half of them are east or west dips, while the supposed arch has an east and west axis which calls for north and south dips, and fails to explain the others. Phinney in discussing the "Wabash Arch" points out that the gas well records furnish evidence against it.

Phinney.—The tilted strata are, according to Phinney, due to irregularity of deposition rather than to deformation, and he states that "they are to be attributed to the building up of coral reefs and rocky prominences over portions corresponding to the dome and offshoots of the Cincinnati Arch or to inequalities in the sea bottom."** A serious objection to the coral reef theory is the frequent absence or scarcity of corals where the dips are heaviest. Corals are not at all abundant in the Niagara of this region. They have not been observed anywhere in sufficient abundance to form reefs. While inequalities in the sea bottom may be responsible for some of the smaller undulations in the strata, neither they nor "offshoots of the Cincinnati Arch" appear to offer a satisfactory ex-

*Fifteenth Ann. Rep. State Geol. of Ind , 1886, p. 241.
**Eleventh Ann. Rep. U. S. Geol. Surv., p. 653.

PLATE X.

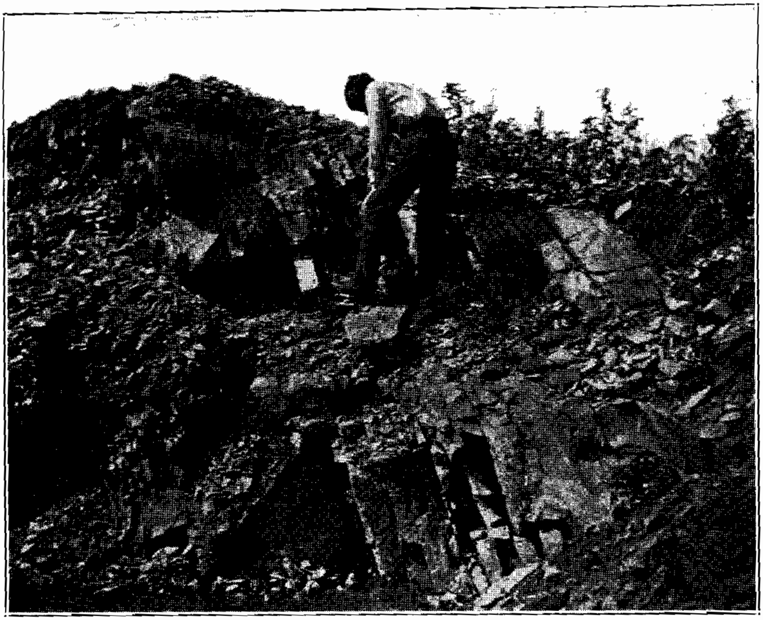


Fig. 1. Tilted Niagara Limestone at McKee Quarry, Kentland, Ind.

Fig. 2. Quarry East of Delphi, Showing Tilted Niagara Strata.

planation of dips of 45° to 75° in the Niagara rocks, which the accompanying photographs show.

Thompson.—Maurice Thompson considered the dip to be the result of the disturbance of beds originally horizontal. He states: "The structure of the Niagara limestone does not in the least indicate false bedding."* Thompson accepts Gorby's hypothetical "Wabash Arch," but evidently had a pretty clear understanding of the local dome-like structures in the Niagara. A summary of his views is best stated in his own words: "The arch formed by this upheaval consists of a vast series of low bubbles or cones that make the surface of the Niagara limestone somewhat like that of a sea in a brisk breeze."†

Elrod and *Benedict.*—In the same volume with Thompson's paper appeared a paper by M. N. Elrod and A. C. Benedict on a portion of the northern Indiana Niagara area. These authors conclude that the Niagara "cones" which they describe are the result of a variety of cleavage which simulates stratification, and cuts across the original bedding plains.

A second paper by the same authors appeared in 1894, in which they deny that there has been any tilting of the Niagara beds of the Wabash Valley.‡ Cleavage, or a "modified form of joint structure" is the explanation offered of the dips. This hypothesis would deserve careful consideration but for the testimony of the fossils. The occurrence of richly fossiliferous bands, running parallel with the so-called cleavage planes, affords conclusive evidence that they are true bedding plains.

Ashley and *Siebenthal.*—Dr. Ashley in his report on Newton County,§ based upon C. E. Siebenthal's notes, mentions the heavy dips at the Kentland quarry and states that "it would almost seem as though volcanic or other agencies had produced an upheaval of a kind seldom found in Nature."**

Kindle.—During the summer of 1899 the writer visited a number of outcrops in northern Indiana, and became convinced that the dips of the Niagara outcrops in northern Indiana were not

*Seventeenth Ann. Rep. Ind. Geol. Surv., 1891, p. 183.
†Seventeenth Ann. Rep. Ind. Geol. Surv., 1891, p. 185.
‡Nineteenth Ann. Rep. State Geol. of Ind., p. 22.
§Twenty-third Ann. Rep. Ind. Geol. Surv., p. 190.
**Twenty-third Ann. Rep. Ind. Geol. Surv., p. 190.

apparent but real dips. Two of the outcrops showing tilted strata which were studied were described in a recent paper.*

Extent and Composition of Beds.—The area in which rocks of Niagara age occur extends from the Illinois line in Newton County eastward nearly to the Ohio line, embracing the upper Wabash Valley. Throughout this area the strata are frequently found to be highly inclined. Highly tilted beds occur in Hamilton County, seventy miles south of the Wabash. It is probable that the Niagara rocks in the intervening territory have heavy dips at many localities, but the great thickness of the drift over this area makes it impossible to ascertain whether or not this is true.

The Niagara rocks of this region consist principally of magnesian limestone, often varying considerably in texture and composition in a short distance at the same horizon.

The principal types include dull buff dolomites, light gray sacheroidal dolomitic limestones and two or three varieties of nearly pure limestone. Beds of buffish or gray calcareous shale are sometimes associated with the limestone. Local lenses of sandstone have been observed in the Niagara limestone at some localities. One of these, near Kenneth, has a thickness of five and one-half feet, and is composed of pure white quartz sand containing only a trace of calcium carbonate and iron. The Niagara outcrops show only a small portion of the total thickness of the beds of this group, none of the sections extending down to the Lower Silurian. The information which we have concerning its thickness is derived from well records. From these it appears that the Niagara has a thickness of from 250 to 500 feet.

Correlation.—A study of the faunas of the region has shown the presence in it of faunas representing two distinct and successive epochs of the Niagara group. In a previous paper** by the author, the earlier of these faunas as represented at a typical locality was listed, and the fauna was correlated with that of the Lockport limestone of New York. The later fauna which has been recognized contains many species of the Guelph limestone fauna of Canada, which has not hitherto been known to occur in Indiana.

*Am. Journ. Sci., Vol. XIV., 1902, pp. 221-224.

**Am. Jour. Sci., Vol. XIV., 1902, pp. 221-224.

The beds holding the earlier fauna are perhaps better exposed at Connor's mill on the bank of White River in Hamilton County than anywhere else in northern Indiana. They will be called, from the township in the northeast corner of which they outcrop, the *Noblesville dolomite.* The rock is a hard, thin-bedded, buff-colored dolomite lying in strata three to ten inches thick, of which there are 25 feet or more exposed at the type-locality. Just what the total thickness is which should be included in this division of the Niagara can not be stated, since the upper and lower limits have not been seen in any single section; it is probable, however, that this formation includes not less than 100 feet of stràta. Faunally the beds are characterized by such well-known Niagara (Lockport limestone) fossils as *Spirifer nobilis, S. radiatus, S. crispa var. simplex, Conchidium multicostatum, Sphærexochus romingeri* etc. No trace of the Guelph fauna appears in it. The faunal affinities of the Noblesville dolomite point to its approximate equivalence with the Lockport limestone. The Noblesville dolomite is well exposed in a quarry southwest of Fishersburg and near Helm's Mill in the southeast part of Hamilton County. The faunal characters are essentially the same at both places as at Connor's Mill, but the dolomite is much softer at the latter point and lighter colored. The Niagara beds at Pendleton are of this horizon, the rock being a soft, drab dolomite, becoming shaly in places. At Delphi the Noblesville dolomite is represented by the outcrops of drab-colored dolomite in the "Old Deer Creek Channel" east of town between Deer Creek and the wagon road. These beds contain *Sphaerexochus romingeri, Cyrtia myrtia,* and other Niagara species without any trace of the varied cephalopod and gasteropod fauna common in the higher beds exposed in the quarries to the northeast.

In the quarries at Huntington is found a fauna of later age, and very different from that of the Noblesville dolomite. The bulk of this fauna consists of a congeries of cephalopod and gasteropod species, mostly of large size, together with a few heavy-shelled brachiopods. Only four of the fifty species of brachiopods which occur in the Niagara rocks of northern Indiana have been recognized in the collections from Huntington. Two of these are ranging *Atrypa reticularis* and the fourth is *Dinobolus conradi,* a species common in the Guelph of Ohio. Only two trilobites have been recognized—a new species of *Encrinurus* and a large *Illaenus* comparable with *I. insignis,* which is associated with the Guelph species in Wisconsin. The cephalopod and gasteropod element of the fauna appears to be of distinctly Guelphic affinities.

This affinity is seen in the presence of *Trochoceras desplainense, Pragmaceras parvum,* three species of *Murchisonia*—one of which is the well known Guelph species *M. bivitata,* and other species which are represented by closely allied forms in the Guelph.

The rock in which this fauna occurs at Huntington is a light gray, or cream colored, granular dolomitic limestone of saccharoidal texture. It differs very decidedly in physical appearance as well as faunal characters, from the dull buff-colored *Noblesville dolomite.* It will be convenient to designate the beds exposed in the Huntington quarries as the *Huntington limestone.* This name was used for the same beds by Cox in the Report of this Department for 1878, p. 66. The total thickness of the Huntington limestone is not known, but it is probably not less than 150 or 200 feet. About 80 feet are exposed at Huntington.

A magnesian limestone similar in physical and faunal characters is seen in the lime quarries northeast of Delphi. The fauna of the *Huntington limestone* at Delphi, as at Huntington, is essentially a cephalopod and gasteropod fauna. Of the eight species of brachiopods recorded from it, four are forms having strong Guelph affinities; these are *Monomorella* sp., *Trimerella* sp. and two varieties of *Pentamerus oblongus.* The latter species, although occurring in the earlier Niagara fauna in New York, is a common form in the Guelph of Ohio and does not appear in the fauna of the *Noblesville limestone* in Indiana.

In the case of the localities which have been mentioned in connection with the Noblesville dolomite and the Huntington limestone, the correlations which have been made are based upon paleontological and lithological data, which appear to be entirely adequate. There are, however, many localities where a scarcity of fossils, or variability of lithologic features have made it impossible in the rapid survey which circumstances necessitated, to secure satisfactory data for correlating the beds with either of the divisions of the Niagara which are here recognized. For this reason the broader term, Niagara limestone, has been generally employed.

Structure.—The general structure of the Niagara beds of northern Indiana is that of a broad arch with gently sloping sides trending northwest and southeast. It represents a northwestern extension of the Cincinnati geanticline. Its axis, approximately located, enters the State near Richmond, and passes northwesterly in the vicinity of Muncie, Marion and Peru, and continues north of the Wabash through Cass, White, Jasper and Newton counties into Illinois. On the two sides of this line of maximum elevation of the Niagara the Devonian and Carboniferous rocks dip in opposite directions; in Michigan and Ohio, toward the north and northeast; in Indiana, toward the southwest or south. The following table shows the elevation of the surface of the Niagara A. T. along a line approximately at right angles to this axis extending from Crawfordsville to Auburn, Indiana, a distance of 140 miles.

*Crawfordsville	81 A. T.
Frankfort	463
Kokomo	778
Wabash	652
Columbia City	599
Auburn	50

The arch described above is not the "Wabash Arch" of Gorby, which apparently was supposed by its author to follow the Wabash Valley in eastern Indiana. The tilted beds which were cited as the evidence of the "Wabash Arch" will be shown in another part of this paper to be independent of the above described arch in origin.

Dips.—A large percentage of the outcrops throughout the Niagara area is characterized by dips of from 5° to 80°. In a few instances the dips represent cleavage planes. In one case (at the Means quarry, Newton County) both cleavage and bedding planes are well defined and nearly at right angles to each other, both being inclined at a high angle to the horizontal. A few localities have also been noted where the dip is the result of irregular or false bedding. But the great majority of the dips can be referred to neither of these causes. They are clearly the result of the deformation of strata which were originally horizontal.

*The figures given above are based upon gas well records published in the 16th Ann. Rep. Ind. Geol. Surv., pp. 217-268.

A brief study of the tilted beds will suffice to show that they are not referable to ordinary anticlines. A description of the beds near Kentland will illustrate this. At the Means quarry (N. E. of N. W. of sec. 25) the rock is a hard gray limestone, very fine grained, in strata 3 inches to 25 inches in thickness, dipping N. 60° to 65°, with strike of N. 82° E. At the McKee quarry, less than half a mile to the east, the strata dip 70° to 75° toward the east, with a strike of N. 12° W., or nearly at right angles to the strike at the Means quarry.

Numerous exposures of the Niagara limestone occur near Delphi, which show dips of from 10° to 45°. The dips here, like those at Kentland, do not conform to an anticlinal structure, but appear to be quaquaversal.

Domes.—At Wabash a fine exposure of the Niagara occurs near the railroad station which affords a key to the puzzling dips at Kentland and other points where only small exposures can be seen. A railroad cut has exposed a cross-section through the center of a small dome in the Niagara limestone and shale. In passing through the cut the beds are seen dipping in all directions from the center. On the northeast, east and south of the dome, the Wabash River has denuded the dome of superficial deposits and the beds are seen dipping sharply in these several directions as shown in the accompanying photographs. At the south end of the cut the strata dip 25° to 30° S. 40° W. Toward the north end of the cut they are seen dipping to the northwest and north. On the east side the dips are east and southeast. The width of the dome from north to south exposed in the cut is about 840 feet. A portion of the south side of the dome has been removed by erosion. It is estimated that the total north and south diameter has been about 1,150 feet. The excavation for the railroad gives a continuous exposure of the Niagara shale and limestone for half a mile form the center of the dome. The dips of the beds going north from the center of the dome are observed to drop down gradually from a maximum of 30° to perfectly horizontal beds. No dip or other disturbance is noticeable in the half-mile exposure north of the dome.

A group of small domes occur in the Wabash Valley near Lagro. One of these, known as the Hanging Rock, is situated about one mile southeast of Lagro. It consists of a mass of limestone and

PLATE XI.

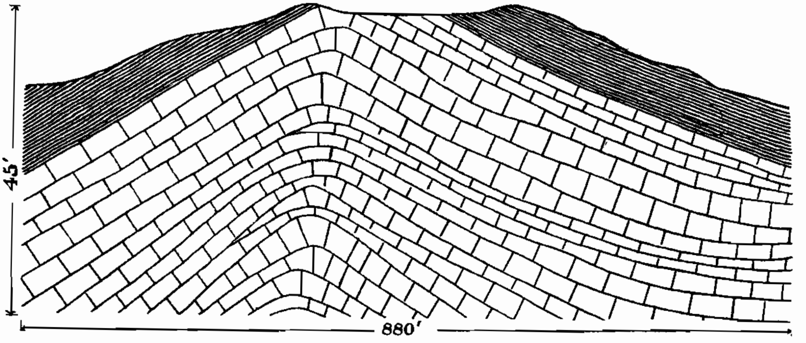


Fig. 3. Cross Section of Wabash Dome.

Fig. 4. East Side of Wabash Dome; Strata Dipping East and Southeast.

shale which rises abruptly from the bank of the Wabash River to a height of about 80 feet. The beds exhibit quaquaversal dips and represent a part of the dome the north and east sides of which have been cut away by the river. The upper beds dip to the south and west at an angle of 25°. The lower strata are less inclined.

At Huntington a large area of Niagara limestone is exposed at the quarry one mile east of town. The beds here exhibit quaquaversal dips and indicate a dome having its center within and near the east side of the area exposed by the quarry. The highest dips noted here are 35° or 40°. The exposures are not sufficiently extended to determine the exact diameter of the dome, but from the horizontal strata exposed in nearby outcrops, it is probable that it does not exceed 2,000 feet. At the old quarry, a quarter of a mile northeast, the strata are horizontal.

The quaquaversal dips show a general tendency to drop rapidly from a high inclination to nothing. This is noticeable at the quarry half a mile west of Huntington. The beds in the new quarries on the north side of the railroad show a dip of 25° to the south, while the strata in the old quarry, not more than 100 yards away, show dips of from 1½° to 0. It was doubtless the proximity of outcrops showing highly tilted strata to those of horizontal beds which led Owen* into the error of reporting tilted Devonian rocks at Huntington resting unconformably on horizontal Niagara beds. There is no evidence of either Devonian beds or unconformity in the vicinity of Huntington.

It has been shown that the dips observed in at least three localities are quaquaversal and the expression of dome structure. Nowhere in the area does the strike and dip of the beds conform to an anticlinal or synclinal structure. The dips seem everywhere to be quaquaversal, and it is believed that all of the tilted Niagara beds of northern Indiana represent small domes similar to those at Huntington and Wabash.

Origin and Age.—There is at present no positive evidence as to the nature of the forces which produced the domes. It seems probable, however, that they may be analogous in origin to the "mud lumps" at the mouth of the Mississippi. From a recently

*Ind. Geol. Surv., 1859–60, p. 66.

published description of the "mud lumps," they appear to have a similar structure to the Niagara domes. Harris has studied these interesting masses of recently elevated sea-bottom and states, "that they rise up in domes or anticlinals and preserve their regular bedding is proven by their present structure."

Whatever the causes may have been which produced the domes, there is clear evidence that they were developed about the close of the Niagara period. Many of them were elevated above the Paleozoic sea, while others probably did not reach its surface. Some of the domes remained above sea level during a considerable portion of the Devonian age, and there is some evidence that others continued as islands to the end of Devonian time. The evidence of the exposures indicates that the gradual deepening of the Devonian sea which initiated the "Black shale" sedimentation submerged some of the Niagara domes which had remained above sea level throughout the Corniferous and Hamilton epochs. These conclusions are based upon the relations which have been observed to exist between the Devonian and Niagara beds at Delphi, Georgetown, Kentland and other localities. At Georgetown the horizontal Corniferous limestone beds rest on Niagara beds showing a small dip, but there is no evidence of land surface conditions having existed previous to the Corniferous sedimentation.

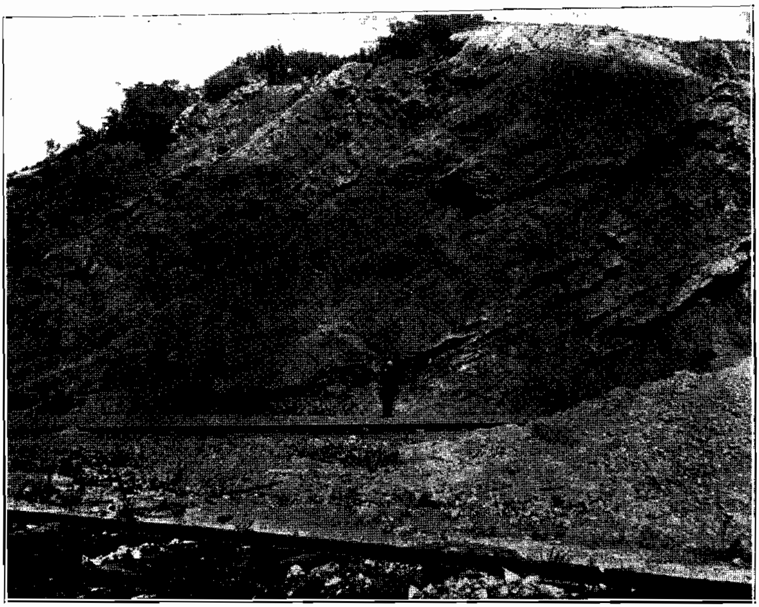
Near Delphi, at one locality, horizontal beds of Hamilton age lie unconformably above the Niagara limestone, which shows a dip of 45°; a bed of ferruginous clay and iron ore separates the two. The New Albany shale is seen resting on the Niagara at another locality near the one last mentioned, the ferruginous clay separating these two as in the first instance.

