Plate I.

Bridge at South Bend, Indiana. Illustrating the use of Portland Cement.

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources.

THIRTY-FIRST ANNUAL REPORT

W. S. BLATCHLEY,

State Geologist.

1906

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1907

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
February 27, 1907.

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

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, June 11, 1907.

The within report contains no financial statement.

J. C. BILLHEIMER,
Auditor of State.

June 11, 1907.

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.

FRED L. GEMMER,
Secretary to the Governor.

Filed in the office of the Secretary of State of the State of Indiana, June 11, 1907.

FRED A. SIMS,
Secretary of State.

Received the within report and delivered to the printer June 12, 1907.

HARRY SLOUGH,
Clerk Printing Bureau.

State of Indiana,
Department of Geology and Natural Resources.
INDIANAPOLIS, Ind., February 27, 1907.

HON. J. FRANK HANLY, *Governor of Indiana:*

MY DEAR SIR—In accordance with law I transmit to you herewith the manuscript of my Twelfth Annual Report, the same being the Thirty-first Report of the Department of Geology. In the main it comprises papers of economic importance relating to the Petroleum, Peat and Iron resources of the State. It also contains the reports of the State Mine Inspector and the State Supervisor of Natural Gas for the calendar year 1906.

Yours very truly,

W. S. BLATCHLEY,
State Geologist.

ASSISTANTS.

A. E. Taylor	Field Assistant.
Chas. W. Shannon	Field Assistant.
Raymond S. Blatchley	Field Assistant.
R. E. Lyons	Chemist.
T. W. Smith	Chemist.
James Epperson	Inspector of Mines.
Andrew Dodds*	Assistant Inspector of Mines.
Jonathan Thomas	Assistant Inspector of Mines.
Robert Irving	Assistant Inspector of Mines.
B. A. Kinney	Supervisor of Natural Gas.
Isadore Kessler	Clerk.
Millard Gilliam	Messenger and Janitor.

*Died December 25, 1906. Robert Irving, of Cayuga, Vermillion County, was appointed to fill the vacancy.

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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 present volume comprises a number of papers on the economic Geological Resources and Natural History of the State. The first paper, entitled "The Natural Resources of Indiana," is intended as a resumé, in condensed form, of the more important Natural Resources, giving briefly the location, extent and approximate value of each. Such a paper was published in the Twenty-fourth (1899) Report of the Department, but in the seven years which have elapsed much information of interest regarding these resources has been gathered. Moreover, the annual output of such resources has increased in value from about $20,000,000 to more than $41,000,000. Extended monographs giving detailed information regarding each of the resources mentioned, have appeared in previous volumes. To them the reader especially interested is referred for more definite information.

During the past ten years several hundred letters have come to the writer from all parts of the United States, asking information concerning the peat deposits of Indiana. Only very indefinite answers could be made, as the extent and character of those deposits were not known. During the past year one of my assistants, Mr. A. E. Taylor, has made a careful investigation of all the principal deposits and his paper on the subject follows next in order. Mr. Taylor shows that in the lake region of northern Indiana, which is embraced within the three or four northern tiers of counties, there are hundreds of thousands of acres of peat, varying in quality from poor to good. This peat is an incipient coal, one form of crude fuel which contains within its mass the heat units stored up by the vegetation, of which it is formed, during the latter's growth. This vegetation grew in, or about the margins, of extensive lakes and marshes in that region, many of which are now extinct.

The better grades of the peat are mainly derived from sphagnum mosses which grow in abundance in certain localities, while the poorer grades are from the semi-aquatic grasses, sedges and other herbaceous vegetation. In forming peat this vegetation does not decay, as the manner of its growth and the surrounding water shut off the oxygen of the air, which is the chief agent of decay. The heat calories stored up by the plants in their growth were thus retained, and when the peat is dried it will burn freely and yield readily the stored heat. A number of analyses of samples collected by Mr. Taylor were made by Dr. R. E. Lyons, of the State University. These show the peat to have a fuel value ranging between 4541.67 and 10466.28 B. T. U., or about two-thirds that of Indiana bituminous coal. The peat can either be spaded and dried and then burned in bulk, or can be compressed into briquettes, which can be handled like anthracite coal. Since wood, the principal fuel used on farms and in the smaller towns of northern Indiana, is becoming very scarce, these peat deposits offer a cheap and easily obtained fuel for local use. As the price of coal advances the use of peat for making briquettes will increase, and the time will doubtless come when many of the larger towns and cities of that portion of the State will derive their fuel supply largely from the bogs and marshes of that region. In addition to its fuel value, the better grades of peat can be used for a number of other purposes, which are enumerated by Mr. Taylor, to whose paper all persons interested are referred.

It has been known for a half century or longer that extensive deposits of limonite or bog ore were located in certain portions of Indiana. At one time there were a dozen or more blast furnaces in the State which drew their supply of ore chiefly from these deposits. With the discovery and development of immense quantities of high grade iron ore in the Lake Superior region, and in Missouri, Alabama, etc., the low grade ores of Indiana were outclassed and the furnaces went out of blast and were dismantled. Within recent years the demand for iron products has increased so rapidly that the high grade ores could not be furnished in sufficient quantity. Moreover, the slag of the blast furnaces, formerly a by-product which had to be handled at large expense and wholly without remuneration, has come to be utilized as an ingredient of certain classes of Portland and puzzolan cements; so that it has a value largely in excess of the cost of handling. These facts have caused a demand for low grade iron ores, such as those of Indiana. Realizing their growing value, Mr. Chas. W. Shannon, of Bloomington, was employed for several months as a field assistant to make a careful investigation of the location and extent of the leading iron ore deposits of the State, and his paper forms the third in order of the volume. In it he shows that large deposits of ore, ranging from 28 to 54 per cent.

in iron, are located in Martin and Greene counties; while smaller deposits, not only of limonite, but siderite or carbonate of iron, occur in a number of other counties. The paper of Mr. Shannon is accompanied by a number of maps and illustrations fully explanatory of the subject, and will be found of much interest to all interested in the iron industry.