The highly tilted beds near Kentland occur on high ground in the open prairie, remote from any stream. Rocks of later age have been encountered at much lower levels in all directions from this point, within two or three miles, and it appears probable that the Kentland dome remained above sea level until the end of the Devonian or later.

The occurrence of outliers of Mansfield sandstone (Pottsville conglomerate) in the center of the Niagara area of northwestern Indiana near Remington and Jasper indicate that a subsidence occurred after the formation of the Niagara domes in northwestern Indiana which submerged all or nearly all of the Niagara area

PLATE XII.

Fig. 5. Northeast Part of Wabash Dome; Strata Dipping Northeast.



of that region beneath the Carboniferous sea. The development of the present Niagara arch in northwestern Indiana was, therefore, of much later date and independent of the formation of the Niagara domes. While the domes date back to the end of the Niagara, the Niagara arch is of Carboniferous or post-Carboniferous age.

The Niagara-Devonian unconformity which has been described, though much more pronounced, may be correlated with that which has been recognized in Shelby County,* Indiana, and with the slight unconformity between the Devonian and Upper Silurian which has been recorded by Newberry,† on the east side of the Cincinnati geanticline. The evidence at hand points to a general elevation of the sea bottom at the close of the Niagara in the area around the northern end of the Cincinnati geanticline. The resulting shallow sea was doubtless an important factor in the sudden disappearance of the Niagara fauna and the substitution of the corraline fauna of the Corniferous.

Area Northwest of the Wabash.

Newton County.—The Niagara limestone outcrops at two localities in Newton County. One of these is one mile northwest of Goodland, and the other is about three miles southeast of Kentland. Elsewhere in this county the bedrock is deeply covered by the drift with the exception of localities in section 25, T. 27 N., R. 8 W., where Collett reports outcrops of the Lower Carboniferous.‡

The Niagara limestone has been quarried in a small way northwest of Goodland in the S. E. of the N. W. quarter of section 22. At the time of my visit the quarry was filled with water and only the uppermost layers of the rock were visible. These show a rather soft, buff magnesian limestone. It is too soft to make a very good "road metal" but has been used to some extent in road building and also for foundation work. The strata appear to lie horizontal and are covered by three or four feet of surface clay and soil. The same rock is struck in ditching a few hundred yards to the northwest of the quarry. On the Blough and Conway farms,

*Twenty-fifth Ann. Rep. Ind. Geol. Surv.

which are near the quarry, bed rock is encountered in shallow excavations. Apparently the Niagara limestone approaches very near the surface over an area of several hundred acres in sections 22 and 15 T. 27 N., R. 8 W. Fossils are very scarce, but sufficient fragmentary material was secured to indicate the Niagara age of the bed.

Three miles southeast of Kentland, in section 25, the Niagara limestone outcrops on the highest ground in the vicinity. The limestone here approaches very near to the surface over an area of more than one hundred acres in sections 24 and 25. In the surrounding country bedrock is seldom found in wells nearer the surface than fifty feet, and frequently it lies at more than twice that depth. The quarries have been opened at points where the rock outcrops or reaches to within a few feet of the surface. The McKee quarry is the most easterly of these and gives the best exposure of the rock. It is located in the N. E. quarter of section 25, T. 27 N., R. 9 W. In the vicinity of the quarry the limestone outcrops or comes within a few inches of the surface for two hundred yards in a direction corresponding with the strike. The strata dip 70° to 75° toward the west, with a strike of N. 12° W. magnetic. A thickness of about 50 feet is exposed in the quarry. On the east side the rock is a hard gray limestone with a semi-lithographic texture and breaking with a conchoidal fracture; cone-in-cone structure is developed in some of these strata. The texture of the stone changes gradually toward the center of the quarry, and on the west side the beds are composed of soft buff magnesian limestone. A large amount of stone has been quarried here and crushed for road building. The harder beds furnish an excellent stone for this purpose.

A low mound which rises perhaps twenty feet above the strip of prairie separating it from the McKee quarry lies about one-fourth of a mile to the northwest of the latter. Hard gray limestone outcrops along the top of this knoll. The strike here is nearly north and south, but the exposure was not sufficient to measure the amount of dip, which appears to be nearly 90°. The Fidelity Insurance Company is opening a quarry at this locality for the purpose of supplying material for road building. The rock is a very tough, hard limestone of excellent quality for

About 300 yards west of the Fidelity Insurance Company's quarry, a quarry has been operated on the farm of Mr. S. A. Means for a number of years. The rock here is similar in appearance to that at the McKee quarry; the dip is 60° to 65° to the north, strike N. 82° E. The strata are in layers 3 to 25 inches in thickness. In one part of the quarry a system of cleavage planes, somewhat resembling bedding, have been developed nearly at right angles to the true bedding. These were doubtless developed by the pressure which produced the heavy dip seen here. Fossils are scarce, but more common than at the other quarries.

Deep wells at Kentland and other points within a few miles to the west, northwest and southwest reach the New Albany shale at depths varying from 80 to 180 feet below the surface.* The top of the New Albany shale at some of these wells is more than 100 feet lower than the Niagara at the McKee and Means quarries. The outcrops of the New Albany shale on Carpenter's Creek, a few miles to the northeast, are also lower. Rocks of Carboniferous age lie at a lower level two miles south of the McKee quarry. This would indicate that the Niagara and Devonian are unconformable in Newton County, as they have been shown to be in the Wabash Valley. The relations observed indicate one or more Niagara domes whose summits and sides remained above the sea during Devonian sedimentation and probably through a part of Carboniferous time.

Jasper County.—The principal outcrops of the Niagara limestones occur along the Iroquois River in the vicinity of Rensselaer. Bed rock, which is probably of Niagara age, is also reported in the bed of the Pickamink River. High water covered these outcrops, as well as most of those in the vicinity of Rensselaer at the time of my visit. The beds which could be examined were composed of hard, gray magnesian limestone of good quality for road building.

Collett† reported Devonian limestone overlying the Niagara at the dam in Rensselaer, but this bed was not exposed at the time of my visit.

Niagara beds reach the surface in the highway near the center

*Collett, 12th Ann. Rep. Ind. Geol. Surv., pp. 53-56. Collett, 23d Ann. Rep. Ind. Geol.

of section 29, six and a half miles east of Rensselaer, and also at Pleasant Ridge station. The Niagara holds a small amount of petroleum in some localities. In section 35, T. 29 N., R. 6 W., a well 35 feet in depth, on Andy Yoeman's farm, furnishes a small amount of dark lubricating oil.

In the south part of the county the New Albany shale outcrops at intervals for more than three miles along Carpenter's Creek. The "black shale" outcrops begin at Remington, where it forms the bed and sides of the stream, exposing a thickness of 15 feet of bluish black to drab shale. In descending the stream the New Albany shale outcrops are interrupted in the north part of section 24 by exposures of the Mansfield sandstone ("Millstone grit") which forms the bed and sides of the creek at the wagon bridge, three-quarters of a mile northwest of Remington. At this point the creek flows through a post-glacial gorge in this formation. The rock is a coarse buff sandstone, locally conglomeritic, the pebbles varying in size from buckshot to hickory nuts. Geodes five to six inches in diameter occur in it. About forty rods below the bridge the New Albany shale again appears in the bed and sides of the stream. At the forks of Carpenter's Creek the Mansfield sandstone outcrops on the east side of the stream and the New Albany shale on the west side. Further down the stream the two formations may be traced to within a few yards of each other at the same level, but the contact of the two was not observed. The relationship to each other of the outcrops described above seems to indicate that the two formations are unconformable. Apparently the Mansfield sandstone has been deposited in an old valley of erosion in the Devonian shale.

White County.—The only outcrops of the Niagara limestone in this county known to the writer occur along Monon Creek. It is well exposed in the bed of the stream just west of the railway at Monon. Both the New Albany shale and the Devonian limestone outcrop at much lower levels a few miles to the southeast. These have been described by the writer in a previous paper.* The outcrops at Monon apparently represent one of the Niagara domes. Collett recognized the quaquaversal character of the dips here and stated that "the strata seem to dip from this point in almost every direction."* The limestone at Monon has been used to some extent for making lime.

Four miles northeast of Monon, the Big Monon Ditch cuts through the Niagara limestone for 3,300 feet. The beds here show a dip of from 30° to 45° toward the southwest.

Just west of Wolcott the Mansfield sandstone approaches the surface. It is extensively quarried for glass making in the S. W. quarter of section 25. The section exposed in the quarry shows:

Surface clay	6 ft. 8 in.
Light bluish gray, coarse sandstone with coarse quartz pebbles scattered through it............	25 ft.

The sandstone is very friable, and in a part of the quarry is but little more than an unconsolidated sand.

Wabash Valley.

Carroll County.—No other county offers so good an opportunity to study the relationship between the Niagara and the Devonian rocks as Carroll. Both the Devonian and the Niagara are well exposed in the vicinity of Delphi. The Niagara limestone is a magnesian limestone, buff or gray, usually very hard, but sometimes showing soft beds.

At the mouth of Little Rock Creek, in the northeast part of the county, the lower division of the Devonian limestone ("Corniferous") is seen resting on the Niagara limestone. Both appear to be horizontal at this point. One mile below this the Niagara limestone outcrops opposite Lockport in the banks of the Wabash. Here the beds show a northwesterly dip of 35°. They show a light gray ragged looking limestone, splitting into irregular fragments by frost action.

At Delphi the Niagara limestone is well exposed in the old Deer Creek channel on the northeast side of town. Just south of the Monon railway in the quarry a thickness of 150 feet is exposed. This is the greatest thickness which has been observed in any single section in the county. The dip here varies from 30° to 40°. This series of beds belongs to the Huntington limestone formation. The Noblesville dolomite is represented by outcrops

*Rep. Geol. Surv. Ind., 1872, p. 303.

between the highway south of the quarry and Deer Creek. Above the upturned edges of the Huntington limestone rests a thin bed of impure Devonian limestone of Hamilton age. A bed of iron ore and red clay eight or ten inches thick lies between the two unconformable beds. In the railroad cut just north of the city high school building the unconformity of the Niagara and the Devonian may also be seen, a thin bed of ferruginous clay separating the two as at the quarry section. In the latter case, however, the Devonian is represented by the New Albany shale, the Niagara at this point having evidently remained above the Devonian sea until the beginning of the New Albany shale epoch or later.

At the lime quarry of Harley Brothers the Niagara limestone shows dips of 10° to 15°, mostly toward the south, although the direction of dip tends to swing round toward the west in the north part of the quarry.

In the quarry one-half a mile northeast of the Harley Brothers' quarry the beds dip 20° to 30° toward the northeast.

The Niagara limestone at Delphi makes an excellent lime and is extensively quarried and burned for this purpose at the above mentioned quarries. Lime was formerly burned from outcrops near the river west of Delphi, but the kilns there have been abandoned.

In Carrollton township the Niagara beds reach the surface in the bed and sides of Little Deer Creek, about 200 yards above its junction with the north fork of Deer Creek. The limestone here is a light gray crystalline rock, apparently containing but little magnesia.

Cass County.—Nearly all of the outcrops of bedrock in this county are confined to the bluffs of the Wabash River; the exceptions being those along Pipe Creek and in the vicinity of Adamsborough and Logansport. The Niagara limestone outcrops at very frequent intervals along the Wabash from the Carroll County line almost to Miami County. Small patches of Devonian limestone of Corniferous age occur, but less frequently.

The irregular manner of occurrence of the Devonian outcrops is due to the unconformity existing between the Niagara and Devonian beds. Many outcrops of the latter appear to have been deposited in depressions of the Niagara limestone. An example of this is seen in the Devonian limestone which forms the bed of the Wabash one-half mile below Georgetown. The Niagara limestone rises from 10 to 20 feet above the bed of the river immediately above and below this point. Just below Georgetown both the Niagara and the Devonian are exposed on each side of the river. From five to eight feet of gray, crystalline Devonian limestone rests unconformably on the Niagara. The line of contact between the two is an irregular one, frequently rising or sagging. On the east side of the river the Niagara dips from eight to sixteen degrees to the east, while the Devonian limestone lies horizontal above it.

At Logansport, the Niagara limestone forms the bed of the Wabash. The Devonian limestone appears above it at a number of points in and near the city. It caps the knoll on which the hospital for the insane is located, and outcrops over sixty acres or more in section 2, southeast of the city. At the last named locality it is quarried and burned for lime by Mr. Harry Lux. It makes a superior quality of lime, which is free from magnesia and whiter than the lime from the Niagara dolomite.

The extensive outcrop at the upper Eel River dam in Logansport shows the following section:

1.	Gray limestone (Devonian)	3 ft. 4 in.
2.	Bluish clay shale	2 to 3 in.
3.	Hard gray limestone breaking with conchoidal fracture (Niagara)	2 to 4 ft.

The Niagara beds in Cass County exhibit three well marked varieties of limestone: (1) a hard gray, fine-grained limestone, breaking with conchoidal fracture; (2) a crystalline or semi-crystalline, moderately soft rock, and (3) a buff or gray, evenly bedded magnesian limestone, usually with saccharoidal texture. These three appear to represent local varieties of the same beds. The exposure in the banks of the Eel and the Wabash rivers at Logansport are mostly of the first class. An interesting lens of very pure white, fine-grained sandstone about six feet thick, occurs in the hard gray limestone below Kenneth about half a mile. The lateral extent of the bed is not known, as only a single exposure has been seen at the head of a small ravine entering the Wabash from the north. The stone will make an excellent glass sand.

The second variety of limestone is seen in the outcrops one-half mile above Georgetown, on the north bank of the Wabash, and at a few other localities. These limestones were formed under conditions favorable to molluscan life and contain an abundance of fossils.

The beds which are so extensively quarried at Kenneth belong partly to the third class.

The section exposed in the quarry north of Kenneth Station is as follows:

1.	Clay and soil	6 to 8 ft.
2.	Blue limestone	20 ft.
3.	Buff magnesian limestone in strata 10 to 4 in. thick	30 ft.
4.	Thin bedded bluish-gray limestone	10 ft.
5.	Heavy bedded dark gray limestone	20 ft.

The beds lie nearly horizontal, showing only slight wavy undulations.

A small amount of number three is used for dimension stone; the remainder is used by the Chicago Steel Company as a flux. Several hundred carloads per week are shipped for this purpose. The blue limestone (No. 4) contains a few fossils, but the other beds are almost entirely barren.

In the quarry on the south side of the railroad near Kenneth, which was formerly operated by Harry Lux, the beds exposed are similar to those of the above section.

At Keesport, three and a half miles east of Logansport, the Niagara limestone is quarried and burned for lime.

Miami County.—Both the Devonian and Niagara limestones outcrop on Pipe Creek, near Bunker Hill. Elsewhere in the county the Niagara beds are the only beds outcropping. They show numerous exposures along the Wabash near Peru, and in the bluffs of the Mississinewa River the outcrops are almost continuous from the county line to its mouth. At the old limekiln, one mile above Peru, the Niagara limestone shows a dip to the west of 28°. Some very irregular dips are exposed in a small quarry on the south bank of the Wabash, one-half mile above the railroad bridge, which are due to false bedding.

The limestone is quarried from the bed of the river at Peru, and various small quarries have furnished rock for foundation work. Much of the stone is of a poor quality. It has been burned for lime one mile above Peru.

Wabash County.—The Niagara limestone outcrops in great force along both the Wabash and the Mississinewa rivers. At most of the exposures along the latter stream the beds lie nearly horizontal, but inclined beds occur at a few localities. At the mill dam one mile above Somerset a small stream enters the river, exposing in its bed and sides the highly inclined beds of the Niagara dipping toward the north at an angle of about 30°.

The Wabash crosses the county from east to west, flowing in a valley which, in many places, has been cut into the Niagara rocks. The bluffs, 40 to 80 feet high, which border the valley, afford many good exposures of the Niagara beds. The domes which interrupt the otherwise horizontal beds of the Niagara limestone at many points along the Wabash constitute the most interesting feature of the geology of this county. These have been described in another section of this paper. The occurrence of a group of these domes in the flat plain of the Wabash near Lagro is doubtless due to the fact that their development elevated beds of limestone offering considerably more resistance to erosion than the softer Niagara shales in which the lower levels of the Wabash Valley are excavated.

The exposure at the Wabash dome in Wabash affords the longest continuous section noted in the county. It is as follows:

1.	Drab gray calcareous shale....................	45 ft.
2.	Bluish gray to buff limestone..................	4 to 10 ft.
3.	Bluish shale	7 ft.
4.	Buff dolomitic limestone.......................	75 ft.

In some sections a bluish calcareous shale or hydraulic limestone is exposed. This is seen at the base of the Hanging Rock section. It is said to make a good cement and has been used for that purpose. The limestone at Wabash is extensively quarried for flagstone and foundation stone.

Upper Wabash Valley.—Above the Wabash and Huntington County line outcrops cease along the river for about seven miles. Near the forks of the river they reappear, and for more than four miles the Niagara limestone appears at numerous exposures in

Huntington the channel of the stream is cut in the Niagara limestone. The beds show heavy dips at Huntington which have been described in another part of this paper. The limestone at Huntington makes an excellent quality of lime and is extensively quarried and burned for that purpose. The chemical composition of the stone used for lime is shown in the following analysis:*

Water at 212°	0.50
Silicic acid	1.50
Lime	31.92
Magnesia	7.58
Alumina and ferric oxide	8.25
Carbonic anhydride	49.52
Sulphuric acid	0.34
Loss	0.39
	100.00

Prof. E. T. Cox refers to the "Corniferous epoch" a bed of sandstone at Huntington. He states that "in Huntington County it forms the upper fifteen inches, close grained and loosely coherent." The bed referred to is probably a thin bed which appears in the quarry just west of Huntington. This bed lies between strata of Niagara limestone and is tilted with them at an angle of 25°. While no fossils were noted in it, its position between beds of Niagara limestone show it to be a local sandstone lens in the Niagara.

Occasional outcrops of the Niagara limestone occur along the south or main branch of the Wabash as far east as the State line. At Markle, Buena Vista and other points, the limestone has been quarried for local use. The exposures near Markle show highly tilted beds.

The Niagara limestone does not outcrop in the vicinity of Decatur, but it is extensively quarried after removing the 15 to 20 feet of drift clay and sand. The quarry at the north side of town shows the following section:

1.	Surface clay and gravel	19 ft.
2.	White, soft, thin-bedded saccharoidal limestone	8 ft.
3.	Heavy-bedded, white saccharoidal limestone	15 ft.