Papers on the "Petroleum Industry in Indiana in 1906" and on the "Princeton Petroleum Field of Indiana," by W. S. and R. S. Blatchley, respectively, give in detail the new developments and statistics for the year in that important industry. Each paper is accompanied by a map showing the field as it was on January 1st, 1907, that for the Princeton field being the first authentic map of that field which has been published. On account of the low average price of crude oil, 88 3-5 cents for the Trenton Rock and 77½ cents for the Princeton product, as well as on account of the excitement incident to the opening up of a new oil field of large proportions in eastern Illinois, developments in Indiana were retarded and the total production fell off 3,095,371 barrels, or 28.2 per cent.; the total output for the State during the year being 7,873,937 barrels, valued at $6,968,089.

The reports of the State Supervisor of Natural Gas, Mr. B. A. Kinney, of Marion, and of the State Mine Inspector, James Epperson, of Linton, follow next in order, and to them persons interested in gas or coal are referred.

For a number of years it has been the custom to close the volume with one or more papers dealing with the Natural History of the State, since, when the Department was re-organized, in 1881, the first phrase of the act was as follows: "A Department of Geology and Natural History is hereby established." In 1889, for political reasons solely, the name alone was changed to that which it now bears, viz., "Department of Geology and Natural Resources." These papers on natural history have, we believe, been of especial use and interest to teachers and pupils in the public schools of the State, inciting them to a closer study of some of the many forms of life which inhabit the surface of our domain. In the present volume, therefore, two brief papers are offered. The first entitled "A Preliminary List of the Arachnida of Indiana," etc., is by Nathan Banks, of Washington, D. C., assistant entomologist of the U. S. Department of Agriculture, and a well known authority upon spiders and allied forms. This paper is based upon a collection of spiders made in all parts of the State by this Department, and is accompanied by keys to families and genera of spiders, which will enable the student to identify these interesting forms so common everywhere in both city and country.

The second paper, by Mr. E. B. Williamson, of Bluffton, Indiana, contains many interesting facts regarding the life history of the crayfish of Wells County, and also a description and illustrations of an undescribed species from that region.

THE NATURAL RESOURCES OF THE STATE OF INDIANA.

BY W. S. BLATCHLEY.

The natural resources of the State of Indiana, as of any other restricted area of the earth's surface, may be classified into two great groups. The first of these consists of those forms of matter which have stored within themselves potential energy in the form of heat. When this is set free by combustion and then controlled by some device of man, it is used by him to perform the work of the world. Such natural resources are called *fuels,* the most important of which, as found in Indiana, being *coal, petroleum* and *natural gas.*

The second group of natural resources consists of those forms of matter which are devoid of any kind of stored energy which may be set free by combustion, but which are themselves used by man for varied and important purposes. They comprise the *raw materials,* which he fashions into varied forms for the use of the world. The most valuable members of this group found in the State are *limestones, sandstones, clays* and *marls.* Other and less important members are sands, iron ores, mineral paints, etc.

FUELS OF THE STATE.

At the present time the relative importance of any State or Nation in the world is very largely determined by the amount of available fuel which that State or Nation possesses. The fuels of Indiana, viz., *coal, petroleum* and *natural gas,* are valuable only for the stored energy which they contain. How came that energy within their matter? When was it there confined? Let us try to answer briefly these two questions.

Matter and energy are the two things which comprise the universe. *Matter* is anything which occupies space, as stone, water, gas. *Energy* is that which produces, changes or destroys motion in matter. In other words, it is the power of doing work. Energy exists in a number of different forms, as heat, light, electricity, gravitation, etc.

About the year 1800, man began to study more closely than ever before both matter and energy, and as a result he made, during the nineteenth century, many important discoveries concerning them. The two greatest of these discoveries, which, more than anything else will make that century famous throughout all time—are embraced in those grand natural laws known as the "Law of the Indestructibility of Matter," and its correlative, "The Law of the Conservation and Correlation of Energy."

The first of these laws merely asserts that "*Matter cannot be created, cannot be destroyed:*" that the same amount, the same number of tons, pounds, ounces, yea, even grains, exists in the universe to-day as existed at the beginning of time. If the reader can bring himself to understand this great law and all that it embodies; to feel and know that every particle of soil, clay, stone or coal on, or in the earth has been formed from matter already in existence; that every living plant or animal is made up of matter which has existed for thousands, aye, millions of years, and much of which has been used over and over again in the structure of previously existing animals and plants, he will have gotten the main idea of this law, and will be the better able to understand many of the statements in the pages which are to follow.

The law of conservation and correlation of energy asserts: "*That energy, like matter, cannot be created, cannot be destroyed, but that one form can be changed into any other form.*" In speaking of the natural fuels of the State, it is this law which we must ever bear in mind, as stored in these fuels is found the heat or energy which will drive the engines and turn the wheels for future generations. Man can invent no new forms of energy, nor can he produce a single iota of energy. He can only devise machines for setting free, and transmuting or changing forms already existing into other and more available forms.

Another great truth which has become fully understood only in recent years, but which is very important in this connection, is that the *sun is the source of all the energy used in performing the work of the world.* From the sun comes heat and light which fall upon the grass and grain and trees of the earth and furnish the power or force necessary for their growth. The plants use the heat and light to assimilate their food and promote their powers of vegetation, and at the same time they store up these forms of energy within their cells.

Suppose, for example, that 1,000 calories (heat units) of heat are used in producing an ear of corn. When the ear is mature, that amount of heat, no more, no less, is stored up within its cells. This heat can be made available to perform work for man in two ways; (a) By burning the corn in a furnace, when the heat will be freed and can be used to generate steam which in turn will cause wheels to revolve. (b) By feeding the ear of corn to a horse, in whose body the heat will be changed into muscular energy which can be exerted in turning wheels or in pulling loads. Or man himself can eat the corn, and the heat which is stored up in it will in his body be changed into muscular and mental energy. Thus the muscular force with which these words are written and the mental energy necessary to evolve the thoughts which they comprise, can be traced back to the sun's heat, which somewhere, in days gone by, fell upon and was stored up by plants, which directly or indirectly have formed the recent food of the writer. In other words we move muscles and think thoughts with the energy derived from the sun's heat and light.

The falling waters pulled by the force of gravitation down to the level of the sea, and on their way doing work for man by turning the wheels of many forms of machinery, were raised from the ocean by the heat of the sun; while the winds which bore those waters in the form of clouds to the higher levels of the land also owe their power of movement to the unequal heating of the atmosphere by the sun's rays. Every ounce of steam and every current of electricity utilized by man is therefore derived from or produced by the sun's heat.

Plants alone have the power of thus storing up the energy of the sun's light and heat. Animals are wholly lacking in this power, and can only utilize the energy so stored by plants. The vegetable cell is thus a storer of power, a reservoir of force. It mediates between the sun, the sole fountain of energy, and the animal life on the globe. The animal cannot use an iota of power that some time, either directly or indirectly has not been stored in the plant cell. This storage is forever going on. Of the vast floods of energy that stream forth from the sun's disk in the form of heat and light, an insignificant fraction is caught up by the earth as it revolves in its orbit. Of the little fraction that the earth thus arrests an equally insignificant part is used directly in plant growth. Yet the entire productive force of the living world turns on this insignificant fraction of an insignificant fraction.

Bearing in mind this great truth, we can better understand how in ages past the sun's light and heat were locked up in the cells of those plants which flourished in the swamps of the old Carboniferous age. For thousands of years it accumulated within their stems and leaves and spores, and when, by the processes of nature, the plants were changed into coal, it still remained, a most valuable heritage for future man.

In the same way the heat stored up in the petroleum and natural gas of the Trenton rocks came from the sun and was stored in the cells of those countless smaller forms of plants which grew on the margins or in the waters of the ancient Silurian seas. Animals used these plants for food, and so received the heat, and when they died, by a process of slow destructive distillation, the carbonaceous matter within their bodies was changed with its imprisoned heat into the gas and oil now so valuable as fuels.

We have thus seen that a fuel is but a form of matter containing within itself a stored supply of potential energy in the form of heat. This stored energy is the richest inheritance which has come down to man from the ages past. Millions of years have been necessary for its accumulation. At the present rate of consumption a few thousand will suffice for its total dissemination. We are drawing upon it with a lavish hand. It came to us without great labor, as comes oftentimes the accumulated riches of a toiling and thrifty parent to a spendthrift son and, as with the latter, "come easy, go easy," seems to be our motto.

The most important thing to remember in treating of these natural fuels is that *no coal, no oil, no natural gas is being formed beneath the surface of our State to-day.* Our present supply of each of these fuels will never increase, but ever diminish. Each constitutes a great reservoir or deposit of reserve energy upon which the people of the present generation are daily drawing without adding thereto. Like a bank account under the same conditions, it is only a question of time until it will become exhausted.

Coal.—Seven thousand square miles, or nearly one-fifth of the area of the State of Indiana, is underlain with coal.* This area is found in the western and southwestern parts of the State, and ranges from ten to sixty miles in width. It lies west of a line passing through Williamsport, Greencastle, Paoli and a little to the east of Cannelton. There are between 20 and 30 horizons at which coal occurs, of which five contain workable coal over large areas, and not less than seven others contain work-

*For a detailed account of the coal fields of Indiana, with maps and charts showing the distribution and thickness of the different veins, full analyses, etc., the reader is referred to the "Coal Deposits of Indiana," by Dr. George H. Ashley, published in the 23d (1898) annual report of this Department.

able coal over small areas. The workable coal runs from three to ten feet in thickness. The upper beds or "bituminous" coals average between four and five feet thick, while the lower or "block or semi-block" beds average three feet one inch. The upper beds occur in large basins, often hundreds of square miles in area, through which they often maintain great uniformity of thickness and minor detail. The lower beds are characteristically in small basins, often of only a few acres, but some with an area of several square miles. The coal in these basins is thick in the center and thins toward the edges.