*[illegible]

The section exposed in the J. S. Bowers quarry, one-third of a mile northwest of Decatur, is as follows:

1. Gravel and clay .... 20 ft.
2. Dark gray, very hard saccharoidal limestone with frequent patches of chert in the strata in layers of 5 to 18 in. thick.................................. 20 ft.

The contrast in color and texture between the limestones at these two quarries is most marked, but they probably expose beds of the same geological horizon and the differences doubtless represent local variations of the stone. The white stone is easy to work, and has a handsome appearance when dressed.

Area South of the Wabash.

Hamilton County.—This county is located slightly north of the geographical center of Indiana. The drift in this part of the State is so deep that the Paleozoic rocks are rarely exposed at the surface. Only a few outcrops occur in the county. The most extensive exposure is the one at Connor's mill on White River, five miles above Noblesville. Two small quarries southwest of Fishersville afford an equally good opportunity to study the Paleozoic rocks of the county. Several days were spent by the writer in collecting from the beds exposed at these two localities.

Connor's Mill.—The outcrop at Connor's mill consists of a hard, light buff dolomite, which is exposed for two or three hundred yards below the dam. The beds show a dip of from 20° to 40° to the southwest. Above the dam one-third of a mile the limestone outcrops again, dipping 30° to the northwest.

The following is a list of fossils collected from beds exposed below the dam:*

Favosites favosus ....r.
Streptelasma cf. calicula. ....r.
Amplexus shumardi..................................r.
Eucalyptocrinus cf. crassus ....r.
Conchidium multicostatum..................................a.
Conchidium sp..................................r.

*The list here given is a revision of a preliminary list published in the Am. Jour. Sci.,

Atrypa reticularis	c.
Strophonella williamsi n. sp	c.
Leptaena rhomboidalis	c.
Meristina maria	r.
Spirifer nobilis	r.
Spirifer cf. crispa	r.
Dalmanella elegantula	r.
Plectambonites cf. sericeus	r.
Conocardium sp	r.
Platyostoma cf. niagarense	c.
Spherexochus romingeri	a.
Calamene vogdesi	c.
Illaenus insignis	c.
Phacops cf. pulchellus	c.
Encrinurus americanus n. sp	c.

Fishersburg Quarries.—Southwest of Fishersburg one-half mile a very pure, white sandstone has been quarried for glass making. It is a fine-grained, massive, loosely cemented rock, crumbling easily. A buff dolomite, having the same lithological characteristics as the outcrop at Connor's mill, rests upon the sandstone. The line of contact between the two formations is clearly shown in the quarry, and is seen to be a very irregular one, resembling unconformity. The sandstone is believed, however, to be a local lens. Such lenses are known at other localities in the State where both the upper and lower contact with the Niagara is clear. The limestone on either side of the projecting mass of sandstone extends below the surface of the pool which fills the quarry. The limestone beds show a dip of about 35° to the north.

The following section is exposed at the east pit:

1.	Surface clay	2 ft. to 18 in.
2.	Buff magnesian limestone	1 ft. to 0
3.	Hard, fine-grained white sandstone	5 ft.

A careful search failed to discover any fossils in the sandstone.

The fauna of the limestone, as well as its physical characters, indicate that it belongs to the same formation as the beds at Connor's mill.

A comparatively short time was spent in collecting from the Fishersburg quarries, and for this reason the following list of fossils from that locality include fewer species than the preceding list:

Streptelasma cf. calicula	r.
Favosites niagarensis	c.
Spirifer cf. radiatus	r.
Conchidium multicostatum	a.
Reticularia sp	r.
Orthothetes subplanus	r.
Stropheodonta sp	c.
Meristina maria	c.
Nucleospira pisiformis	r.
Leptaena rhomboidalis	r.
Spirifer nobilis	r.
Illaenus insignis	r.
Spherexochus romingeri	r.
Phacops cf. pulchellus	r.
Encrinurus americanus n. sp	r.

In the southwest part of the county the Niagara dolomite comes near the surface in sections 5, 6 and 32 on the north side of the Fall Creek. A small outcrop of hard gray limestone occurs at the roadside about one-half mile northeast of Helm's mill. Just north of this a small amount of stone has been quarried on Samuel Patterson's land. The quarry has not been worked recently, and only ten inches of buff dolomite are exposed.

A small amount of stone for local use has been quarried in the southwest quarter of section 32, T. 17 N., R. 6 E. The excavation exposes about two feet of thin-bedded, light orange colored magnesian limestone with from two to four feet of stripping.

Outcrops were reported along Duck Creek by Brown,* but a careful search failed to locate them.

Correlation.—Richard Owen described the outcrop at Connor's mill in his report published in 1863,† but offered no opinion as to the age of the bed. The earliest reference to the age of these beds occurs in a report on the geology of Hamilton County** by Dr. R. T. Brown, who considered them to be of Devonian age. No paleontological evidence was offered in support of this opinion, the author of the report stating that "the outcrops of rock in Hamilton County are quite barren of fossils." In 1901 the limestones at Connor's mill and near Fishersburg were referred by the writer‡ to the Niagara, but the paleontological evi-

*Rep. Ind. Geol. Surv., 1884.

†Rep. Ind. Geol. Surv. for 1859-62, p. 102.

**Fourteenth Ann. Rep. Ind. Geol. Surv., 1884, p. 27.

dence for this determination was not given. The faunal lists here given clearly show the Niagara age of these beds. The Lockport (Niagara) limestone is their probable equivalent in the Niagara group. As stated on a preceding page the local name Noblesville dolomite has been given to these beds.

The Hamilton County outcrops are the most southern exposures in the State which show highly tilted Niagara strata. The orogenic disturbances, which caused a general tilting of the Niagara rocks in northern Indiana previous to the beginning of Devonian sedimentation, did not affect the southern portion of the State, where they lie nearly horizontal, and are conformable with the Devonian rocks. North of the Ohio River eighty miles the Niagara rocks are slightly unconformable with the Devonian,* but nearly horizontal. The Devonian rocks have not been observed in contact with the Niagara in Hamilton County, but it is very probable that they are unconformable, as they have been shown to be farther north in the Wabash Valley.

Madison County.—The Niagara beds outcrop at three points on the south bank of Fall Creek in the town of Pendleton. These are at the lower edge of town, at the foot of the fall, and on a knoll 200 yards below the fall. The formation is represented at the foot of the fall by a bluish drab calcareous shale or fine-grained sandstone, above which rests the massive Pendleton sandstone (Devonian). The section at the fall is as follows:

1.	Hard gray limestone	3 ft. 6 in.
2.	Heavy bedded white sandstone	6 ft. 8 in.
3.	Bluish drab, fine-grained calcareous sandstone or shale	10 in.

The beds exposed 200 yards below this section are composed of buff to ash colored soft magnesian limestone and lie at nearly the same elevation or a little higher than the Devonian beds of the above section. It was doubtless the relative elevation of the Devonian and Niagara beds which led Cox† into the error of placing the latter above the Devonian sandstone and limestone in his section of the Pendleton rocks. The buff dolomite contains *Sphaerexochus romingeri, Spirifer niagarensis* and other Niagara

*Kindle, 25th Ann. Dept. Geol. and Nat. Res. Ind., p. 559.
†Eighth Ann. Rep., Ind. Geol. Surv., 1879, p. 60.

fossils in considerable abundance, and belongs to the Noblesville dolomite formation. The beds appear to lie horizontal. The occurrence of Devonian beds at a lower level than the Niagara, in outcrops so near those of the latter, is doubtless due to unconformity.

Niagara limestone of the hard, gray facies outcrops on Foster's Branch four miles below Pendleton. On the north bank of Fall Creek north of Alfonte it is extensively burned for lime.

About two miles west of the Anderson courthouse a quarry has been opened in the Niagara beds on the south bank of White River. The rock is a drab colored limestone, very shaly, and most of the beds are of little value for dimension stone. This quarry has furnished a considerable amount of macadamizing material.

Other points where Niagara limestone has been quarried in Madison County are near Frankton on Pipe Creek and two miles northeast of Frankton, in section 33, T. 21 N., R. 7 E.

Other Outcrops.—A single outcrop of the Niagara is known in Henry County. At the Quarry mills, three miles southwest of Greensborough, limestone was formerly quarried and burned for lime. All that can be seen of the bed at present is about two feet of shaly, bluish-gray limestone near the old limekiln. The foundation of the mill is constructed of this stone.

In Grant County numerous outcrops of the Niagara limestones occur along the Mississinewa River below Marion.

Niagara beds are said to outcrop in the bed of White River above Muncie, but they have not been seen by the writer. Mr. Charles Gough, County Surveyor of Delaware County, states that bed rock lies within a few feet of the surface in the following sections:

Section 14	Township 20	Range 10 East.
Section 14	Township 20	Range 9 East.
Section 16	Township 21	Range 11 East.
Section 23	Township 22	Range 10 East.
Section 27	Township 21	Range 11 East.
Section 28	Township 21	Range 11 East.
Section 21	Township 21	Range 11 East.

A number of outcrops of the Niagara occur in Randolph County. The stone is used for lime and quarried for flagging and other purposes. The following analysis of the Randolph County limestone is republished from the Report of the State Geologist for 1878, p. 59.

	Macksville.	*Ridgeville.*
Water at 212°F.	1.18	0.90
Silicic acid	1.20	0.70
Ferric oxide	1.30	2.70
Alumina	4.40	3.75
Lime	45.45	45.08
Magnesia	4.01	4.36
Carbonic anhydride	40.12	89.21
Sulphuric acid	0.27	0.44
Combined water and loss	2.07	2.86
	100.00	100.00

PART II. PALEONTOLOGY.*

BRACHIOPODA.‡

Dinobolus conradi Hall.

Pl. I, fig. 8.

The natural cast of the brachial valve, which is figured from the Gilbert collection, is the only specimen observed. A feature not shown in most of the figures published of this species is a low, indistinct ridge traversing the broad, shallow, longitudinal groove which crosses the muscular plate.

Rare. Huntington.

Monomorella sp.

Pl. I, fig. 1.

Internal casts of the brachial valve of an undescribed species show the following characters:

*NOTE.—Mr. C. L. Breger has assisted in the preparation of the greater portion of Part II and is the joint author of this part of the paper.

For the loan of literature and assistance in the determination of certain species, acknowledgments are due to Dr. C. D. Walcott, Professor H. S. Williams and Prof. C. E. Beecher.

Mr. J. R Gilbert, of Huntington, has generously loaned us his valuable collection of Huntington fossils, a number of which are here figured. To Mr. G. K. Greene we are indebted for the opportunity to compare the northern Indiana species with those in his Niagara collection from Louisville and southern Indiana.

The illustrations are by Dr. J. C. McConnell and Mr. G. S. Barkentin, with the exception of the figures on plate 25, which were made by Mr. Breger.

The *Coelenterata* and *Echinodermata* and parts of some other groups have been omitted from this paper because of the scarcity of satisfactory material in the collections.

‡The student is referred to Bull. No. 87, U. S. G. S., for the synonomy of the species.

Brachial valve semi-circular in outline, uniformly concave; length of largest specimen 75 mm., width 110 mm. The smallest is about half this size. Platform pear-shaped, tapering toward the front. The platform is divided transversely about the middle into two parts by a shallow furrow, bending backward in the middle; the posterior division is subdivded by a similar but less conspicuous furrow at right angles to the first. Two diverging low ridges extend forward from the ends of the transverse furrow. A second pair extend forward from the anterior end of the platform and reach nearly to the margin of the valve. No specific name will be proposed until a more complete description is possible.

Six specimens have been found at Delphi.

Trimerella sp.

Pl. I, fig. 2.

This genus is represented in the collection by a single fragment which is here figured, of the internal cast of the valve of an undetermined species.

Delphi.

Crania sp.

Pl. I, figs. 9, 10.

Shell broadly ovate, truncated posteriorly; apex rather depressed, near the posterior margin. Anterior adductor scars about one-third the distance from the truncated margin to the front. Surface, apparently with fine concentric striæ.

Only one specimen has been seen which is a cast of a brachial valve from Pendleton, Ind.

Strapheodonta cf. corrugata Conrad.

Pl. I, fig. 3.

Shell nearly flat; surface marked by fine, prominent, radiating striæ; these are nearly equal, bifurcating at intervals and crossed by fine concentric striæ. Four or five oblique folds appear on the hinge margin near the extremities of the hinge line. The alternating finer striæ which are said by Hall to characterize the New York forms have not been observed.

A single, well marked specimen from Georgetown.

Pholidostrophia niagarensis n. sp.

Pl. II, figs. 13-15.

Shell small, semi-elliptical, highly arched; the height of the convexity equals half the width of the shell. Greatest width between the hinge extremities which are slightly pointed. The very convex pedicel valve rises abruptly from the hinge line. The gibbous umbonal region projects slightly beyond the hinge line, then descends regularly to the front and sides. Beak small and incurved. Brachial valve not seen. Surface with nacreous luster, smooth except near the front, where faint traces of distant radiating striæ may be observed under a strong lens. Inner surface of shell strongly and coarsely punctate.

Two specimens from Little Deer Creek, Carroll County.

Strophonella cf. striata Hall.

Pl. I, fig. 4.

Four or five poorly preserved specimens are provisionally referred to this species. Shell resupinate. Strong radiating plications cover the surface.

Connor's Mill, Hamilton County.

Strophonella williamsi n. sp.

Pl. I, figs. 6, 7 and 11.

Shell semi-elliptical, length about three-fourths the width; extremities of hinge line mucronate, extending beyond the rest of the shell. Shell profoundly reflexed about the middle of the valves. Pedicel valve near the beak slightly concave; anterior to the concave region the valve is deeply convex; the depth of the convexity is equal to nearly half the length of the shell. Brachial valve nearly flat or slightly convex near the hinge line, elsewhere very convex. Interior with a strong bilobed cardinal process, directed forward. Inner margin of narrow area crenulated on each side of the beak for about half the distance to the extremities. Surface covered with fine, closely arranged, fasciculate striæ in bundles of from five to ten, which are separated by distinct grooves, most of the latter reaching to the beak. Each groove has the width of about two striæ.

This species is readily distinguished from *Strophonella semifasciata* of the Waldron shale by the absence of the strong elevated striæ which characterize the Waldron species.

The species is represented by about ten specimens from Georgetown, Pendleton, Connor's Mill (Hamilton County), and Delphi.

Stropheodonta sp.

A number of casts represent a nearly flat *Stropheodonta* of undetermined species.

Common at Connor's Mill, Hamilton County.

Leptaena rhomboidalis Wilckens.

Pl. II, fig. 17.

Shell semi-elliptical to semi-circular in outline; valves nearly flat or slightly convex on dorsal, and concave on ventral side in posterior portion of shell; abruptly deflected towards the front sometimes at a right angle to the plane of the posterior portion of the shell. Surface marked by numerous strong, radiating striæ. Six to fifteen strong, concentric wrinkles mark the flat portion of the shell.

The species is common, occurring at Georgetown, Pendleton, and at Connor's Mill, Hamilton County.

Plectambonites cf. sericeus Sowerby.

Pl. II, fig. 22.

Shell transversely semi-oval, greatest width of the shell along the hinge line, which is slightly extended in mucronate points. The interior of the pedicel valve shows a strongly marked, bilobed, muscular impression.

The specimens are casts of the interior and show only internal features. The surface is marked according to Hall "by fine striæ which are even and uniform or alternating with stronger ones; striæ increasing in number toward the margin; granulose or papillose, crossed by a few lines of growth."

Two specimens from Connor's Mill, Hamilton County.

Orthothetes subplanus Conrad.

Pl. I, fig. 5.

Shell semi-circular to semi-elliptical, depressed, convex; length of hinge somewhat greater than the width of the shell. A distinct area extends the length of the hinge in both valves. Surface marked by forty to fifty prominent, rounded, radiating striæ which increase both by interstitial addition and by bifurcation; these are crossed by fine concentric striæ.

A few specimens from Little Deer Creek, Carroll County, are doubtfully referred to this species. In size they resemble Whitfield's *O. hydraulicus,* the largest measuring 6½ mm. in length and 8½ mm. in width. They differ from Whitfield's species in having the radiating striæ of nearly equal strength. The shell is rounded at the cardinal extremities and has a very high area. Beak of pedicel valve sometimes twisted.

The species is rare; found at Pendleton and Georgetown.

Chonetes cf. cornutus Hall.

Pl. II, fig. 12.

Shell small, transversely subelliptical; strongly arched in the middle of the shell; length about one-half the width. Hinge extremities pointed and projecting somewhat beyond the sides of the shell. Four to six small spines on each side of the beak. Surface covered by twenty-five or thirty rounded striæ.

Abundant at Bunker Hill and Logansport; one specimen from Pendleton.

Orthis flabellites Foerste.

Pl. II, figs. 3, 4, 5, 6 and 11.

This species occurs in the dolomitic limestones as natural casts having the appearance shown in the figure. The cardinal area of the pedicel valve forms a low triangle. Surface marked by 22 to 30 broad, prominent radii which are crossed by fine concentric striæ.

Comparatively rare. Known from Wabash and Lagro, Pendleton, and Little Deer Creek, Carroll County.

Orthis (?) *subnodosa* Hall.

Pl. II, fig. 7.

The species is represented by two pedicel valves.

Hinge line somewhat shorter than the width of the shell; area with triangular foramen extending to the beak; beak slightly incurved. A shallow undefined mesial depression extends from the beak to the front bearing two or three plications. Surface marked by fifteen to eighteen bifurcating plications, which are crossed by fine lamellose lines of growth. The shell shows traces of fimbriate surface markings in the best preserved portions.

Rare. Little Deer Creek, Carroll County.

Dalmanella elegantula Dalman.

Pl. II, fig. 9.

Pedicel valve strongly convex, brachial valve nearly flat, longitudinally concave in the middle. Beak of the ventral valve incurved over the high narrow area. Surface covered with fine, radiating striæ.

Rare. Found at Georgetown, at Little Deer Creek, Carroll County, and Helm's mill, Hamilton County.

Rhipidomella hybrida Sowerby.

Pl. II, fig. 8.

Shell rather small, suborbicular, valves nearly equal. Pedicel valve gently convex; brachial valve moderately convex, but with a flat or depressed area along the middle. Surface marked by fine, closely-set, bifurcating striæ arching upwards on the sides of the posterior portion of the shell.

The species is represented by natural casts in the dolomitic limestone showing the impressions of the cardinal teeth and strongly marked muscular areas. Length and breadth apparently equal.

The species is common at Wabash; it occurs rarely at Pendleton, Little Deer Creek (Carroll County), Big Monon Creek (White County), and at Connor's Mill (Hamilton County).

Rhipidomella circulus Hall. ?

Pl. II, fig. 16.

A couple of specimens referred doubtfully to this species are subcircular in outline, slightly broader than long, and moderately convex. Surface covered with fine radiating striæ.

Rare. Georgetown.

Anastrophia internascens Hall.

Pl. II, fig. 10.

Five natural casts of brachial valves represent this species in the collection. These exhibit the following characters:

Valves gibbous, width slightly exceeding the length; surface marked by from 13 to 17 radiating, angular plications, which occasionally increase by intercalation or by bifurcation; fold not well defined, marked with five or six plications. A short, thin septum is present on each side of the beak.

Rare. Found at Wabash and at Pendleton.

Conchidium laqueatum Conrad.

Pl. III, figs. 1, 2; Pl. IV, fig. 3; Pl. VI, figs. 1, 2.