The Indiana coal field is a part of what is known as the *Eastern Interior Coal Field,* which comprises 46,000 square miles, in central and southern Illinois, northwestern Kentucky and southwestern Indiana. It occupies an elliptical basin with a center in southeastern Illinois toward which the different layers of rock slope or dip from every direction. The Indiana field being on the eastern edge of the basin, all the coal and other rocky beds tend to dip or get deeper toward the southwest or center of the basin. The result of this is that along the eastern edge of the Indiana field only the lowest coal bed is found. Going westward, this descends at the rate of about 24 feet to the mile, and gradually the other beds set in, until, along the Wabash River, the lowest bed may be 700 or 800 feet below the surface, and as high as 16 other beds have been found above it in a single drilling, the total thickness of the coals in this case being over 32 feet. As a rule, not more than one or two workable beds will be found at any locality, and at many points, constituting together perhaps one-fourth of the field, none of the underlying beds are workable. In a few cases three or more beds are workable at a single point.

For convenience, the Indiàna coal field may be considered as occupying four belts or areas which merge one into the other. The eastern edge of the field includes eastern Fountain and Parke; western Putnam and Owen, and the eastern four-fifths of Greene, Martin, Dubois, Orange, Crawford, Spencer and Perry counties. Most of this area is hilly, and contains but limited quantities of workable coal. The lower, pockety coals are nearing outcrop, so that most of the mines are small and worked by drifting. These coals tend to be block or semi-block in character.

West of this belt is another from 10 to 20 miles broad, where the coals are still shallow, the mines seldom reaching a depth of 100 feet. The coals are block or semi-block and, though in pockets, are largely workable. The surface of this belt is flat or rolling. It crosses western Fountain, central Parke and Clay, western Greene, central Daviess and eastern Pike and Warrick counties.

Still west of this is a third belt, 10 to 20 miles wide, where the upper coals are near outcrop and are extensively mined. The coals in belt two are here deeper and, as a rule, not workable. Most of the larger mines of the State are in this and the preceding belt. This third belt covers Vermillion, southwestern Parke, Vigo and western Clay, eastern Sullivan and Knox, western Daviess, Pike and Warrick counties.

Gibson, Vanderburgh and Posey and western Sullivan and Knox counties comprise a fourth belt or area, where the upper coals are generally workable but deep; the mines, as a rule, being 250 feet or more in depth. The lower coals are here usually thin. On account of the surface rocks in this area showing little or no coal, the impression is general that there is but little coal in this belt. The data at hand lead to the conclusion, however, that not only is this view erroneous, but that this area will some day prove the richest part of the Indiana field.

The most active mining regions at present are in Clay and Vigo, southern Parke and Vermillion, eastern Sullivan, western Greene and northeastern Knox counties. The quantity of coal in Clay and Greene is not great, but will yet last for many years. Parke and Vermillion counties have somewhat larger quantities. The coal of Vigo and Sullivan counties, though long and extensively mined, has hardly as yet been touched. This is still more true of Knox, Gibson and Vanderburgh counties. Pike County has a bed of unusual thickness outcropping or very near the surface, but as yet hardly touched. The same bed is present in Warrick County, though not covering as large an area. Daviess County still has much workable coal, but in thin beds. Limited areas of unmined block coal exist in southeastern Parke and western Clay counties, and near Patricksburg, Owen County.

The presence of a hitherto unknown basin of block coal comprising some 12,000 to 14,000 acres in southern Clay County, was proven by sixteen test bores and a shaft sunk in 1906. This basin lies near Howesville, and is penetrated by the new division of the C. I. & L. (Monon) railway, which extends from Quincy to Linton. The bed runs from three and a half to four feet in thickness, and the coal is said to be up to the average of the best Brazil block coal in quality.

The block coal, wherever found, is one of the most valuable fuels in the State. It possesses a laminated structure, and is composed of alternate thin layers of vitreous, dull black coal and fibrous mineral charcoal. It can be mined in blocks as large as it is convenient to handle. These blocks split readily in the direction of the bedding plane, but in the opposite direction are broken with difficulty.

It is as pure as splint coal, is almost free from sulphur or phosphorus, and has the softness and combustibility of wood. In burning it swells so little that its expansion is scarcely perceptible, does not change form, and never cakes or runs together; hence, it is a most valuable fuel for the blast furnace and the cupola of the iron founder.

For steam and household purposes it has an unrivaled reputation. It burns under boilers with a uniform blaze that spreads evenly over the exposed surface, thus securing a more uniform expansion of the boiler plates. Its lack of sulphur also causes it to have but little detrimental effect upon the boiler, grates or fire boxes. In household grates it burns with a bright and cheerful blaze, like hickory wood, making a very hot fire which, for comfort and economy, cannot be surpassed by any fuel except an abundant supply of natural gas.

The bituminous coals of the State, which far outrank the block coals in abundance, are also of excellent quality. Realizing some years ago that the natural gas supply of the State was going to fail. and wishing to retain as many of the factories in Indiana as possible, I had average samples of coal collected from 19 of the leading mines of the State. These were sent to Dr. W. A. Noyes, of the Rose Polytechnic Institute at Terre Haute, who made a complete chemical analysis of each and at the same time determined its heat value and steam producing value. Seven samples of Pittsburg and West Virginia coals were also secured from the Marmet Coal Company, of Cincinnati, Ohio, and the same facts concerning them were determined in order that a comparison could be made of analyses determined under the same conditions. The results of these analyses are herewith given as follows:

ANALYSES OF INDIANA COALS.

Number.	COUNTY.	NAME OF COAL AND OWNERS.	Total Combustible Matter.	Volatile Combustible Matter.	Fixed Carbon.	Moisture.	Ash.	Sulphur.	Heating Effect—Calories per Kilogram, Calculated.	Heating Effect—Calories per Kilogram, Berthier's Test.	Evaporative Effect—Pounds of Water per Pound of Coal.
1	Vanderburgh	Sunnyside Coal and Coke Company, Evansville (V)	86.73	38.59	48.14	6.44	6.83	1.85	6,924	6,759	12.9
2	Warrick	Deforest mine (V)	84.16	39.09	45.07	6.08	9.76	2.14	6,705	6,339	12.5
3	Knox	Edwardsport Coal mine Edwardsport Coal and Mining Co. (VI)	82.03	36.00	46.03	8.75	9.22	3.08	6,495	6,345	12.1
4	Knox	Bicknell mine, Bicknell Coal Company (VI)	83.76	35.22	48.54	7.61	8.63	1.67	6,692	6,489	12.5
5	Daviess	Cabel & Kauffmann (V)	87.15	37.99	49.16	6.50	6.35	1.85	6,958	6,981	13.0
6	Sullivan	Star City (VI)	87.30	38.53	48.77	9.40	3.30	1.23	6,995	7,002	13.0
7	Sullivan	Alum Cave (V)	84.77	42.60	42.17	6.49	8.74	3.18	6,712	6,894	12.5
8	Greene	Buckeye or Fluhart, Linton Coal and Mining Company (IV)	86.79	35.69	51.10	7.81	5.40	0.72	6,974	6,618	13.0
9	Greene	Summit mine, Dugger and Neil Coal Company (IV)	87.54	35.30	52.24	7.44	5.02	0.61	7,041	6,852	13.1
10	Greene	Island City mine No. 1, Island City Coal Company (IV)	86.47	35.97	50.50	7.12	6.41	0.84	6,944	6,819	13.0
11	Vigo	Ray mine, Seeleyville, Vigo County Coal Company (VI)	84.46	40.25	44.21	7.57	7.97	4.01	6,656	6,762	12.4
12	Clay	Gart No. 5 shaft, Brazil Block Coal Company (III)	85.27	36.11	49.16	11.20	3.53	0.62	6,856	6,774	12.8
13	Clay	Brazil Block No. 1 shaft, Brazil Block Coal Company (III)	85.12	45.16	49.96	13.82	1.06	1.47	6,810	6,888	12.9
14	Clay	Eureka mine No. 1, Carbon, Eureka Block Coal Company (III)	86.74	36.32	50.42	9.80	3.46	0.34	6,985	7,050	13.1
15	Clay	Crawford No. 3 mine, Crawford Coal Co. (III)	84.58	36.34	48.23	11.26	4.16	0.56	6,803	6,858	12.7
16	Clay	Columbia No. 2 mine, Teller, McLelland & Co. (III)	89.52	36.75	52.77	7.47	3.01	0.57	7,202	7,344	13.4
17	Owen	Lancaster No. 4 mine (III)	83.85	36.45	47.40	12.73	3.42	0.55	6,744	6,636	12.6
18	Parke	McIntosh No. 1 mine, near Diamond, I. McIntosh & Co. (III)	87.70	36.69	51.01	8.21	4.09	0.95	7,039	7,008	13.1
19	Parke	Cox No. 3 shaft, "bituminous," Brazil Block Coal Co. (VI)	88.33	41.88	46.45	6.49	5.18	2.93	7,009	6,897	13.1
20	Pittsburg coal	Beck's Run, first pool, Hays Coal Company	96.06	36.01	60.05	2.09	1.85	0.64	7,726	....	14.6
21	Pittsburg coal	Anchor, fourth pool, Beaumont Coal Company	89.84	35.30	54.54	1.30	8.86	0.45	7,230	....	13.5
22	Pittsburg coal	Caledonia, fourth pool, T. J Wood	90.26	35.22	55.04	1.35	8.39	0.69	7,256	....	13.5
23	Pittsburg coal	Stony Hill, fourth pool, John D. Nixon	92.74	35.46	57.28	1.11	6.15	0.56	7,462	....	13.9
24	Pittsburg coal	Little Redstone, fourth pool, Little Redstone Coal Company	91.08	35.88	55.20	0.98	7.94	0.82	7,316	....	13.7
25	West Virginia coal	Raymond, Marmet Smith Coal and Mining Company	91.16	40.14	51.02	3.20	5.64	2.25	7,266	....	13.6
26	West Virginia coal	Belmont, Belmont Coal Company, Belmont, W. Va	90.04	37.84	52.20	1.45	8.51	0.46	7,248	....	13.5
		Average of Indiana Coals	86.36	38.22	48.14	8.45	5.61	1.52	6,879	......	12.8

A comparison shows the quality of the Indiana coals to be much better than expected; the average steam producing value, or evaporative effect, of the nineteen samples being 12.8 pounds, as against 13.7 pounds, the average for the foreign coals. The small value of .9 pound in favor of the Pittsburg coals is more than offset by their additional cost of transportation.

In 1898 Dr. George H. Ashley, after a careful survey of the coal area of Indiana, estimated that there were 40 billions of tons of coal in the State, of which one-fifth, or eight billions of tons, were workable under present conditions. The distribution of this coal by counties was given by Dr. Ashley as follows:

DISTRIBUTION OF AVAILABLE COAL IN INDIANA BY COUNTIES.