In mature, well preserved specimens with both valves in conjunction, the shell is trigonal or trapezoidal, ventricose and with the depth as great as, or greater than, the width. The pedicel valve is larger and more gibbous than the brachial, the latter being merely operculate. The former valve is elongate, the ratio of length and width being 3 : 2, with the greatest width in front. The beak is hooked down so that its tip is in the plane of the hinge line. The depth of the valve is equal to half the length, the greatest depth being one-third the distance from the beak to the anterior margin. The lateral portion of the shell is abruptly deflected to meet the hinge line, thus producing a high, rather concave face on each side of the valve. The surface is marked by from 22 to 32, but usually 28 rounded or subangular plications which disappear as the lateral faces are approached. These faces and the umbonal quarter of the ventral valve are smooth except for a few concentric wrinkles of growth, which are very obscure. The delthyrium is equilaterally triangular and extends to the tip of the beak.

The brachial valve is smaller, less elongate and less robust than the pedicel valve. Whole specimens are pentagonal, with the greatest width at the anterior margin. The beak is obtuse and curved down, so that its tip is below the plane of the hinge line, while the umbonal region is concealed in the delthyrial opening of the pedicel valve. This concealment, when both valves are conjoined, makes the brachial valve seem to be smaller and flatter than it really is. The surface markings are about the same as those of the pedicel valve except that the lateral smooth faces are perceptibly lower than those in that valve. Internal casts are marked by two parallel septa, about three millimeters apart in the middle of the valve. These septa extend three-quarters of the length of the valve and diverge only very slightly. The dental sockets are long, parallel to the margin, and diverge at an angle of nearly 90 degrees.

Abundant. Delphi, Big Monon Ditch (White County), Huntington and Georgetown.

Conchidium cf. littoni Hall.

Pl. III, figs. 3-6; Pl. IV, figs. 1, 2, 4; Pl. V, figs. 4, 5.

Pal. New York, III, 1859, p. 262.

"Shell ovoid, somewhat elongate. Dorsal valve moderately and regularly convex from base to umbo; beak almost rectangularly incurved beneath the beak of the opposite valve. Ventral valve very gibbous; beak subattenuate, incurved. Surface marked by about eighteen or twenty simple subangular plications. There is a broad, concave, smooth space on each side below the beak of the ventral valve, and a much narrower space on each side of the dorsal valve."

The specimens here referred to this species are considerably larger and more gibbous than the specimens heretofore figured, but seem to agree in most essentials with the original description given above.

Common at Georgetown.

Conchidium cf. multicostatum Hall.

Pl. VI, fig 3.

Several pedicel valves are referred to this species. Beak moderately incurved, valve sloping uniformly to the sides and front.

Surface covered by about thirty-five rounded, closely set plications. Septum extending two-thirds of the distance from the beak to the front.

Connor's Mill, Hamilton County, Ind.

Conchidium trilobatum n. sp.

Pl. V, figs. 1-3.

Shell large, subovate in outline. Both valves strongly trilobed; greatest width at about the anterior termination of the lateral lobes. Brachial valve deeper than the pedicel valve, beak incurved; cardinal slopes not plicated, descending abruptly, almost vertically, to the margin of the shell. A strong sinus on each side of the median line of the shell and extending nearly to the beaks divides the shell into three lobes, the median lobe being broader and much higher than the lateral lobes. Brachial valve with the beak closely incurved, depth about one-half that of the pedicel valve. Lateral sinuses shallow near the beak, deepening rapidly toward the front and dividing this valve, like the other, into three lobes. Surface of the shell marked with 40 to 70 strong, angular, bifurcating plications. Concentric lines of growth cross these at irregular intervals.

Known only from Huntington.

Conchidium unguiformis Ulrich. (?)

Pl. VI, figs, 4, 5.

A single brachial valve is doubtfully referred to this species. The posterior third of the valve is bent nearly at right angles to the rest of the shell. Beak incurved; surface marked by about eighteen strong angular plications, eleven of which reach to, or nearly to the beak; the remainder arise at one of the strong lines of growth. The plications are crossed by sublamellar, concentric striæ.

Rare. Little Deer Creek, Carroll County.

Pentamerus oblongus var. cylindricus Hall and Whitfield.

Pl. VI, figs. 6-10; Pl. VII, fig. 6.

Shell large, elongate-ovate; subcircular in transverse section. Valves more or less distinctly trilobed in the anterior half, rounded or truncate in front; in the latter case a shallow sinus is present near the front in each valve. Ventral valve deeper and more convex than the brachial; beak arched over the umbone of the opposite valve.

Surface smooth except for occasional concentric ridges of growth.

Common in a single zone at Delphi.

Pentamerus oblongus var. compressa, n. var.

Pl. VII, figs. 1-5.

This variety is distinguished from *P. oblongus* var. *cylindricus* with which it is associated by the great inequality in the depth and width of the shell. The greatest height of the shell is from two to two and one-half times the greatest width. The depth of the pedicel valve is about one and one-half times that of the brachial valve. Anterior end of shell rounded or truncate. One specimen shows obscure traces of obsolescent, rounded plications at the anterior end. All other specimens observed have the surface smooth except for occasional ridges of growth.

Abundant in a single zone at Delphi.

Gypidula (Sieberella) galeatus Dalman.

Pl. II, figs. 20, 21 and 23 to 29.

Shell ovoid or subglobose; valves unequal, the pedicel valve being much larger and more convex than the brachial. Pedicel valve uniformly rounded from the umbone to the front, the outline being nearly that of a segment of a circle; beak very gibbous and strongly incurved. Some specimens have an indistinct, broad fold at the front bearing four or five plications. In most individuals, however, there is little or no trace of a fold. Surface frequently marked with low, indistinct plications, which are obsolescent in the umbonal region. Fine concentric striæ are seen in perfectly preserved specimens. Many specimens show no trace of radiating plications. Very few brachial valves have been observed. These show a broad shallow sinus with three or four plications which are obsolescent posterior to the middle of the valve.

The specimens from Georgetown, which occur in a nearly pure limestone, greatly exceed in size those from other localities, which are all from dolomites. An average brachial valve from the

Georgetown locality measures in width 26 mm., length 27 mm. An average specimen from the dolomite measures in width 15 mm., length 16 mm. A brachial valve from the dolomite has the following dimensions—width 17 mm., length 12 mm.

The species occurs commonly as natural casts showing the single strong septum of the pedicel valve extending about one-third the distance to the front, and in the brachial valve two much finer septa in the umbonal region.

Hall and Clarke in the Pal. N. Y., Vol. VIII, have proposed to distinguish the Niagara Group forms of this species by the name *Gypidula (Sieberella) roemeri.* The specimens from the Glades in Perry County, Tenn., which have been made the types, are similar in all respects to the Georgetown material. However, no difference can be detected between these forms and the typical expression of Dalman's species, as the latter occurs in Europe and in well preserved specimens in the Lower Helderberg of New York. *G. roemeri,* which was never described, must therefore be considered only as a synonym of *G. galeata. G. nucleus* should also, perhaps, be referred to this species, as the Indiana material shows many gradations between the round plications of *G. galeata* and the more angular ones of *G. nucleus,* while some specimens are smooth. Prof. Whitfield informs us that the specific description of the latter species was drawn from the best specimen which happened to have angular plications, though many, if not most, of his specimens were either smooth or had rounded plications. The name "nucleus," therefore, can represent at most only a variety.

It is worthy of note that at Georgetown, where the only specimen of the type of *G. nucleus* was found, *G. galeata* is quite abundant and varied.

The species is common, occurring at Georgetown, Pendleton, Wabash, Fishersburg, and Little Deer Creek, Carroll County.

Gypidula (Sieberella) nucleus Hall and Whitfield.

Pl. II, figs. 18, 19.

This "species," which is represented by a single pedicel valve from Georgetown, shows the following characters:

Valve ventricose and strongly arched; umbone inflated and beak incurved. Surface marked by seven angular plications which become obsolescent in the umbonal region. The two strongest of these are slightly elevated to form a median fold.

Camarotoechia sp. undt.

Pl. VIII, fig. 3.

A single brachial valve of an undetermined species appears in the collection from Little Deer Creek.

The valve is very gibbous, length three-quarters the width. Surface marked by twelve strong plications, four of which are elevated into a median fold.

Rare. Little Deer Creek, Carroll County.

Camarotoechia cf. acinus Hall.

Pl. VIII, figs. 1, 2.

Casts of two or three brachial valves are doubtfully referred to this species. Surface with seven rather strong plications, two or three of which are elevated into a median fold which is not very prominent.

Rare. Pendleton.

Wilsonia saffordi Hall.

Pl. VIII, figs. 4–9.

Shell very gibbous or subglobose; surface marked by from 20 to 36 plications which vary in strength according to their number; plications frequently marked by shallow median groove near the front. Fold and sinus not sharply defined, apparent only at the front and marked by 5 to 11 plications. Beak of pedicel valve acute, curved over the brachial valve.

This shell is comparatively rare. Found at Georgetown and at Bunker Hill.

Eatonia goodlandensis n. sp.

Pl. VIII, figs. 10–12.

Shell subcircular, hinge line straight, equal to two-thirds the greatest width of the shell. Brachial valve ventricose, the gibbous umbone extending over the hinge line, while the beak is incurved closely against that of the pedicel valve. An indistinct fold is developed near the front. Pedicel valve moderately convex in the umbonal region, from which the slope to the margin is quite regular. A deep, rounded sinus toward the front deflects a tongue-like projection of the valve into the front of the opposite valve nearly at right angles to the plane of the margin. A weak plication marks the bottom of the sinus; beak closely incurved against the beak of the brachial valve. Surface smooth except for the plication in the sinus and occasional lines of growth.

The species is known from a single specimen from a quarry one mile northwest of Goodland.

Atrypa calvini Nettleroth.

Pl. VIII, figs. 13-15.

Shell small, brachial valve more convex than the other. In young specimens brachial valve is nearly flat. Ventral valve sloping gently from the convex umbonal region toward the lateral margins, near which it is abruptly deflected downwards, forming a concave zone inside the margin; beak prominent, pointed and slightly incurved. Sinus most prominent at the front, where its junction with the fold forms a high U-shaped loop. Two or three plications usually occupy the sinus. Dorsal valve with well developed fold toward the front usually bearing two plications; fold scarcely elevated above the adjacent parts of the shell. The plications of the fold are sometimes depressed below the general surface in the posterior portion of the shell, giving the appearance of a sinus. Surface of the shell marked by 15 to 20 strong, rounded plications, which increase by bifurcation and interstitial addition. No other surface markings visible.

This species is placed by Schuchert as a synonym of *A. rugosa* (Hall), but the specimens though showing the finer growth lines afford no trace of the strong, elevated lamellæ characterizing that species.

This is one of the most abundant and generally distributed species in the Niagara of Northern Indiana, occurring at Georgetown, Delphi, Logansport, Pendleton, and other localities.

Atrypa reticularis Linnæus.

Pl. VIII, figs. 16-18.

Shell subcircular in outline. Valves moderately convex to gibbous; usually the two valves are about equally convex, but the brachial valve is sometimes much more convex than the pedicel valve. Pedicel valve frequently with a faintly defined sinus at the front; brachial valve sloping regularly to the front and sides. Surface marked with thirty-five to fifty fine, radiating plications which bifurcate freely in the posterior half of the shell. The largest specimen seen measures in length 20 mm., in width 19 mm. An average specimen has a length of 16 mm., width, 16 mm., and thickness, 11 mm. The most striking difference between the Niagara phase of this species and the form occurring in the Devonian limestones of Indiana is in the size, the latter being three or four times the size of the former; in the Devonian form, also, the brachial valve is usually much the more convex in contrast with the nearly equal convexity of the valves in the forms here described. The species is common at some localities. It occurs at Wabash (4A), and at Little Deer Creek, Carroll County.

Spirifer foggi Nettleroth.

Pl. VIII, figs. 24, 25.

Outline of the shell as shown in the figure; ventral valve more convex than the pedicel; umbonal region gibbous, beak incurved. Fold and sinus prominent, with four to six, low, rounded plications on each side; entire surface covered with fine, thread-like striæ which dichotomize toward the front.

The largest specimen in the collection has the following dimensions: Width, 19 mm; length, 20mm; thickness, 13½ mm.

This species as suggested by Nettleroth is very closely allied to *Spirifer radiatus,* and it is doubtful whether it should be regarded as anything more than a variety of that species approaching the *Sp. niagarensis* type.

Known only from Georgetown, where four specimens were secured.

Spirifer nobilis Barrande.

Pl. IX, figs. 1-5.

Shell transversely elliptical, valves moderately convex, cardinal extremities rounded; prominent fold and sinus, the former broad and simple, the latter without plications in the material examined. There are from four to eight strong, dichotomizing plications on each side of the fold and sinus. Entire surface covered by distinct, fine, radiating striæ.

The bifurcating and much stronger plications distinguish this form from *Sp. niagarensis*.

This is not a common species; from one to three specimens represent it in the collection from each of the following localities. Pendleton, Connor's Mill (Hamilton County), and Georgetown.

Spirifer radiatus Sowerby.

Pl. VIII, figs. 19–23.

Shell rather large, rotund or robust; cardinal extremities rounded. Beak of the ventral valve incurved over the area, sinus broad and shallow; surface of the shell everywhere covered by fine, radiating striæ.

Two specimens of this shell from Georgetown show no trace of radiating plications, agreeing in this respect with the species as it occurs in the Waldron shale; all of the other specimens are marked by very low, rounded, radiating folds, of which there are four or five on each side of the fold and sinus. The latter type in some individuals approaches *Sp. niagarensis* closely in appearance.

The species is rather rare, occurring at Georgetown, Wabash, Connor's Mill (Hamilton County), and at Pendleton.

Spirifer (Reticularia) crispus var. simplex Hall.

Pl. VIII, figs. 26, 27, 28.

Shell small, gibbous; ventral valve much more convex than the dorsal. There are two or three rounded plications on each side of the fold and sinus, the outer ones not reaching to the beaks; plications are crossed by fine lamellose, concentric striæ which have, fringing their margins, numerous very fine setæ; the latter characters are very well preserved in the natural moulds. Specimens from Waldron show them well developed. Ventral valve with thin, low, median septum extending about one-third the distance to the front. A thin dental plate, half the length of the septum lies on each side of it.

Comparatively rare, occurring at Georgetown, Pendleton, Little Deer Creek (Carroll County), and at Connor's Mill (Hamilton County).

Reticularia proxima n. sp.

Pl. IX, figs, 6–8.

Shell transversely subovate; area short and low, partly concealed by the closely approximate beaks. Pedicel valve more convex than the brachial, marked by a distinct subangular sinus extending from beak to front. Brachial valve moderately convex in the posterior half. Slope very gentle to the front, but more abrupt to the hinge line. A mesial fold limited by a narrow but distinct depression extends from the umbone to the front; the fold is not elevated above the adjacent portion of the shell. Entire surface of shell marked by strong concentric lamellæ.

This species may be distinguished from *R. bicostata petilla* (Hall) by the lower area, and the absence of lateral plications or folds.

Rare. Represented by one specimen from Fishersburg, Hamilton County.

Reticularia sp.

Pl. IX, fig, 9.

Two imperfect pedicel valves from Pendleton show the following characters: Strongly convex, sloping regularly to the front and sides; a very shallow sinus extends from the beak to the front; and a low, median septum extends about one third that distance; shorter dental plates on either side of the septum. Surface marked by fimbriate, concentric striæ; no plications or folds. The surface markings resemble those of *Spirifer crispus* as figured by Clarke and Ruedeman, Pl. IV, Memoir V, N. Y. State Mus.

Pendleton.

Cyrtia myrtia Billings.

Pl. IX, figs. 10–12.

Shell pyramidal from front view; brachial valve semi-elliptical in outline. Pedicel valve with greatly elevated, slightly concave, triangular area, the beak inclined slightly backward over it. Surface sloping at an acute angle from the beak to the margin of the shell. A prominent rounded sinus extends from the beak to the front of the valve. Brachial valve gently and regularly convex. A low, rounded, indistinct fold extends across the middle of the valve. Surface of both valves covered with fine radiating striæ, of which there are eight or ten in the space of 1 mm.

Rare. Only two specimens seen, Georgetown and Delphi.

Whitfieldella nitida Hall.

Pl. IX, figs. 13, 14.

Shell small; valves strongly and nearly equally convex; beak of pedicel valve acute and incurved. Surface smooth except for lines of growth. Front straight, slightly emarginate or rounded; faint sinus is present in emarginate specimens at the front of both valves.

Rare. Represented by five specimens from Georgetown and from Helm's Mill, Hamilton County.

Nucleospira pisiformis Hall.

Pl. VIII, fig. 29.

The species is represented by poorly preserved casts showing the shallow sinus in each valve and the impressions of the low median septum of the pedicel valve extending nearly the entire length of the valve. Hall's description of the species as it occurs at Waldron is as follows:

"Shell lenticular, globose; valves nearly equal, each valve with a depression down the center. Ventral valve somewhat more convex, with the beak more elevated than in the dorsal valve. Area narrow, small, scarcely extending beyond the width of the beaks at their base. Surface marked by fine concentric striæ usually obscured by the covering of minute hair-like spines, which, when removed, leave a punctate surface."

Rare. Pendleton, and at Connor's Mill, Hamilton County.

Anoplotheca congregata n. sp.

Pl. IX, figs. 18-20.

Shell small, subcircular and plano-convex. Pedicel valve very convex, beak incurved and extending slightly beyond the brachial valve. Two strong plications with a third intermediate somewhat weaker one form a prominent median fold, extending from beak to front. Three or four plications appear on each side of the fold. Interior of pedicel valve with transverse tooth on each side anterior to the area. A strong median septum extends one half to three quarters the distance to the front. Sides of brachial valve

From one to three indistinct plications occupy the sinus; surface on either side marked by three or four plications.

This species is abundant at one point in Logansport. The only species observed associated with it is a *Chonetes*. The species apparently does not belong to the Niagara fauna and is probobly a representative of the "Waterlime" fauna.

Meristina maria Hall.

Pl. IX, figs. 29-32.

Shell large, outline as shown in figure. Valves about equally convex. Pedicel valve with incurved beak, gibbous in the umbonal region, becoming deeply sinuate toward the front and deflected upward in a linuiform extension. Interior of the valve with a deep, triangular-shaped muscular impression. Brachial valve convex in the umbonal region, sloping abruptly to the cardinal and lateral margins of the shell. A subangular or rounded ridge extends from the umbo to the front. Interior with a low septum extending one-third the distance from the beak to the front. Surface apparently smooth.

Common, occurring at Fishersburg, Georgetown, Pendleton and Connor's Mill, Hamilton County.

Meristina rectirostris Hall.

Pl. IX, figs. 21-24.

Shell broadly ovate, margin nearly straight from the beaks one-third the distance to the front; thence regularly rounded to the front. Valves about equally convex. Pedicel valve sloping regularly to the sides from a median line of maximum elevation. Beak acute, nearly straight, and projecting beyond the opposite valve; area triangular. Brachial valve regularly convex; beak small and closely incurved. No surface markings preserved.

Rare. Known only from Little Deer Creek, Carroll County.

Maristina cf. princeps Hall.

Pl. IX, fig. 25.

A single brachial valve has been seen which probably belongs to this species. It differs from *M. maria* in having the surface marked with distinct radiating striæ toward the front and lateral

PELECYPODA.*

Tellinomya cf. nasuta Hall.