COUNTY.	Number of Coals Contained.	Greatest Thickness Recorded.		Area Underlain by Coal, in sq. miles.	Area Underlain by Workable Coal in square miles.	Estimated Total Tonnage of Coal.	Estimated Total Tonnage of Coal removed or rendered Unworkable.	Estimated Total Tonnage of Workable Coal Left.
		Ft.	*In.*					
Warren	4	4	2	300	30	472,000,000	60,000	43,500,000
Fountain	7	8	+	325	75	500,000,000	2,733,000	128,750,000
Montgomery	1	....		½	0	100,000	0	0
Putnam	2	3	0	C.M.100	¼	56,000,000	25,000	1,800,000
Parke	11	7	6	C.M.470	100	1,000,000,000	12,000,000	424,000,000
Vermillion	11+	7	0	250	100	1,457,600,000	5,350,000	441,000,000
Owen	4	6	1	125	30	67,000,000	600,000	15,000,000
Clay	14	8+		250	100	1,000,000,000	50,000,000	150,000,000
Vigo	11	7+		400	300	3,375,000,000	6,500,000	1,000,000,000
Greene	9	7		300	50+	1,000,000,000	4,000,000	150,000,000
Sullivan	9+	9+		440	365	4,650,000,000	9,000,000	950,000,000
Martin	7?	4		175	14	330,000,000	300,000	20,000,000
Daviess	15	7	3	400	200	2,378,000,000	5,250,000	320,000,000
Knox	15	6+		540	300+	7,000,000,000	760,000	950,000,000
Orange	2	2	8	1	¼	840,000	200	200,000
Crawford	3	4		12	½	9,200,000	None?	400,000
Dubois	9	5		300	40	947,000,000	87,000	52,500,000
Pike	10+	10	2	330	200	1,836,000,000	1,293,000	630,000,000
Gibson	10+	7	7	450	400	6,675,000,000	66,000	1,175,000,000
Perry	7	5	8	30	6	36,500,000	3,400,000	8,750,000
Spencer	7	5	10	300	25	1,000,000,000	200,000	50,000,000
Warrick	8	9	0	356	175	2,000,000,000	2,000,000	345,000,000
Vanderburgh	7+	4	6	240	200	2,258,000,000	3,000,000	835,000,000
Posey	6+	2	6	420	200	1,600,000,000	None	400,000,000
Total	27‡	10	2	6,508	3,051	39,618,240,000	106,024,200	8,090,900,000
Approximately	27+	10		6,500	3,000	40,000,000,000	100,000,000	8,000,000,000

Total area surveyed, about 9,000 square miles.*

*Ashley, 23 Rep. Ind. Dep. Geol. and Nat. Res., 1898, p. 1422.

It was estimated that up to the year 1899, 100 million tons, 1-400 of the total amount, or 1-80 of the workable amount had been mined.

Since that date 70,213,404 tons have been mined, the output for each year to January 1, 1907, being as follows:

Year.	*Tons produced.*
1899	5,864,975
1900	6,283,063
1901	7,019,203
1902	8,763,197
1903	9,992,563
1904	9,872,404
1905	10,995,972
1906	11,422,027

It was estimated by Dr. Ashley that if the past rate of increase of production be maintained, the coal supply of Indiana would last not less than three hundred years. Owing to the rapid failure of natural gas the rate of increase of production was greatly enlarged, fully seven-tenths as much being mined in the last eight years as in the previous fifty years. During the past four years the output has been more steady, averaging a little above ten million tons per annum, and from now on a smaller and more regular rate of increase will doubtless be maintained. In the words of Dr. Ashley: "Constantly improving methods will tend to lengthen the life of the field by securing a larger proportion of the coal in a given area and by rendering workable much coal now considered unworkable. On the other hand, changes and exhaustion of competing fields and the invention of better methods of utilizing the Indiana coal, by increasing the demand, will tend to shorten the life of the field. On the whole, it seems safe to assume that the life of the Indiana coal field is at least 300 years, and probably more."

Finally, it may be said that the human mind cannot conceive the vast amount of energy at present locked up in the coal fields of the State, nor place anything like an accurate value upon it. The richest men of the nation to-day are those who have utilized the stored energy found in coal in years gone by; who have bought this energy at low prices, and either sold it in the form of manufactured articles at many-fold its cost price, or used it in transporting, for hire. man and his products to the four quarters of the globe.

Not being familiar with the production and use of "producer gas," I asked Mr. W. H. Duncan, Secretary of the Terre Haute Commercial Club, to prepare a brief statement regarding such gas for this paper, as at Terre Haute such gas is made and used in quantity in the glass furnaces. He kindly agreed to do so, and has furnished the following statement, which is herewith printed just as handed in by him:

Producer Gas.—Producer gas was first brought into use some thirty years ago, and has been applied with such marked economy for so many purposes that it is now considered essential to the prosecution of many lines of industry, notably steel works, rolling mills, smelting furnaces, glass works and chemical works. During the life of the natural gas fields producer gas received little attention in Ohio and Indiana, though used to considerable extent in Pennsylvania and Illinois. However, since the failure of natural gas manufacturers everywhere realize that the only staple and reliable source of heat on a large scale is coal, and that the most satisfactory method of utilizing its heat is to first convert it into gas.