Pl. X, fig. 1.

A single specimen found east of Kentland has the following characters:

Shell transverse, length twice the height. Beak a little anterior to the center. Upper margin extending forward in a direction parallel to the transverse axis, thence continuing in a broad curve extending downward to a point in front of the middle of the ventral margin; thence deflecting upward in a broad, shallow, undefined sinus. Posterior end half the height of the anterior end, sharply rounded, nasute; superior margin straight or barely arcuate to the umbo, deflected a little upward. The beaks are broadly obtuse, incurved, slightly directed forward, and extending very little beyond the hinge. The most convex portion of the shell is just back of the anterior muscular scar. In front of the posterior scar is a somewhat flattened shelf or platform. The pallial line is fimbriate, entire, and does not partake of even the very shallow sinus of the ventral margin. The muscular scars are large, deeply impressed in the shell, with a distinctly elevated rim except at the distal ends, and with their major axes in the respective lines running from the middle of the beak to the center of the anterior margin, and from the beak to the posterior margin. The anterior muscular scar is seven-eighths as high as long, close to the superior margin, and two-fifths in length the distance from the beak to the middle of the anterior margin. Posterior scar in similar relative position, but narrower, with the length more than twice the height and equal to two-fifths the distance from the beak to the middle of the posterior margin. The anterior and posterior limits of the muscular scars undefined. Each of the scars is a little nearer the anterior or posterior margin respectively than to the beak. There are no umbonal scars, nor accessory retractile scars, nor can the dentition be seen. This shell evidently belongs to the typical group of *Tellinomya* as represented by the *T. nasuta* from the Trenton limestone. A shell very similar in outline, the *Nucula hanoverensis* of Kindle is found in the Devonian lime-

*For references to the original descriptions of the species of this and succeeding groups stones, but the latter represents a species which generically is very distinct. About the only difference which can be detected between our species and *T. nasuta* as found in the Trenton of Wisconsin is that in the former the posterior end is just perceptibly narrower than in the Wisconsin forms.

The single specimen described above is a left valve and its cast from Kentland (1C1). The inside surface of the shell is smooth as is also the cast. The height of the shell at the posterior end of the anterior scar is 23 mm. The transverse axis passing just below the scars is 49 mm., and the valve is about 4 mm. thick.

Whitella (?) siluriana n. sp.

Pl. X, fig. 15.

Shell small, quadrate, rhomboid, length and height about equal. Hinge line straight, three-fourths the length of the shell, and forming at an angle of about 130 degrees with the upper part of the posterior margin. The last named is arcuate to the gonial angle which is broadly rounded. Basal margin straight or nearly so; abruptly curved at a right angle into the short vertical anterior margin. Beaks consisting only of the upper end of the gonial ridge, incurved, protruding, depressed to the plane of the margin. Gonial ridge very prominent, hardly arcuate, becoming less well defined posteriorly. Point of greatest convexity of the shell on the ridge, just above the middle. Cast smooth.

Only a single right valve which is the type of the species is known. Length, 6½ mm., height, 5½ mm., thickness, 2½ mm. It is referred to *Whitella* with some hesitancy. There is a striated external ligament, and a very pronounced linear posterior elevation which seems to be a well developed tooth rather than the platform of an internal ligament as Ulrich considers a somewhat similar feature in Ordovician typical forms of the genus. The form is somewhat like Hall's *Cypricardites (?) quadrilatera,* but our species is higher, with the superior and ventral sides parallel, and has a rather different hinge structure. There is some resemblance to *W truncata* (Ulrich) but that is a much more gibbous shell.

Cypricardinia sp.

Pl. X, fig. 14.

A single external mould of a left valve from Pendleton has the following characters:

Shell small, rhomboidal; anterior end small, ventral margin formed by two subequal, slightly arcuate lines extending from the antero-ventral and postero-ventral margins and meeting in a broad angle; posterior margin, abruptly truncated, forming an angle of 135 degrees with the hinge. There is a slight retral curve to the posterior margin which produces an alation and gives the shell an aviculoid appearance. Hinge line unknown but apparently straight. The markings consist of concentric folds which have a slight but very distinct sinus at the anterior fifth and another sinus corresponding to the alation of the posterior margiu. The folds are small and at the anterior portion of the shell are close together; but from just back of the sinus to the gonial ridge these folds are very strong, becoming obsolescent on the posterior slope. There are faint traces of fine concentric striæ.

This shell has the outline of the *Clidophorus* (?) *mc. chesneyanus* of Winchell and Marcy, which is now considered a *Colpomya* but which Miller believed to have been identical with the *Modiolopsis rectus* of Hall. The first named species differs from that described above in the absence of the strong folds and also of the posterior alation.

Our specimen from Pendleton has a length of 15 mm., and height of 8 mm.

Pterinea sp. undet.

Pl. X, fig. 8.

In the subcentral position of the beaks there is a resemblance to the *Pterinea curiosa* of Billings. The beak of the left valve of the Indiana species is not protruded beyond the hinge line, nor is it elevated. The casts are smooth with no markings whatever.

Of the two specimens found, the larger which is figured is from

Amphicoelia neglectu McChesney.

Pl. X, fig. 10.

A large left valve belonging to this species shows the following characters:

Shell large, gibbous; approximate length, 72 mm., height 56 mm., thickness 18 mm. Beaks anterior, ventricose, incurved, pointed forward. Most convex point on the shell at upper and anterior third. Cast marked by fine striæ, of which there are twenty in 16 mm., at a distance of 50 mm. below the beak. These striæ are very low on the cast, though distinctly visible; more prominent in front. Towards the umbones and posteriorly, they become obsolescent, while below the hinge the cast is smooth. The hinge line is nearly equal to the length of the shell.

One specimen, Wabash.

Paleopinna sp. undet.

Pl. X, fig. 13.

A fragment from Wabash (4/A2), is figured on Pl. X, Fig. 13. The hinge line is long and straight. The beak is anterior. The umbonal region is gibbous with an undefined post cardinal cincture or sinus. Shell thin, covered with radiate striæ and concentric growth lines. The latter are sharply elevated and are stronger than the radial striæ, which increase by implantation.

Conocardium multistriatum n. sp

Pl. X, fig. 4.

Shell smaller than *C. oweni,* the only specimen found having an approximate height of 8 mm., length 9 mm. and thickness 6 mm. The anterior truncation is obsolescent, being represented merely by a slight deflection of the surface and the cessation of the surface markings. The latter consist of about twenty-seven fine striæ which are flat-topped in the casts but angular on the surface. The interspaces in the casts are fine impressed lines. The posterior striation is greatly enlarged and serves to demarcate the posterior portion of the shell which forms an angle of about 50 degrees. This posterior portion is covered by about eleven striæ or plications, which are very faint near the strong rib, but increase quite rapidly in size and strength as the posterior tube is approached.

The concentric markings consist of very fine, close-set rugose striæ, which are most prominent on the umbones and on the posterior portion of the shell. There are also two or three secular growth lines.

This species may be recognized by the fine surface markings.

The single specimen described above was found at Georgetown.

Conocardium oweni n. sp.

Pl. X, figs. 2, 3.

Shell small, gibbous, the type specimen being 11 mm. long, 8 mm. high, and 6½ mm. thick. Anterior end abruptly truncated. Anterior margin beginning a little below the front end of the hinge line, and at an angle of about 100 degrees thereto, extending in a very slightly concave line to the base of the truncation which is the most anterior point in the shell. From this point, the ventral margin rounds strongly to near the middle, where it is gradually deflected in a broad curve up to the posterior opening. Hinge line straight. Beaks prominent, extending little beyond the hinge, and directed slightly backward. Greatest convexity of the shell one-third the distance from the beak to the base, and just behind the truncation. The front of the shell down to the top of the anterior edge is drawn out into an apparently broad but very short tube or opening.

The surface is marked by radiating, narrow plications crossed by lines of growth which become lamellose on the post-cardinal slope. There are two or three rounded plications on the truncate end near the upper edge, but these become obsolescent toward the umbones and toward the front, so that the base of the foward one is at the middle of the anterior edge. The interspaces are indistinct and are crossed by very faint lines of growth which become stronger near the anterior tube. From the edge of the truncation to the posterior tube, the surface is covered by about 18 low, rounded plications. These are most sharply defined on the more convex portions of the shell, where they are nearly flat-topped and with smooth interspaces about equal in width to, or perhaps a trifle wider than, the plications. Posteriorly the plications are a little sharper, but the interspaces and the plications too, are rather less developed than in front. Simultaneously with the obsolescence of the interspaces, the growth lines begin to develop quite strongly. These are hardly perceptible on the convex portion of the shell, but beginning at the post-cardinal slope they become lamellose so that at the base of the posterior tube, they are nearly as strong as the radiate markings. These lamellæ when well preserved cross the ridges of the plications and produce a minutely crenulated effect, but usually they are preserved only in the interspaces, where they show a rather cancellate structure. The surface of the posterior tube is smooth except for faint growth lines. No secular growth lines have been observed.

This species is very closely allied to and perhaps identical with the *Pleurorhynchus antiqua* of D. D. Owen (Rep. Geol. Reconnaissance of Wis., Minnesota and Iowa, 1852, Pl. 2B, Fig. 19). Owen's species is very poorly figured, not at all described, and even the locality at which it was found is omitted. Poor as his figure is, there is, however, a rather close resemblance to our species. There is also a close resemblance to *C. niagarense* of Winchell and Marcy; but the lamellose lines of growth characterizing our species are not recognized in *C. niagarensis,* nor does the figure of the Chicago species (nor the description) show the anterior end partially plicate as is the case in our species.

The type specimen and another fragment were found at Little Deer Creek, while a third fragment of a specimen similar to the above was observed from Connor's Mill, Hamilton County. The last named must have been at least 15 mm. long when entire.

Plethomytilus cuneatus n. sp.

Pl. X, fig. 9.

Shell mytiloid, height about one and a half times the width. Greatest width two-fifths the distance from the base up. Anterior margin approximately straight, rounding off basally and posteriorly. Beaks gibbous, acuminate, protruding beyond the hinge, not twisted nor laterally bent. The point of greatest convexity is in the anterior portion and one-third the height from the umbones. Anterior slope perpendicular to the plane of the margin. Posterior slope very steep at the umbones, but becoming less so at the base. Muscular scar (?) ventro-posterior. Ligamental area with one or two striations posteriorly.

This species is much wider than *Mytilarca acutirostra* Hall's sp. The beak is more acuminate than in his *Ambonychia aphea,* and is not twisted as it is in that species. From the *Mytilarca sigilla* (which is probably an Ambonychia) our species differs in the absence of the posterior alation.

A single left valve was found at Georgetown (3/A1). It has the following dimensions: Height, 32 mm.; width, 22 mm.; thickness, 8 mm.

Streptomytilus n. g.

Shells mytiloid, erect, beaks twisted toward the front, acuminate, protruding beyond the hinge line. Surface markings concentric growth lines. Hinge furnished with a posterior ligamental groove. There is an internal linear platform or septum as in *Mytilus edulis* to which the ligament is attached. This platform is present as a groove in the cast. There are no teeth nor are there any ligamental striations. Type, *S. wabashensis n. sp.*

Ambonychia aphea (Hall) and the *Mytilarca eduliformis* (Conrad) and of Clarke and Ruedeman should also be included in this genus.

Streptomytilus wabashensis n. sp.

Pl. X, figs. 11, 12.

Shell small mytiliform, erect, height less than one and a half times the width. Anterior margin straight from the hinge half way to the base, thence curving in an arc of 240 degrees to half way up the posterior side, and continuing in an arcuate line to the umbonal hinge, which is rather obtusely rounded. Beaks terminal, gibbous, twisted to the front, protruding beyond the hinge lines, and depressed to its plane. Greatest convexity of the shell one-third the distance from tip of beak to the base. Anterior and posterior slopes about equal. Shell thin. Surface markings faint, concentric growth lines.

Only a left valve of this species is known. It was found at Wabash, and has a height of 13 mm., width 9½ mm., thickness 3 mm. It is, however, so distinct as to fully warrant its generic separation from the known forms of lamellibranchs. It differs from *Plethomytilus,* its nearest Paleozoic ally in the absence of a straight hinge line, of lateral teeth, and of the striations on the ligamental groove. From the recent forms of Mytilus, it may be distinguished by its more protruding and twisted umbones.

Anodontopsis wabashensis n. sp.

Pl. X, figs. 5–7.

Shell small to medium sized, rhomboidal to trapezoidal in outline; length twice the thickness and one-fourth greater than the height. Margin rapidly rounded in front, broadly rounded ventrally to the posterior two-thirds; thence curving upward to the postero-ventral angle, where there is a more or less abrupt and oblique truncation at an angle of about 120 degrees to the hinge. The last named is straight and half the length of the shell. Beaks in the anterior sixth, quite prominent, pointed forward, and extending very little beyond the hinge line. Point of greatest convexity posterior and superior to the center. Post cardinal slope steep and slightly concave. Surface markings faint concentric growth lines. The hinge characters are preserved in only one large specimen which shows fairly long, linear tooth. Anterior portion of the hinge unknown.

The type specimen is 20 mm. long, 16 mm. high, and has a thickness of 5 mm. (one valve).

The species may be recognized by the short hinge line and character of the surface markings.

Six valves of this species all of nearly the same size were found at Wabash (4/A2 and 4/A4) in a few hours' collecting.

GASTEROPODA.

Platyceras (Diaphorostoma) cornutum Hisinger.

Pl. XIII, figs. 9–16.

In the dolomitic limestones of northern Indiana several localities have shown the presence of this species. The specimens from Little Deer Creek, Pendleton, Georgetown, and Wabash bear but little resemblance to the spire-bearing forms from Waldron, but show a great affinity to Roemer's Tennessee specimens, and especially to that phase of the species described from Chicago by Winchell and Marcy as *Platyceras campanulatum*.

The spire is depressed, with the apex more or less below the volutions are minute, but there is a sudden expansion and increase in the size of the body whorl. The body whorl is partially free. The aperture, where preserved, is flaring and the peristome is reflexed like the end of a trumpet. The surface markings are usually almost imperceptible lines of growth. A large Georgetown specimen shows about fifteen fine, revolving lines on the volution next to the body whorl, while the latter exhibits only very lamellose ridges of growth increasing in number as the peristome is approached.

At Connor's Mill, Hamilton County, from the dolomitic limestones of which place more specimens of the species have been obtained than from anywhere else in northern Indiana, there is in the general aspect great difference from the forms described above. All the seven specimens obtained from here show a remarkable uniformity of characteristics. The spire is elevated, consisting of three regularly-rounded and contiguous whorls, increasing gradually in size from the apex to the mouth. The length of the spire is two-thirds the greatest width of the body whorl. The surface is marked by nine or ten low, rounded, revolving bands which disappear on the upper side near the suture and are crossed by almost imperceptible lines of growth. The apertural characters are unknown, but the peristome was evidently not reflexed. It is possible that the remarkable uniformity of the Connor's Mill material, and its persistent differences from the forms of *Platyceras cornutum* occurring in the surrounding portions of northern Indiana, may be sufficient cause for the separation of the former specimens from that species.

The forms referred to this species have a world-wide distribution, occurring in Bohemia, the Hartz, France, England, Wales, Scotland, Ireland, Canada, and the United States. In England the species has also a great vertical distribution; but on this continent, where it has been recorded from New York, Canada West, Michigan, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, Kentucky, and Tennessee, it is confined to the beds of the Niagara Group (including the Guelph dolomites). The species occurs in great abundance in the Rochester shale of New York, and at Waldron, Indiana.

Known from Carroll County, Pendleton, Connor's Mill, and

Bucania sp. undet.

Pl. XI, fig. 3.

A fragment of a Buchania similar to those figured in Vol. II, Pal. N. Y., Pl. 76, Figs. 5, 6, was found at Georgetown.

Pleurotomaria (?) *idia* Hall.

Pl. XII, fig. 6.

Spire depressed convex. Width of the shell two or more times the greatest height. Volutions three or four, very gradually increasing in size; not marked in the casts by any peripheral band or keels. Umbilicus broad and open.

A large cast referred to this species has a height of 45 mm., and width of 21 mm., and there are apparently only three or three and a half whorls. In all other respects it is like the typical forms described from Racine, Wisconsin.

Rare. Huntington.

Pleurotomaria laphami Whitfield.

Pl. XI, fig. 4.

Spire conical, moderately elevated, apical angle about ninety degrees or less. Volutions three to three and one-half, subtriangular, flattened exteriorly in the direction of the apical angle, subangular in the periphery and rounded below; suture distinct in cast, indistinct on surface of shell; umbilicus large. Surface of shell smooth or marked only by striæ of growth.

The above description is drawn mainly from Whitfield. The species is occasionally seen in the form of casts at Delphi.

Pleurotomaria hoyi Hall.

20th Rep. N. Y. State Cab. Nat. Hist., 1867, p. 364, pl. 15, fig. 10.

"Shell broadly depressed—conical. The spire moderately elevated, consisting of about four volutions, which are gradually enlarged from the apex, the last one being slightly ventricose toward the aperture. Volutions flattened on the upper side, and the entire height of each one showing above the other; periphery somewhat flattened, with a depressed band truncating the upper angle. Lower side of volutions flattened, except the outer half of the last one, which is rounded toward the aperture and abruptly descend-

"Surface finely striated on the lower side of the volution, with a deep retral curve on the band, where the striæ are somewhat fasciculate. The periphery of the cast is sometimes marked by three or four strong, but obscure striæ below and parallel to the revolving band."

The above description by Hall is based upon much better material than the collection at hand affords.

This species is represented by casts from Delphi.

Pleurotomaria pauper Hall.

Pl. XII, figs. 5, 6.

"Shell small, depressed conical, the apical angle being about seventy or seventy-five degrees; volutions three or four rounded and somewhat rapidly increasing in size from the apex; the aperture has been a little longer than wide. The specimens occur in the condition of casts, which preserve the evidence of a spiral band a little above the middle of the volution, and between this and the suture line there is a slightly elevated line or carina.

"The surface of shell is unknown."

The above is the original description of the species (20th Rep. N. Y. State Mus., p. 343).

Casts and moulds of this species occur in the quarries at Huntington.

Pleurotomaria sp. undet.

A single quite remarkable fragment belonging to a probably undescribed group of the *Pleurotomarias* has the following characters (only the body whorl is preserved):

Width of body 35 mm., height 18 mm. Whorls subcircular in section, columella solid, narrow; umbilicus quite wide but shallow. Slit-band prominent, vertical, elevated at the periphery, slightly concave. About midway between the band and the suture there is a strong raised line, which is one-third as wide as the slit-band. Between this line and the suture the surface is marked by strong, rounded, transverse undulations. From the line to the slit-band, the surface is smooth except for faint traces near the line of the undulations. The surface markings are faint lines of growth which follow the undulations. Above the slit-band, where the unand sixty degrees. There are apparently no other revolving markings. In the markings above the slit-band, this species is remarkably similar to the *Pleur. dolium* of Lindstrom, but is decidedly distinct in all other respects. There is also a resemblance in the presence of a sort of revolving line between the band and the suture to some of the forms referred by Clarke and Ruedeman to *Lophospira*.

One specimen. Old Deer Creek channel (2A3), Delphi.

Pleurotomaria (?) axion Hall.

Pl. XII, fig. 4.

Shell subconical, volutions about four, contiguous, the upper ones increasing gradually in size; the body whorl is greatly enlarged. Suture nearly transverse, deeply impressed with more than half the preceding volution* exposed above it. Whorls rounded to ventricose, nowhere flattened nor sharply angular.

Mouth very large, about half the length of the shell. Inner lip long, directly anteriorly, slightly recurved. Slit-band at the middle of the body whorl, but in the upper whorls a little more than its width above the suture. In the Bridgeport, Ill., specimens, there are, according to Hall, "strong revolving striæ which are crossed by concentric striæ of less strength giving a cancellated structure." The aperture is not preserved in the Illinois specimens so that its description is drawn from the Huntington specimen. This is an external mould which, with the exception of the faintly-preserved carina, shows no surface markings. Its height is 48 mm., width, 28 mm.

There is a rather close resemblance to the variable European *Pl. lloydii*, but the inner lip of the American species is much longer and recurved.** In our form also, it cannot be determined whether this recurved cylindrical lip is hollow (a canal), or solid.

Rare. Huntington.

Pleurotomaria eloroidea n. sp.

Pl. XIII, figs. 1, 2.

Shell subconical, medium sized. Whorls contiguous, about four in number. Sutures not deeply impressed, and nearly

*Exclusive of the prolongation of the inner lip.

**The direction of this "recurvature" is the opposite to that ordinarily met with; that transverse. Whorls depressed above, broadly rounding off down to the peripheral band; outline slightly concave just above the concave (?) slit-band. The lower border of the slit-band is developed into a rim or flange, the inner edge of which forms the suture. Surface or character of the volution below the slit-band unknown. The markings consist of strong lines of growth and revolving lines. The former begin quite transversely from the suture, but after extending in this direction two-fifths the distance to the keel, they swing back in a broad curve, become almost parallel to the slit-band for a short distance and just above it, and then develop slight lunulæ on the band. By the unequal crowding of these lines of growth, the surface is thrown into very low, indistinct folds. The revolving lines are very fine, and nearly a millimeter apart.

Known from a single specimen which has a width of 50 mm., height from apex to flange, 18 mm., half of this partial height being in the body whorl.

There is a very close resemblance in the outline and rim of this species and that present in the genus *Euomphalopterus,* but an examination of the characters described above will reveal the fact that not even a generic identity can exist between the two. The broad backward swing of the striæ above the slit-band and their direction parallel to the latter just above the band, show the presence of a very deep notch and of a slit (?) not found in *Euomphalopterus.* The flange also is a free extension of each border of the slit-band (see Pl. XIV sp. *cf. eloroidea*) so that the similarity between *Pleurotomaria eloidea* and *Euomphalopterus* is wholly superficial. There is no sigmoid curve to the striæ and the flange does not rest on the lower whorls as it does in *Euomphalopterus,* but these are minor characters.

A generic comparison may perhaps be made with *Mourlonia,* but the extension of the flange along the suture in our species at once distinguishes it from that genus in which the flange is exposed near the middle of all the whorls.

There is some resemblance in outline between our species and the *Pleurotomaria elora* of Billings.

Rare. Delphi.

Pleurotomaria cf. eloroidea.

Pl. XIV, fig. 3.

Shell very large, resembling the preceding in outline and in surface markings.

The slit-band in the form now described is very plainly convex. It is bordered on both sides by diverging curved flanges. The lunulæ are shallow and evenly convex. The striæ of growth in the upper portion of the whorl swing back, and this backward swing is continued across the slit-band and lunulæ.

The characters described show a close similarity to *Mourlonia,* from which our shell differs in having plain crescents, and the flanges disposed along the suture. It occupies an extremely important position which can not be overlooked between *Euomphalopeterus* and *Mourlonia,* and forming a phylogenetic series with those two in the order named. A recurving of the upper face of the flange would be almost all that would be required to develop from *Euomphalopterus* the form represented by our species. The development of the whorls so that the flanges would be on the periphery instead of on the suture would generate a form which would very easily pass off into the *Mourlonia limata* type by the chronogenetic addition of the lobe to the crescent.

Rare. Huntington.

Euomphalopterus alatus var. americanus n. var.

Pl. XIII, fig. 6.

Shells small depressed conical, consisting of three to four very gradually increasing and contiguous whorls. The volutions are subcircular in cross-section; horizontally flattened or depressed convex near the suture, sharply rounded at the sides, and rounding off into the umbilicus. The latter is very wide and included in a broad columella which is as wide at the base as the cross-section of the body whorl. At the middle of the periphery is a very sharp and projecting carina or rim, somewhat similar in character to that in the *Murchisonia worthenana* of Miller, and especially to the forms of *Pleur. alata* from Gotland. The surface is covered with close-set, transverse lines which arch very strongly forward over the rim or flange. Some of the striæ dichotomize on both faces of this flange. There is an obscure line or ridge concentric with, and near to, the inner edge of the flange.

The suture between the whorls is along the bottom face of the rim, which, when flattened over the upper portions of the younger whorls, presents a false appearance of a shoulder. Apertural characters unknown. The rim extends all along the suture, and may be traced almost to the initial whorls. The striæ as exposed on the upper face of the rim along the sutures, are straight and pointed forward.

Two specimens have respectively the following dimensions: Width, 10 mm. and 6 mm.; height (approximate), 5 mm. and 3 mm.

This shell belongs to the group of the *Pleurotomarias* designated by Roemer in 1876, *Euomphalopterus,* with *E.* (*Pleur.*) *alatus* as the type. It includes *Pleurotomaria alata, pretexta, togata, frenata, undulans, marklini,* and among American forms the *E. alatus* of Ulrich, which was recently (1897) described by that author as coming from near Waldron, Ind. The group is characterized by the expansion of the "slit-band" into a rim or flange which extends along the suture line. There is no slit, and in most of the typical forms the striæ are directed forward to the rim. There are no revolving bands and only rarely faint revolving markings. This is perhaps the most strongly marked and easily separated group of the *Pleurotomarias.*

The variety described above is very close to Lindström's variety *opposita,* but the American form is a much smaller shell with lower spire and fewer whorls, and with the striæ when dividing, bifurcating instead of being divided into a brush as in the Gotland variety. From Ulrich's variety and also from true forms of *Euomphalopterus,* the variety described above differs in having the band situated at the middle of the periphery and having the whorls regularly rounded.

Though apparently widespread and abundant in Europe, *Euomphalopterus* is quite rare on this continent, where Ulrich's variety has been the only representative known up to date. A closely allied form is the *Murchisonia worthenana* of Miller, which is probably equivalent to *Pleurotomaria* (*Mourlonia*) *limata* of Lindström, though Miller's name has priority. In *Mourlonia* the striæ always curve backward to the band, there is a true slit-band, while the rim, instead of extending along the suture as in *Euomphalopterus,* is exposed some distance above the suture near the periphery of the upper whorls. There are also some minor differences which will be noticed later.

Rare. Little Deer Creek, Carroll County.

Euomphalopterus alatus var.

A single specimen of a third variety of this species resembles a large form of the variety *americanus;* but is discoidal, almost plane-coiled. The flange along the suture is the only important character observed. It has not the smaller line or ridge near the inner edge possessed by the variety *americanus,* and the striæ on the flange are almost straight, pointed forward, and crenulated by very fine, faint, revolving lines, which are barely visible under a strong magnifying glass.

Rare. Georgetown.

Euomphalopterus alatus var. limatoidea n. var.

Pl. XIV, fig. 4.

Shell very large, depressed turbinate. Whorls four or five or more, contiguous, flattened above by the sutural band, turned in a broad curve downward, slightly concave just above the flange, and continuing below the latter in a nearly horizontal plane, curving upward toward the middle. The flange is therefore on the lower margin of the periphery, and may almost be said to bound the umbilicus. The umbilicus is very broad. The surface is marked by striæ arching forward to the flange, and also by revolving lines.

A single, large specimen, belonging to the Indiana State Museum, has an approximate height of 36 mm., and a width of 70 mm. The body whorl is 23 mm. high.

This form, as the name is intended to signify, is intermediate between *E. alatus* and *Pleur.* (*Mourlonia*) *limata.* It is larger than either, and has a greater umbilicus and lower spire. Its markings are very distinctive. It should more probably be made a separate species.

Rare. Delphi.

Murchisonia (*Turritoma*) *laphami* Hall

Pl. XIII, fig. 7.

Shell rather large, turreted, height several times the width. Volutions contiguous, seven or eight in number, and increasing gradually in size. Sutures close and oblique. Sides straight or flat, sloping from the suture to the slitband, which is concave, but becomes almost flat on the body whorl, where its height is one-sixth the height of the whorl. The lower portion of the volution is ventricose. The band is in the center of the body whorl, but in the upper whorls it is half its height above the suture.

Owing to the unnatural and improper divisions which have been formed from Murchisonia, it is preferred in this paper to regard all the species thereof as species of the original genus.

Several casts and moulds of this species have been obtained at Huntington. One mould of the three lower whorls showed a height of 44 mm., width 23 mm., height of body whorl 22 mm. The outline, etc., seem to be the same as in typical forms of M. laphami, but the slit-band of the Huntington specimens is rather wider than that of the Wisconsin material.

Murchisonia (Coelacaulis) bivittata Hall.

Pl. XIII, fig. 4.

Shell very elongated, consisting of about twelve rounded volutions without trace of carina, but with a strong biplicate columella.

The plicate columella and the absence of the dorsal band are characters which should remove this species from the *Murchisonia* group.

A large internal cast referred to this species was found at Huntington by Mr. Gilbert. There are six of the lower plications exposed, showing a height of 50 mm., a width at the base of 29 mm., and at the summit of 14 mm. There are obscure traces of revolving lines on the surface and of a plicate columella in the highest whorl.

Rare. Huntington.

Murchisonia sp. undet.

Fragments of a very large species of Murchisonia are quite common at Huntington. The specimens are larger and differ from any of the species of that genus hitherto described from the Silurian. An idea of the size may be obtained when it is stated that a cast of the body whorl and one upper whorl has a height of at least 54 mm. The whorl above the body whorl has an exposed height of 18 mm. There are several specimens quite as large as the one mentioned. The uppermost portion from the suture down to the shoulder, is flat, or perhaps a trifle concave. From the shoulder the sides extend straight downward, making with the upper, flattish portion an angle (in profile) of about 135 degrees. The base of the whorl is broadly rounded. A section of the body whorl is subhexagonal, higher than wide, with the suture at the upper angle. In the upper whorls only the flat, sloping portion from the suture to the shoulder and the vertical sides are exposed. There is a general resemblance in the contour of the whorls to those of *Trochonema fatuum* Hall, but our form is evidently a turreted Murchisonia, much larger in size, and the vertical sides in Hall's species are smaller than in ours.

Two or three other species of large *Murchisonias* occur at Huntington, but they are unidentifiable. It is an interesting fact that no species of this genus have hitherto been recorded from the Silurian of Indiana.

Common. Huntington.

Oriostoma huntingtonensis n. sp.

Pl. XIV, figs. 14, 15.

Shell turbinate, fairly large, consisting of three or more rounded volutions which are circular in cross-section and increase gradually in size. The whorls are contiguous, and each shows almost its entirety above the others. Shell substance thick and composed of at least three layers. The outer one is marked by strong revolving ribs with the interspaces concave and about equal to the ribs in width. The umbilicus is large and open, and is bounded by a very strong keel, which is stronger than any of the other keels on the surface. With the exception of traces of another keel in further in the umbilicus, the only markings observed in the latter are faint revolving striæ. The finer surface markings are but poorly preserved, and the test is found only on the lower half of the body whorl of the type specimen. This shows ten ribs in 17 mm. from the umbilicus to the middle of the periphery. Aperture unknown.

The specimens have the following dimensions:

	Height.	*Height of Body Whorl.*	*Width.*
Type	35 mm	24 mm	43 mm.
Second	36 mm	25 mm	46 mm.
Third	36 mm	23 mm	45 mm.

This species is closely related to the forms of *O. macrolineatum* as found in the Guelph limestone at Elora and Durham, C. W., and also to *Poleumita scamnata* of Clarke and Ruedeman, but the Indiana forms are distinct. The specimens found at Huntington show much stronger and more closely-set ribs, while the remarkable keel bounding the umbilicus is a feature never seen in any of the others, in which respect our forms are very close to the Gotland species described by Lindström.

Rare. Huntington.

Oriostoma (?) opercula.

Pl. XIV, figs. 10-13; Pl. XI, fig. 6.

Opercula referred to this genus have been found at Huntington by Mr. Gilbert, who, after a search of several years, has brought to light four of these specimens. They are all low cones. The apical region (the nucleus) is nearly smooth, but beginning a short distance from the center are eight to thirteen nearly lamellose coils, the number varying with the individual. The marginal characters are indistinct, but there seems to have been a low cylindrical extension rather than a flat band.

A natural mould at hand shows the characters of both the exterior and interior surfaces of the operculum, the specimen preserving about five-sixths of the latter and one-fifth of the former. The outer half of the interior surface is nearly flat and surrounded by a wide rim. From nearly flat the surface changes to moderately concave toward the center, a small circular, rather shallow pit appearing at the center. The interior surface is smooth except for a slight depression and groove on one side, which may not be structural features.

Following is a short tabular account of their characters:

Specimen.	*Width.*	*Coils.*
1	22 mm.	7¾
2	23 mm.	9
3	29 mm.	13
4	23 mm.	11½

The specimens may doubtless be referred to *H. huntingtonense.* The size of the mouth in the known specimens of that species corresponds very well with the size of numbers 1 and 2. Both the opercula and the type of *P. huntingtonense* were found in the same quarry.

Oriostoma huntingtonensis var. alternatum n. var.

Pl. XIV, fig. 9.

This differs from the above in the surface markings and in being a little more depressed. The markings from the umbilicus to the suture consist of eight or nine rather more distant ribs than are met with in the typical forms of the species, while between each pair of these ribs is a fainter one. The stronger keels are equal in strength, but the fainter, alternating ones, are obsolescent near the suture, and gradually increase in strength, descending toward the umbilicus until the lowest one is quite equal to the strongest keels. The umbilicus is wide and open, and is marked by faint revolving striæ and by a sharper keel near the middle.

Two specimens, preserving only the body whorl and part of the upper. Both show a width of the former of 34 mm., and a height of 17 mm. Both were found at Huntington.

Oriostoma plana n. sp.

Pl. XIV, figs. 7, 8.

Shell discoid, with the apex of the spire varying from the plane of the upper side of the whorls to depressed, so that the umbilicus of the apical side is almost equal to that at the opposite side. Volutions 3 to 3½, contiguous, regularly rounded and as wide as high or wider, increasing very gradually in size. Surface marked by 10 or 12 sharp revolving bands, which become closer, more crowded and stronger toward the periphery. The interspaces are flat or slightly concave, and about 1½ times as wide as the bands. These bands are crossed by very fine, clearcut, imbricating lamellæ, which arch slightly backward between the revolving bands, and swing forward across the ridges of the latter. The lines of growth, however, as seen in well-preserved casts, are much finer, more numerous, closer and less regular than the imbricating lamellæ, and arch *forward* between the ribs and swing gently *backward* across the ridges. These lines of growth are crossed by extremely fine revolving lines, barely visible under a strong lens.

In the number and disposition of its revolving ribs and in the depression of the spire, this very prettily marked shell is intermediate between *O. angulatum* and *O. lineatum*. In the finer markings there is some resemblance to *Poleumita scamnata,* but that species as described and figured by Clarke and Ruedeman is clearly different from our shell.

The type specimen from Georgetown has a width of 18 mm. The body whorl just back of the mouth is 8 mm. wide. The height of the shell (the height of the body whorl) is 7½ mm. A second specimen from Georgetown has these respective dimensions: 15 mm., 7 mm., 6¾ mm.

Oriostoma sp. undet.

Pl. XIV, figs. 1, 2.

Shell large, turbinate. Volutions five in number, the apical one minute, the lower ones increasing in size rather rapidly, but regularly; whorls subcircular in cross-section. Sutures transverse, impressed, exposing nearly all of the whorl above. The upper portion of the volution is flat or very much depressed, convex; from this, broadly rounding off in subangular arches toward the umbilicus. Umbilical and apertural characters unknown.

Surface marked by low, unequal, longitudinal ribs, which are rather distant and narrow. These are crossed by peculiarly wavy, transverse striæ. From the suture to the first rather prominent rib, a distance of 2½ mm., the striæ arch backward; but thereafter, between each pair of ribs they arch forward. These markings are on the inside of the outermost layer or else on the outside of the next inner layer of the shell, and correspond in position and in direction to those on the "casts" of *O. plana.*

In the outline of the body whorl, and especially in the flattened upper portion, there is a resemblance to *Pleurotomaria eloroidea,* and this resemblance is increased by the low ribs. But the peculiar direction of the transverse striæ is sufficient evidence to include the shell described above in the genus *Oriostoma,* or perhaps in *Poleumita.*

One specimen. Huntington.

Schizolopha sp.

Pl. XII, fig. 3.

A single shell belonging to the State Museum has the following characters:

Medium-sized, turbinate; slightly higher than wide. Aperture two-fifths and body whorl two-thirds the height of the spire.

Mouth (as shown by the lines of growth) very deeply notched. Slit-band convex, not quite vertical, producing a subangular periphery. Profile above the slitband depressed, almost horizontal, forming a broad, low, double curve to the suture. Surface marked by distant, strongly elevated lines of "growth." Between these strong lines are 6 to 20, usually 12 to 15, very fine, even, raised lines, parallel to the lines of growth. The whole is crossed by fine concentric, revolving, raised lines, intermediate in strength between the two kinds mentioned above. The revolving lines are two or three times as far apart as the finer lines of growth. The species differs from *Clathrospira* in the convex slit-band. The aperture is not exposed, so that the presence of a slit is doubtful. In all other characters there is a generic resemblance to *Schizolopha moorei* Ulrich.

Should our species prove to be new, as it probably is, we would suggest the specific name, *S.* (?) *prosseri*, named after Prof. C. S. Prosser, of the Ohio State University.

One specimen. Delphi.

Cyclonema cancellata Hall.

Pl. XIV, figs. 5, 6.

A small but very well preserved specimen has the following characters:

Shell small, turbinate; volutions four or more, the upper ones small, rapidly but regularly increasing in size to the body whorl, which is very large, and constitutes six-sevenths the height of the spire. The whorls are, as shown by the mouth, oblique-vertically oval in section. The outer lip is not perceptibly expanded. The inner lip is slightly reflexed and is produced anteriorly so that the small umbilicus is exposed nearly at the middle of the length of the shell. The sutures are deeply impressed and quite transverse. Shell substance extremely thin, covered by revolving lines, one of which, near the periphery, is only slightly more prominent than the others. These lines are obsolescent in the umbilicus, and then become subequal, frequently double and about twenty in number up to the near suture, where they suddenly terminate. The interspaces are wider than the striæ. Just below the suture there is a smooth space with three or four hardly perceptible, revolving lines.

The shell is marked also by extremely faint but distinct, raised transverse striæ, which extend obliquely backward from the suture across the longitudinal striæ. The latter are very much stronger than the transverse striæ.

The height of the shell is approximately 9 mm.; thickness, 6 mm.; width, 8 mm. The species may be recognized by the turbinate-turriculate outline, and by the fine revolving and finer transverse striæ. There is a strong resemblance to the *Turbo* (*Cyclonema*) *tennesseensis* of Roemer, but that species has forty revolving lines, while ours has about twenty, a few of which, however, are double. In the Georgetown specimen the transverse striæ are very much closer than in the *Cyclonema cancellatum* from the Clinton green shale of New York State.