The manufacture of producer gas is by no means difficult. A gas producer is perhaps the simplest of all metallurgical furnaces; in fact almost any vessel capable of containing a deep bed of incandescent coal through which a current of air, or air and steam, can be forced or drawn is a good producer. In the gas producers as they are now constructed the fixed carbon is consumed in the producer. The volatile matter, together with a certain portion of the fixed carbon, in the form of carbon monoxide, is conveyed to the melting furnace, where it is desired to utilize the fuel. As producer gas is not a fixed gas it must be used while hot; it cannot be carried to exceed 1,000 feet from the producer to the furnace.

Until quite recently anything in the form of a closed box with a grate under it was considered good enough for a gas producer—in fact this was the only kind used in Indiana previous to the failure of natural gas. After that came a change, and now there are a dozen or more styles made by as many different firms, each having its friends.

The ordinary gas producer used for operating glass, iron or steel furnaces consists of an iron shell made of sheet iron, measuring ten feet in diameter and twelve feet in height. It is lined with fire brick, having a suitable grate in the bottom and cast iron plates covering the top, with hoppers for receiving the coal. A bed of fuel is maintained from three-and-a-half to four feet in height above the grate. A steam injector is used for forcing air and steam through the grate at the bottom, and the coal is fed through the hopper at the top in small quantities, at short intervals, the object being to consume a portion of the fixed carbon in order to maintain sufficient heat to distill the volatile gases as the coal is deposited on top of the fuel bed. The gas is led up through an opening in the side of the producer near the top, where the pipes connect to convey the gas to the furnaces. The producers are usually constructed in batteries, and a number of producers can be connected with one main gas flue. The operation is simple, no purifying process being used, and the soot and tar which accumulates in the pipes must be cleaned out once a week. The cost of producers varies from $1,000 to $1,800, exclusive of outlet and steam connections, according to make and size. A good one which will consume twelve tons of run-of-mine coal per twenty-four hours will cost $1,400, and one of fifteen tons capacity will cost $1,600.

The results obtained vary according to the producer and the coal used. With the old style producer still used in Indiana thirty tons of Indiana coal make producer gas sufficient to heat 100 tons of iron for rolling purposes, the heat required being 2,700 degrees. An authority on producer gas says that in the glass business the manufacturer can count on three-fourths of a pound of coal per pound of glass. (In this connection it may be mentioned that the melting point of silver is 1,733°; gold, 1,913°; copper, 1,929°; cast iron, white, 2,075°; cast iron, gray, 2,228°; glass, 2,390°; steel, hard, 2,570°; steel, mild, 2,687°.) Thirty tons of coal to 100 tons of iron is 600 pounds per ton of iron, while, as above stated, glass men can figure on three-fourths of a ton of coal to each ton of glass in the melting process. But the latest producers bring ample proof that they can accomplish 50 per cent. better results than can be obtained by the old process, which means that with thirty tons of our Indiana coal they can make a sufficient quantity of gas to heat 150 tons of iron—400 pounds of coal per ton of iron, which is certainly cheap enough with run-of-mine coal a dollar per ton delivered on the cars at the factory.

The amount of gas produced from a ton of coal varies with the composition of the coal, and also largely with the proportion of steam used in blowing the producer. On the average it is assumed that in Pennsylvania one ton of anthracite buckwheat coal produces about 170,000 cubic feet of gas, containing 138,000 heat units per 1,000 cubic feet. The volume of producer gas from bituminous coal is about the same, but it runs 157,000 heat units per 1,000 cubic feet. One thousand cubic feet of natural gas contain 1,100,000 heat units, which, in point of strength, would make one foot of natural gas equal to seven feet of producer gas. The analyses of the Pennsylvania coals from which these results are taken make the following showings: Fixed carbon, 57 to 60 per cent.; volatile matter, 33 to 38 per cent.; ash, 3 to 5 per cent.; sulphur, 1 to 1¾ per cent. Taking the analyses as a criterion the coals of Indiana are much better than those of any other portion of the west, and compare very favorably with those of Pennsylvania. The Indiana coals contain a higher percentage of volatile matter than those of Pennsylvania, and are somewhat lower in fixed carbon, while in sulphur much of the Indiana coal is superior to that of Pennsylvania. Recently a Pennsylvania producer gas expert came out to Indiana on a tour of investigation. He had never seen any of the Indiana coals before, and after having spent several weeks in various portions of the State, went away with a high opinion of our products. The Greene County, Sullivan County, a portion of Parke and Vigo County coals he pronounced equal to any he had seen anywhere for producer gas purposes, and said they were all far superior to any other found in the west.

Not only are the Indiana coals of good quality for producer gas purposes, but can be converted into a quality of fixed gas which can be used to great advantage in operating machinery. At a recent trial at the government testing plant at St. Louis, it was demonstrated that 2,575 pounds Vigo County coal, converted into fixed gas, operated to its fullest capacity for ten hours continuously a gas engine of 240 horse power.

Petroleum.—Crude petroleum, one of the most valuable of natural fuels, has been produced in commercial quantities in Indiana since 1890, when the first producing well was sunk near Keystone, Wells County. From that time to the present the area of the main Indiana oil field has gradually increased until now it covers an area of 1,280 square miles in the south half of the northeastern fourth of the State.

Throughout this area the oil occurs in porous strata or "pay streaks" of the Trenton limestone at depths ranging from 900 to 1,350 feet below the surface. From this limestone there was produced in the sixteen years from 1891 to 1906, inclusive, the enormous total of 85,109,048 barrels, which sold for $70,999,592, or an average of $4,437,474 per year.