Rare. Georgetown.

Cyclonema elevata Hall.

Pl. XIII, figs. 3, 5.

Shell turriculate, height $1\frac{1}{2}$ times the width. Spire consisting of five volutions, which increase very gradually in dimensions. Volutions in the casts regularly rounded, but the surface (which has never before been known) shows that the upper part of the body whorl is depressed convex, almost flattened, while the lower part is ventricose. The surface is marked by from four to six low longitudinal ribs, which become obsolescent on the upper and lower portions of the body whorl and on the upper portions of the older whorls. There are obscure lines of growth. The lower two-thirds of the whorl next to the body whorl shows three or four ribs. There is no median keel, nor is there any appearance of there having been a slit. A very narrow but distinct umbilicus is present.

This species may be distinguished from *Eunema* (?) *trilineata* by the greater narrowness of the latter. If *E. trilineata* really is a *Eunema* it should have no umbilicus whatever, and this is, therefore, another distinctive character.

The two specimens known, which are both larger than the Wisconsin forms, have a length of 35 mm. and a width of 24 mm.

An external mould of *Cyclonema elevata* has been obtained at Huntington, Ind. Another specimen, consisting of an external mould and its internal cast, was found in the quarries (5/A) one mile east of Huntington.

CEPHALOPODA.

Orthoceras medullare Hall.

Pl. XIX, figs. 1, 2.

Shell a longicone, large, sides straight, tapering at an angle of from 9-12 degrees. Section circular or subcircular, broadly elliptical when compressed. Chambers deep, siphon central, tubular, not at all expanding between the septa. The chambers do not perceptibly deepen with age. In one specimen having a width of about 36 mm. the chambers are 17 mm. deep. In another large specimen the chambers are 24 mm. deep where the shell is 63 mm. wide. Surface without annulations or longitudinal ridges; the specimens of Hall and of Meek and Worthen show, however, beautifully cancellating striæ.

The species may be recognized by the distant septa and the absence of either annuli or ridges in the cast.

Ten large specimens have been obtained at Delphi, and one large specimen from a locality one mile west of Anderson.

Orthoceras (*Kionoceras*) *orus* Hall.

Pl. XXI, fig. 1; Pl. XXV, fig. 2.

Shell a longicone, large, tapering quite rapidly; section broadly oval, sometimes becoming circular or narrowly oval through rock pressure. Septa fairly distant, deeply concave; siphon small, placed three-sevenths the distance from one side to the other. Casts marked by longitudinal ridges; no annulations. Depth of the chambers varying from one-fourth to one-third the width.

Several specimens of body chambers from Huntington are referred to this species. These, together with a specifically identical chamber from Delphi, are circular or subcircular except when evidently much crushed, and bear the longitudinal ridges at the base. Higher up, these ridges become obsolescent. Just behind the mouth there is a broad constriction, below which the chamber is cylindrical. These body chambers are usually about 35 mm. wide and about 65 mm. high.

A narrowly ovate specimen from Wabash, now in the Indiana State Museum, is 175 mm. long, 35 mm. wide at one end and 54 mm. wide at the other. It shows 17 chambers in that distance. A couple of specimens from west of Anderson may be referred to this species.

Rather common. Huntington, Delphi, Wabash and Anderson.

Orthoceras (Kionoceras) delphiensis n. sp.

Pl. XX, figs. 1, 2.

Shell large, straight, tapering slightly, sides almost parallel. Section circular, with tubular siphon between the center and the margin or submarginal surface marked by low, narrow longitudinal ridges, of which there are eleven in 75 mm., at a point where the shell is 47 mm. thick. The ridges are perceptibly closer on the side on which the siphon is situated, where they seem also to be more pronounced. The interspaces are concave, several times as wide as the ridges, and seem to have been covered with coarse longitudinal striæ. There are also transverse striæ. The body chamber is a little constricted just back of the mouth.

The type specimen now in the Indiana State Museum is a fragment with a length of 162 mm., a width of 50 mm. at the mouth, and of 45 mm. about 120 mm. further back. The shell and siphon are greatly thickened.

This species may be recognized by the narrow and distant ridges, the absence of annulations, the slightly constricted mouth and thick submarginal siphon. The large size and straight sides are also distinctive features. It is hardly separable from the *Orth. angulatum* of Worthen, which shows the same thickening of the siphon. In Wahlenberg's species, however, the siphon is more nearly central, and there are some minor differences.

Besides the type, three other fragments have been found at Delphi.

Orthoceras (Kionoceras) kentlandensis n. sp.

Pl. XXI, fig. 2.

Shell a longicone, small, sides straight, slowly tapering. Section slightly oval (due to pressure ?); septa distant, almost flat; siphon large, eccentric. The depth of the chambers is more than half the width of the shell, except near the body chamber, where a few septa become crowded. Surface marked by longitudinal ribs which are quite faint in the cast.

This species is known from a single cast now in the Indiana State Museum (No. 685), which has a length of 78 mm., width at upper end 11 mm., at lower end 7 mm. At the lower extremity there are seven chambers in 32 mm., but just below the body chamber there are only five compartments in 9 mm. Twelve mm. above the base of the body chamber is a raised line, origin unknown.

This form can be recognized by its very distant septa. From *Orth. jolietensis of* Meek and Worthen, this species may be distinguished by the absence in the former of the longitudinal ridges, and the shallowness of the septa in the latter. Our species is also a much smaller shell.

Rare. Kentland.

Orthoceras (*Geisonoceras*) *niagarense* Hall.

20th Rep. N. Y. State Cab. Nat. Hist., p. 356, pl. 20, fig. 3.

The following is Hall's description:

"Shell elongate, gradually tapering; section broadly elliptical; septa deeply concave; depth of chamber 5 lines where the diameter is 1½ inches; siphuncle eccentric. Surface annulated by low, rounded annulations which are from one to two inches distant, according to the size of the shell; intermediate spaces regularly concave. In the larger parts of the shell there are about three annulations to each chamber. The finer surface markings unknown. The section in all the specimens examined is elliptical."

An important feature which Hall figured but failed to describe is the fact that the undulations are very oblique, especially on the wider portions of the shell, but become less oblique in the successive older parts of the same.

A single fragment is referred to this species, 54 mm. long, 14 mm. wide at the lower end, and 18 mm. wide at the upper end. The cross-section is elliptical and the septa are deep so that it corresponds almost exactly with the above. The annulations, though, are weaker and fewer in number, and the chambers comparatively deeper in our specimen, but these are characters which one would expect to find in the young of such a species.

Rare. Quarry one mile west of Anderson.

Orthoceras (Dawsonoceras) cf. annulatum Sowerby.

Pl. XIX, figs. 3, 4.

The Gilbert collection contains a fragment of an *Orthoceras* which is very closely allied to this species. The specimen is nearly 90 mm. long, 58 mm. wide at the broader end, and shows seven sutures in that distance. The annulation is not midway, between the sutures, but is nearer the older suture. The shorter slope of the annulation is depressed convex, and the longer slope with the normal concavity.

Rare. Huntington.

Orthoceras (Dawsonoceras) annulatum var. americanum Foord.

Shell a longicone, small to medium sized; slowly tapering; section circular. Characterized by strong annulations, with concave interspaces; the suture in the middle of each interspace. Septa deep, siphon central. The depth of two or three chambers is equal the breadth of the shell. Surface marked by transverse and longitudinal striæ.

It can be recognized readily by the character of the annulations, which are always strong in casts.

The collection contains about ten fragments, the largest 33 mm. wide. None of the surface striæ are preserved.

Rather common. Delphi.

Orthoceras (Kionoceras) angulatum Wahlenberg.

Pl. XXI, fig. 3.

Shell tapering gradually. Septa distant about one-fourth the diameter of the shell; siphuncle central or subcentral. Surface marked by angular longitudinal ridges.

Rare. Anderson.

Trochoceras (Sphyradoceras) cf. desplainense McChesney. (?)

20th Rep. N. Y. State Cab. Nat. Hist., 1867, p. 359, pl. 16, figs. 8-10.

Shell a torticone of 2 to 2½ volutions, dextral spire very low; cross-section ovate, with flattened sides; siphuncle small, near ventral margin. Surface and casts marked by distinct, sharp ridges, directed backward across the sides and with flat or concave interspaces. Fine markings consist of minutely cancellating, subequal, transverse and longitudinal striæ. (The description above is drawn mostly from that of Clarke and Ruedeman.)

A couple of fragments of casts apparently belonging to this species were found at Huntington.

Lituites marshii Hall.

Pl. XXI, fig. 4.

The principal features are shown by the figure.

This species is distinguished by its slender and more numerous volutions from *L. bickmoreanus.*

Represented by a single specimen from Wabash.

Lituites (*Ophidioceras*) *bickmoreanus* Whitfield.

Pl. XXV, fig. 1.

Shell large, thick, plane-coiled outer volution free and extending in nearly a straight line; subcircular in cross-section, depressed convex or nearly flattened on the back. Surface marked by broad bi-convex undulations, which have ventro-lateral sinuses, swing back across the side and develop a strong dorsal saddle. The undulations are obsolescent on the back and absent near the mouth. The base of the saddle is opposite the sinus of the third or a little nearer to that of the second undulation back. The interspaces are concave.

The finer surface markings according to Whitfield, consist of "almost microscopic lines which run lengthwise of the coils, and also in finer transverse lines of which three occupy the space of one of the longitudinal lines. The septa are moderately concave and are arranged at distances from each other less than that between the transverse undulations of the sides, so that ten of them occupy a distance equal to eight of the undulations."

This species may be readily recognized by its large size, and its low undulations, both of which characters distinguish it from *L. (O.) marshi,* and *L. (Trocholites) multicostatum,* etc., and also from *Trochoceras* (*Sphyradoceras*) *desplrinense,* the latter of which is not plane-coiled.

The species was described by Whitfield in the Bulletin of the American Museum of Natural History, Vol. I, No. VI, pp. 191-

192, Pl. xxi, Figs. 1-3. His specimens are from the dolomitic limestones of the Niagara group at Wabash City, Indiana. Our specimens agree very closely with Whitfield's species. The Huntington specimen is a fragment from just back of the mouth. It is about 60 mm. long, with a lateral width of 35 mm. and ventrodorsal thickness of 30 mm. The angle at the dorsal saddle is a trifle sharper than that in Mr. Whitfield's figures.

Another large fragment was found at a mile west of Anderson (Madison County). The latter is from an individual which must have been over a foot in diameter. The septal sutures are preserved and show a low dorsal saddle, the result of a dorso-lateral sinus on each side. The saddle is under the third undulation from that at which the suture is observed on the ventral side. The dorso-ventral thickness in this specimen is greater than the lateral.

Rare. Delphi, Huntington, Wabash and Anderson.

Lituites (Ophidioceras ?) hercules carrollensis n. var.

Pl. XVI, fig. 1, and Pl. XVII, fig. 1.

Shell very large, nautilian, with the body chamber free and extended in an arched line. Cross section ovoid, flattened on the sides, with ventral and dorsal faces rounded, the latter more broadly so; greatest breadth just above the center; ratio of breadth to thickness is 10 : 11. Siphon eccentric but not marginal. The casts are marked by very broad, low undulations, each with a dorsal saddle. Near the ventral side* there are some longitudinal ribs, but both styles of markings are very obscure in the internal casts.

This variety may be easily recognized by the very large size, the flattened sides, and the peculiar curvature.

The type is a fragment of the body chamber with a few septa which are indistinct. The fragment has a length of 190 mm., breadth 60 mm., thickness 67 mm. The body chamber is 150 mm. long, but when entire must have been at least twice that length. The septa are rather distant, directed backward across the sides, and are furnished with shallow lateral sinuses and a dorsal saddle. Another fragment has a breadth of 67 mm., and thickness

*In the ventral side there is also observable in the type specimen a very shallow groove which should serve to place this form in the genus *Remeleceras*, provided that this groove is normal to this species.

of 75 mm. The depth of the dorsal saddle of the undulations is about 40 mm.

Represented by two specimens from Delphi.

Trimeroceras gilberti n. sp.

Pl. XV, fig. 1.

Shell breviconical, large, the lower portions of the ventral and dorsal sides converging at an angle of nearly 50 degrees. Section ovoid, rather pointed ventrally. Septa distant, 8 in 45 mm. There is a distinct saddle at the ventral side and an azygous sinus at the dorsal, with only one very shallow sinus on each lateral face. Body chamber large, broader than high. Siphuncle one-third the distance from the ventral face to the center. Dorsal periphery of the body chamber vertical, ventral periphery divergent from the base, both depressed convex. The upper side of the body chamber is rather flat, and parallel to the plane of the basal edge. The slit is narrow. Character of the apertural lobes unknown. Surface of septa with rather weak longitudinal ribs. Following are some statistics regarding these forms:

Length of specimen with body chamber and 11 septa........			135 mm.
Length of the eleven septa................................			80 mm.
Length of body chamber............	(1) 72 mm.	(2) 75 mm.	(3) 83 mm.
D.-V. thickness at base (body ch.)....	88 mm.	87 mm.	89 mm.
D.-V. thickness half way up (body ch.)	101 mm.	100 mm.	112 mm.
Lateral thickness at base (body ch.)..	68 mm.	63 mm.	65 mm.

(1), (2), and (3) refer to 3 other specimens.

The species is readily distinguished by its rapidly tapering, conical shape. The body chamber is recognized by the parallel bases and subordinate height. There is a resemblance to *Phragmoceras nestor, var. canadense* Whiteaves, from which our species differs in having the upper and lower bases of the body chamber parallel. Named after Mr. Gilbert, to whose kindness in loaning material the opportunity of studying much of the Huntington *Gasteropoda* and *Cephalopoda* is due. The type and specimens described above are from Huntington, Ind.

Rare. Huntington and Delphi.

Hexameroceras delphicolum Newell.

Proc. Bost. Soc. Nat. Hist., Vol. XXIII, p. 479, figs. 1-4.

Shell an arcuate brevicone, medium sized; transverse section eleven-twelfths of the thickness and situated two-thirds of the distance to the dorsum; siphon ventral, submarginal.

Chambers shallow, three of them with a total depth of 8 mm. on the ventral side and 16 mm. deep on the dorsum. Septa almost flat. Sutures straight with no perceptible sinus or saddle. The chamber adjacent to the body chamber has half the depth of those following it, and has the anterior margin crenulated. The body chamber is dome-shaped, wider than high, with all the sides rounded and with a contracted aperture. The dorsal opening of the living chamber is furnished with three lateral lobes on each side of a narrow median slit which connects them with the single ovate ventral opening. The length of slit and opening equals about five-sixths of the dorso-ventral diameter.

Faint indications of fluted longitudinal markings are present on the septæ. The body chamber is 25 mm. high, 39 mm. wide and 43 mm. deep. The specimens described differ from Newell's description of the species in having the margins of the septæ nearly straight instead of curved. In other respects the present specimen agrees closely with *H. delphicolum.*

Rare. Huntington.

Cyrtoceras gorbyi Miller.

One specimen from Huntington is referred to this species.

Gomphocera wabashensis Newell.

Pl. XX, figs. 3, 4.

Shell a brevicone, small, straight. Septa of moderate depth; siphon moniliform, situated one-third to one-half distance from ventral margin to center. Body chamber conical with the sides nearly straight, converging toward the apex at an angle of about 20 degrees. Aperture simply T-shaped, without any accessory lobes. Cross-section circular to broadly oval.

It may be distinguished from *G. scrinium* by the more conical and proportionally longer living chamber.

This species is quite abundant at Huntington, where about ten specimens have been found. They are preserved as casts of the body chamber. The largest has a height of 53 mm., thickness at the base 40 mm., breadth 34 mm. Another large specimen has a thickness of 39 mm., and width of 36½ mm. The smaller forms are circular in cross-section.

There is a single specimen in the Indiana State Meseum which, labeled *G. subgracile,* is from Delphi.

A single specimen was found at Georgetown.

Phragmoceras parvum Hall and Whitfield.

Shell a small, arcuate, brevicone. Septal portion half the length. The species may be easily recognized by its small size, the tubular extensions of the aperture, and the sharp angle formed by the edge of the aperture and the plane of the base of the body chamber. In all of the figured and described specimens the ventral periphery of the body chamber is convex; but of the two specimens from Huntington, it is flat in one and very concave in the other, which is the specimen figured. This is the only difference to be detected between specimens from Huntington, and those from the Guelph of Canada and New York. The second specimen is a little larger than the one figured.

Common. Huntington.

Phragmoceras angustum Newell.

Pl. XVIII, fig. 1.

Shell large, arcuate; narrowly elliptical in cross section; increasing regularly in dorso-ventral diameter from the smallest cammera to the aperture.

Living chamber elongate, length greater than greatest dorso-ventral diameter. Length of aperture about equal to greatest length of living chamber. Apertural margins not well preserved, but they appear to consist of a small oval opening at the antero-ventral angle and a larger similar opening at the antero-dorsal angle, not connected by a narrow slit. The sutures of the cammera form broad, shallow lateral lobes and have ventral saddles.

The two specimens described are from Grant County. The type locality of the species is Wabash.

Phragmoceras cf. ellipticum H. and W.

Pl. XIX, fig. 5.

The following is the original description taken from p. 152, Pal. Ohio. II.

"Shell of large size, slightly curved, transverse section narrowly elliptical, a very little wider on the outer than on the inner side of convex on the sides, and sharply rounded on the ventral and dorsal edges; the ventral side extended at the aperture, forming a tube-like projection; the remainder of the aperture not known. First chamber below the chamber of habitation very shallow; septa deeply concave; siphuncle large, situated close to the inner side of the shell.

"Formation and locality. In the limestones of the Niagara group, in Highland County, Ohio, associated with *Trimerella ohioensis*."

A large fragment corresponding very well with this species occurs in the Gilbert collection. The base of the body chamber is 6 mm. thick and 39 mm wide. Measured along the center there are five chambers in a depth of 25 mm. On the ventral periphery these five chambers occupy a depth of 19 mm. and on the dorsum of 36 mm. The penultimate chamber in our specimen is not differentiated from the others. The upper and basal peripheries of the body chamber are subparallel as in the Ohio material. The species may be distinguished by the large size, the subparallel bases of the body chamber and by the slight curvature.

Rare. Huntington.

The following additional species of Cephalopoda, represented in the collections at hand by very poor material or not at all, have been described from the Niagara rocks of the Wabash Valley by Frederick H. Newell in the Proc. Bost. Soc. Nat. Hist., Vol. XXIII, pp. 466-486.

Orthoceras crebescens Hall.
  Wabash City.
Orthoceras unionensis Worthen.
  Wabash City.
Orthoceras rigidum.
  Peru.
Orthoceras obstructum Newell.
  Wabash City.
Kionoceras strix Hall & Whitf.
  Wabash City.
Gomphoceras linearis Newell.
  Wabash.

Gomphoceras projectum Newell.
Delphi.
Hexameroceras cacabiformis Newell.
Delphi.
Pentameroceras mirum Barrande.
Delphi.
Ascoceras newberryi Billings.
Delphi.
Ascoceras indianensis.
Delphi.

TRILOBITA.

Illaenus armatus Hall.

Pl. XXII, fig. 6.

Two small pygida are referred to this species. The proportions of length and breadth are respectively three to four, and five to eight. They differ from *I. ioxus* in having the greatest elevation near the posterior end, and in sloping very abruptly to the posterior margin.

Georgetown and Wabash.

Illaenus insignis Hall.

Pl. XXII, figs. 1-5.

Glabella strongly convex, regularly arched from front to back. Anterior and posterior margins of the cranidium strongly rounded, the latter bending backward outside the dorsal furrows and terminating in minute triangular pieces (the fixed cheeks) articulating with the free cheeks. Anterior margin with a thickened border. Dorsal furrows distinct, extending upward and forward from small pits in the occipidal groove; opposite the palpebral lobes they widen and deepen perceptibly for the space of one or two mm.; thence as shallow furrows curving downward and forward, they terminate in deep pits about one-third to one-half the distance from the front of the cranidium to the palpebral lobes. Free cheeks with rounded genal angles, sloping abruptly downward from the eyes.

Pygidium semicircular to slightly paraboloid in outline. Anterior margin broadly rounded in the median two-thirds of its length, making a slight backward bend one-half the distance from the lateral margin to the middle, thence extending nearly straight to the antero-lateral margin. Surface but slightly convex on the top, but sloping rapidly to the margin at the sides.

This species is rather common. It occurs at Connor's Mill (Hamilton County), Delphi, Georgetown, Fishersburg and Wabash.

Illaenus ioxus Hall.

Pl. XXII, fig. 7; Pl. XXIII, fig. 3.

Pygidium rather short, length equal to three-fourths the width or less. Posterior border regularly rounded forming nearly a semi-circle. Articulating margin broadly rounded, sometimes bending backward slightly just at the middle. Surface moderately convex sloping to the posterior margin quite gently.

Cephalon much broader than long. Only one poorly preserved cranidium has been seen. Five pygidia have been found in the collections from Pendleton, Fishersburg, Helm's Mill, and Connor's Mill, Hamilton County.

Ceratocephala goniata Warder.

Pl. XXIV, fig. 13.

Cephalon subquadrangular in outline, width nearly twice the length. Glabella very tumid, consisting of a large median and three pairs of small lateral lobes. Median lobe narrowing slightly toward the front, its greatest width equal to half the length. Lateral lobes separated from the median lobes by deep furrows. Dorsal furrows very weak and indistinct, the lateral lobes merging into the fixed cheeks. One of the free cheeks is partially preserved, showing a nearly flat, broadly crescentric extension forming the antero-lateral margin of the cephalon. The strong ridges at the inner margins of the free cheeks support a pair of spine bases about midway between the genal angles and the anterior extremity of the cephalon. The occipital ring is separated from the glabella by a distinct but rather shallow groove. Two spine bases with a strong tubercle between occupy the ring. The border of the free cheek appears to have been ornamented with a fringe of tubercles or of fine spines. The genal angles terminate in strong diverging spines. The thorax and pygidium have not been seen.

The description is based on a single cephalon from Pendleton, which appears to be identical with the forms described from Bridgeport, Ill., by Hall as *Acidaspis danai* and by Winchell and Marcy as *A. ida*. The lateral gabella lobes are less distinct than in the figures of *A. danai et ida,* but this is due in part to a slight distortion of the specimen.

Odontopleura ortoni Foerste.

Pl. XXIV, figs. 16–19.

Cephalon subcircular in outline, strongly convex with granulose surface; length about one-third the width. Median glabellar lobe of nearly uniform width throughout, length about two and one-third times the width, lateral lobes in three pairs separated from the median lobe by deep furrows. The anterior pair of lobes are very small and situated near the anterior extremity of the median lobe; the posterior pair are oblong masses just anterior to the occipital groove and about twice the size of the median pair. A pair of elongated, subtriangular elevations pointing forward, and flanking the lateral lobes, extend forward to the groove between the anterior pair of lateral lobes. A distinct low ridge extends backwards on each side from the antero-lateral margin of the median lobe to the eyes. Facial sutures not discernible. Lateral margins of the free cheeks set with numerous small spines, about one and one-half millimeters in length, pointing downward. The genal angles terminate in strong spines, which are broken off in the specimen figured. Occipital ring smooth, separated from the glabella by a distinct furrow.

Thorax with nine segments. Axis moderately convex, pleura flattened except at the extremities which are directed downward and terminate each in a sharp spine.

Pygidium very short; flat or slightly concave; axis convex and unsegmented. Margin of the pygidium with a fringe of twelve spines, each about as long as the pygidium, except the third pair from the posterior end which are longer than the others. This pair is continued across the pygidium, in oblique, convex ridges, converging to the anterior margin alongside the axis. The species is represented by two specimens—a nearly complete individual from Georgetown, and a pygidium from Pendleton.

Encrinurus indianensis n. sp.

Pl. XXIV, figs. 14, 15.

Cephalon semicircular in outline; surface covered with large tubercles. Glabella with three very strong lateral tubercles on each side anterior to the occipital groove. Fixed cheeks separated from the glabella by very deep dorsal furrows. Genal angles apparently terminating in spines. Thorax unknown.

Pygidium elongate-triangular, strongly convex; the lateral lobes curve sharply down from the dorsal furrows to the margin. In the type specimen, the annulations of the axial lobe number 15; in each of the lateral lobes there are ten pleuræ, which are directed backward. Each annulation of the axis bears from three to five tubercles, the one at the middle of the annulation being the strongest. Three to six tubercles mark each of the lateral segments.

The cephalon and pygidium have not been found united, but the only *Encrinurus* cephalon found is from Connor's Mill, Hamilton County, which has furnished a number of *Encrinurus* pygidia all belonging to the species here described. This association makes the specific identity of the parts here figured very probable. This species seems to have no very close ally among described forms. The pygidium approaches somewhat to *E. variolaris* Brogn., from the Wenlock of England. The latter has nine to twelve annulations on the axis of the pygidium as compared with nine to fifteen in *E. indianensis,* and seven to eight pleura on the lateral lobes against nine to ten in the present species. The median annulations in *E. variolaris* (on the pygidium) have three tubercles, while the form here described has five except in the extreme posterior part, where the number is three.

Connor's Mill and Fishersburg (Hamilton County), Huntington, Little Deer Creek (Carroll County), and at Wabash.

Calymene cf. vogdesi Foerste.

Pl. XXIV, figs. 1-7.

Cephalon semicircular; surface granulose, most coarsely so on the cheeks. A wide, flat band forms the anterior margin. Glabella varying from moderately convex to strongly tumid; lateral lobes of the glabella in three pairs, the posterior twice the size of the median pair, and the anterior pair very small.

Thorax with ten segments, axial lobe convex and elevated above the lateral lobes. Each annulation bears a pair of strong nodes, just above the dorsal grooves. The pleuræ are horizontal for one-third their length from the dorsal groove, then they bend abruptly downward, terminating in broad paddle-shaped ends; pleuræ grooved four-fifths the distance to their outer extremities.

Pygidium with nearly straight postero-lateral sides, their union making an obtuse angle. Axial lobe tapering gradually to a smooth rounded extremity; annulations eight or nine, the anterior three or four showing small indistinct nodes at the dorsal furrows continuous with those of the thorax. Lateral lobes with five or six annulations. The annulations are directed backward and are grooved along the outer half of their length.

This species is rather common; Connor's Mill (Hamilton County), Georgetown, and at "Hanging Rock" (Wabash County).

Ceraurus (*Crotalocephalus*) *niagarensis* Hall.

Pl. XXIV, fig. 8; Pl. XXIII, figs. 1, 2.

This species is represented by three specimens showing the glabella and a portion of the fixed cheeks. The nearly straight anterior margin of the glabella shown by one of the figures is due to the imperfection of the specimen, the normal condition being rounded and tumid in front.

The specimen from Marion is of unusual size, the glabella measuring 50 mm. in length and 35 mm. in its greatest width.

Rare. Connor's Mill (Hamilton County), Marion and at Georgetown.

Sphaerexochus romingeri Hall.

Pl. XXII, figs. 8, 9, 12–15

Glabella very large, constituting the bulk of the head, spheroidal in form, surface smooth. The posterior glabella lobes, resembling large tubercles, are limited by a pair of deep, semicircular grooves; the lobes are separated by a space equal to one and a half to two times their width. The free cheeks are small, subtriangular pieces extending downwards from the base of the posterior glabella lobes. Two or three specimens show two pairs of shallow linear grooves anterior to the posterior glabella lobes which extend upward and forward from the antero-lateral margin of the glabella. The posobserved. Occipital ring highly arched, limited by a deep furrow. The largest specimen observed has a width of 31 mm., and a length of 23 mm. Another very spherical cephalon measures in width 21 mm., length 18 mm., height from base of posterior glabella lobes to the highest part of the glabella is 14 mm. Thorax unknown.

Pygidium transversely elliptical in outline, axis terminating in a triangular-shaped piece, anterior to which are three strong annulations; the lateral lobes are divided into three broad, simple pleura, the posterior pair directed backwards.

The marble-shaped glabella of this species are among the most common and generally distributed fossils of the Niagara of northern Indiana. It is worthy of note that this species, so common throughout northern Indiana is entirely absent from the Niagara fauna in the vicinity of the Falls of the Ohio.

Phacops cf. pulchellus Foerste.

Pl. XXIV, figs. 9, 12.

Cephalon ovate to semicircular in outline, proportions of length to breadth as five to eight. Anterior end with a narrow thickened border; genal angles rounded. Occipital groove well marked, with deep pits at the intersections with the dorsal furrows. A deep groove also terminating in pits in the dorsal furrows crosses the constricted base of the glabella; anterior to this groove, in some specimens two pairs of very weak lateral furrows mark the sides of the glabella, opposite the palpebral lobes. Most specimens show no trace of these furrows. The frequent absence of these furrows, and their slight development when present, constitute the principal difference between Foerste's species and the forms here described.

Thorax unknown. Pygidium semicircular in outline posteriorly, anterior margin slightly rounded. Axial lobe strongly elevated above the lateral lobes, width equal to three-fourths that of the lateral lobe; profile regularly arched from the anterior to the posterior extremities. The annulations on the axial lobe are about nine in number, and arch slightly backward in crossing the top of the lobe. The median row of tubercles characterizing the axial lobe of *P. pulchellus* is absent. Lateral lobes with five or six segments, each with a median groove; the pleuræ become indistinct posteriorly and the surface nearly smooth opposite the posterior end of the axis.

Rather common at Connor's Mill. Rare at each of the following localities: Georgetown, Pendleton, and Connor's Mill.

Dalmanites (*Synphoria*) *vigilans* Hall.

Pl. XXIV, fig. 20; Pl. XXIII, figs. 4-7.

Pygidium depressed, elongate triangular, terminating in a sharp point or spine. Axial lobe with ten to twelve annulations. Lateral lobes with about ten pleuræ directed backward, flattened and traversed by a median furrow.

The species is represented by a few fragmentary pygidia from Anderson, and by a cephalon from Pendleton.

TABLE SHOWING DISTRIBUTION OF NIAGARA FOSSILS IN NORTHERN INDIANA.*

	Little Deer Creek.	Georgetown.	Pendleton.	Wabash.	Delphi.	Huntington.	Connor's Mill.	Helm's Mill.	Fishersburg.	Bunker Hill.	Goodland.
1. Cornulites sp			+								
2. Spirorbis sp			+								
3. Dinobolus conradi						r					
4. Monomerella sp					r						
5. Trimerella sp					r						
6. Crania sp			r								
7. Stropheodonta cf. corrugata		r	+?								
8. Pholidostrophia niagarensis	r										
9. Strophonella cf. striata	+	c	r				c		+		
10. Strophonella williamsi		+	+		+		+				
11. Leptaena rhomboidalis		a	r				c		c		
12. Plectambonites cf. sericeus							r				
13. Orthothetes subplanus	c	+	r	r					+		
14. Chonetes cf. cornutus			r							a	
15. Orthis flabellites			c	r				+			
16. Orthis (?) subnodosa	r										
17. Dalmanella elegantula	c	+	+	c			r		c		
18. Rhipidomella hybrida			r	r	r		r				
19. Rhipidomella circulus(?)	r	r									
20. Anastrophia internascens			r	r				r			
21. Conchidium laqueatum					a	c					
22. Conchidium cf. littoni		c									
23. Conchidium cf. multicostatum							r				
24. Conchidium trilobatum						r					
25. Conchidium unguiformis (?)	r										
26. Pentamerus oblongus var. compressa					c						
27. Pentamerus oblongus var. cylindricus					c						
28. Gypidula galeata	r	c	c	c				c	c		
29. Gypidula galeata var. nucleus		r									
30. Camarotoechia cf. acinus			r								
31. Camarotoechia sp. undet	r										
32. Wilsonia saffordi		c								+	
33. Eatonia goodlandensis											r
34. Atrypa calvini	r	a	r				+				
35. Atrypa reticularis	a	a	c	c		r	c	r	c		
36. Spirifer foggi		r									
37. Spirifer nobilis		r	c				+	c	r		
38. Spirifer radiatus	+	r		+	r		c	+	r		
39. Spirifer (Reticularia) crispa	+										
40. Spirifer (Reticularia) crispa var. simplex			c				r	+			
41. Reticularia proxima			+								
42. Cyrtia myrtia		r			r						
43. Whitfieldella nitida	+	+									
44. Nucleospira pisiformis			r								

TABLE SHOWING DISTRIBUTION OF NIAGARA FOSSILS IN NORTHERN INDIANA—Continued.*

	Little Deer Creek.	Georgetown.	Pendleton.	Wabash.	Delphi.	Huntington.	Connor's Mill.	Helm's Mill.	Fishersburg.	Bunker Hill.	Goodland.
45. Meristina maria	...	c	c	r	...	...	+	...	c	...	...
46. Meristina cf. princeps	...	r	...	...	...	...	...	...	...	...	...
47. Meristina rectirostris	c	...	...	...	...	...	...	...	...	...	...
48. Whitella siluriana	...	...	...	r	...	...	...	...	...	...	...
49. Cypricardinia(?) sp	...	...	r	...	...	...	...	...	...	...	...
50. Pterinea sp	...	...	...	r	r	...	...	...	...	...	...
51. Amphicoelia neglecta	...	...	...	r	...	...	...	...	...	...	...
52. Palaeopinna sp	...	...	...	r	...	...	...	...	...	...	...
53. Conocardium multistriatum	...	r	...	...	...	...	...	...	...	...	...
54. Conocardium oweni	r	...	...	...	...	...	...	...	...	...	...
55. Plethomytilus cuneatus	...	r	...	...	...	...	...	...	...	...	...
56. Streptomytilus wabashensis	...	...	...	r	...	...	...	...	...	...	...
57. Anodontopsis wabashensis	...	...	...	r	...	...	...	...	...	...	...
58. Platyceras (Diaphrostoma) cornutum	c	r	...	...	...	...	c	+	...	...	...
59. Bucania sp. undet	...	r	...	...	...	...	...	...	...	...	...
60. Trematonotus chicagoensis	...	...	...	...	+	+	...	...	...	...	...
61. Pleurotomaria idia	...	...	...	...	...	r	...	...	...	...	...
62. Pleurotomaria (?) hoyi	...	...	...	...	r	...	...	...	...	...	...
63. Pleurotomaria (?) sp	...	...	...	...	r	...	...	...	...	...	...
64. Pleurotomaria pauper	...	...	...	...	...	c	...	...	...	...	...
65. Pleurotomaria (Eotomaria) laphami	...	...	...	...	r	...	...	...	...	...	...
66. Pleurotomaria (?) axion	...	...	...	...	...	r	...	...	...	...	...
67. Pleurotomaria (Euomphalopterus) alatus var. americanum	r	...	...	...	...	...	...	...	...	...	...
68. Pleurotomaria (Euomphalopterus) var. limatoidea	...	...	...	...	c	...	...	...	...	...	...
69. Pleurotomaria (?) eloroidea	...	...	...	...	r	...	...	...	...	...	...
70. Pleurotomaria (?) sp. cf. eloroidea	...	...	...	...	...	r	...	...	...	...	...
71. Murchisonia (Turritoma) laphami	...	...	...	...	...	c	...	...	...	...	...
72. Murchisonia (Coelocaulus) bivittata	...	...	...	...	...	r	...	...	...	...	...
73. Murchisonia (Coelocaulus) sp	...	...	...	...	...	c	...	...	...	...	...
74. Oriostoma huntingtonense	...	...	...	...	...	+	...	...	...	...	...
75. Oriostoma huntingtonense var. alternatum	...	...	...	...	...	+	...	...	...	...	...
76. Oriostoma plana	...	r	...	...	...	...	...	...	...	...	...
77. Oriostoma sp. undet	...	...	...	...	...	+	...	...	...	...	...
78. Schizolopha sp.	...	...	...	...	r	...	...	...	...	...	...
79. Cyclonema cancellata	r	...	...	...	...	...	...	...	...	...	...
80. Cyclonema elevata	...	...	...	...	...	r	...	...	...	...	...
81. Orthoceras medullare	...	...	...	...	c	...	...	...	...	...	...
82. Orthoceras sp	...	r	r	...	...	...	...	...	...	...	...
83. Orthoceras (Dawsonoceras) cf. annulatum	...	...	...	...	...	r	...	...	...	...	...
84. Kionoceras orus	...	...	...	...	r	+	...	...	...	...	...
85. Kionoceras delphiensis	...	...	...	...	r	...	...	...	...	...	...
86. Trochoceras cf. desplainense	...	...	...	...	...	r	...	...	...	...	...
87. Lituites marshii	...	...	...	r	...	...	...	...	...	...	...
88. Lituites (Ophidioceras) bickmoreanus	...	...	...	r	...	r	...	...	...	...	...
89. Lituites (Ophidioceras) herculeus carrollensis	...	...	...	...	r	...	...	...	...	...	...
90. Cyrtoceras gorbeyi	...	...	...	...	...	r	...	...	...	...	...
91. Gomphoceras (Poterioceras) marcyae	...	r	...	...	...	...	...	...	...	...	...
92. Trimeroceras gilberti	...	...	...	...	r	+	...	...	...	...	...
93. Tetrameroceras cf. herzeri	...	...	...	...	...	r	...	...	...	...	...
94. Phragmoceras parvum	...	...	...	...	...	r	...	...	...	...	...
95. Phragmoceras ellipticum	...	...	...	...	...	r	...	...	...	...	...
96. Illaenus armatus	...	r	...	r	...	...	...	...	...	...	...
97. Illaenus insignis	+	c	...	...	r	+?	c	...	c	...	...
98. Illaenus ioxus	...	...	+	...	...	...	...	...	...	...	...
99. Illaenus sp. undet	...	...	...	...	r	...	...	...	...	...	...
100. Ceratocephala goniata	...	...	r	...	...	...	...	...	...	...	...
101. Odontopleura ortoni	...	r	...	...	...	...	...	...	...	...	...
102. Encrinurus indianensis	c	...	c	...	r	r	c	...	c	...	...
103. Calymene vogdesi	...	c	+	...	...	...	c	...	...	...	...
104. Ceraurus (Crotalocephalus) niagarensis	...	r	...	...	...	...	r	...	...	...	...
105. Sphaerexochus romingeri	r	c	c	a	r	...	c	+	c	...	...
106. Phacops. cf. pulchellus	...	...	r	...	...	...	c	...	...	...	...
107. Dalmanites (Synphoria) vigilans	...	...	+	...	...	...	...	...	+	...	...

*This list includes only those localities from which collections sufficiently full to be

GENERAL INDEX.