The low average price, the discovery of oil in large quantities in Illinois, and other minor reasons, caused the output of Trenton rock petroleum in Indiana in 1906 to decrease, the output being but 7,762,825 barrels, or 3,129,613 barrels less than in the year preceding. This brought, on the market, $6,877,863, an average of 88 3-5 cents per barrel.

The causes above mentioned prevented the sinking of as many wells in 1906 as in the year previous, there being but 1,132 new bores put down as against 1,882 in 1905. Of these 124 were dry. Of the producing wells, the average initial output was 14.6 barrels to the well, as against 20.6 in 1905.

In addition to the Trenton rock petroleum, there is produced from a limited area about Princeton, Gibson County, in the southwestern corner of the State, a crude petroleum from the Huron sandstone, one of the Lower Carboniferous or Mississippian formations. The output of the Princeton field in 1906 was 103,843 barrels, valued at $81,771.

A few wells in or near Terre Haute, Vigo County, also yield crude petroleum from the Corniferous limestone of the Devonian formation. The output of these wells for the year was 7,269 barrels, valued at $8,456.

Unless the area of production be much increased, the output of petroleum from the Indiana fields will from now on gradually dwindle, as several thousand new bores are necessary each year in order to offset the decrease in output of those already producing. These are possible only when the market price is such as to stimulate the producer and guarantee him a fair profit on his capital invested. Whether or not any new productive area of consequence will be added to that already known only the future use of the drill will show; since the great depth at which the oil bearing strata lie makes it imposible to guage from the surface their area and content.

Natural Gas.—One of the most valuable and convenient fuels known to man is natural gas, the volatile part of crude petroleum. During the ages which have elapsed since the petroleum was formed in the depths of the Trenton and other rocks of Indiana, large portions of it volatilized or changed into gas. Wherever possible, this gradually rose and passed into the higher porous portions of the limestone, where it was held by either petroleum or salt water behind it. From its discovery in Indiana in 1886 the field was gradually developed until it reached an area of approximately 2,500 square miles, embracing part or all of seventeen counties near the center of the eastern half of the State. The original rock pressure was 350 pounds and some of the wells yielded 12 to 14 million cubic feet per day.

In the early history of the field there was an enormous waste, some of the wells being turned on full blast and allowed to burn as an advertisement. It was estimated that in the last six months of the year 1887, fifteen billion cubic feet of gas, worth, at an extremely low estimate, $1,500,000, was wasted in this manner in the Indiana field.

So greedy was the citizen of the gas belt in those days, so ignorant of the real value of this gaseous fuel and the manner of its formation, so reckless in its consumption, that at the end of a score of years there remains only the dregs of the plenty that has been.

The value of the gas produced in the State slowly increased until 1900, when it began to decrease. The output had begun to dwindle several years before this, but about 1898 it began to be sold by metre measurement. Under this system the producer received about five times as much per thousand for his gas as under the old flat rate system everywhere in vogue during the palmy days from 1887 to 1900. As a consequence, while the production has fallen off very greatly, the total value still represents a considerable amount.

The following table shows the value of natural gas produced in Indiana during the 20 years from 1886 to 1905, inclusive:

VALUE OF NATURAL GAS PRODUCED IN INDIANA, 1886–1905.

Year.	Value.	Year.	Value.
1886	$300,000	1897	$5,009,208
1887	600,000	1898	5,060,969
1888	1,320,000	1899	6,680,370
1889	2,075,702	1900	7,254,539
1890	2,302,500	1901	6,954,566
1891	3,942,500	1902	7,081,344
1892	4,716,000	1903	6,098,364
1893	5,718,000	1904	4,342,409
1894	5,437,000	1905	3,094,134
1895	5,203,200		
1896	5,043,635	Total	$88,234,440

At the present time there are but few attempts made at drilling for gas exclusively, the greater proportion being secured while drilling in search of oil. The majority of the manufacturing plants in the "Gas Belt" of the State have been forced to abandon natural gas as fuel and to substitute coal, wood or manufactured gas, or seek new localities where cheaper fuel is available. Occasionally a fair gas well is found where a limited reservoir has escaped previous notice, but the lives of such wells are usually short, owing to the limited area upon which they have to draw.

Pumping stations which artificially exhausted the gas and thereby created a vacuum in the porous strata, thus allowing the water to flow in and drown out the fuel, have caused the abandonment of much territory which would otherwise be still productive. The poor plugging of abandoned wells has also been a partial cause of failure of the supply in many parts of the field.

Every one will admit that the highest use to which natural gas can be put is that of household consumption, especially in cook stoves. With no kindling, no replenishing, no ashes, no soot, the duties of the housewife are decreased many fold. For this reason every effort should be made to husband the present supply by stopping at once all unnecessary use or wanton waste. Any attempt to evade the law relative to the waste of gas should be promptly reported to the proper officers. Even yet an occasional oil operator is found who pipes the gas into a pile of brick and burns it, hoping thereby to keep himself within the pale of the law. All such persons are wholly lacking in public spirit, and devoid of every feeling which tends to advance the interests of humanity.

It must also ever be remembered that with both natural gas and petroleum we are drawing upon stored products which are not being increased a single iota, and that therefore the end of the supply of both is sure to come.

RESOURCES OTHER THAN FUELS.

LIMESTONES.

*The Indiana Oolitic Limestone**.—For her output of building and ornamental limestone Indiana far outranks any other State in the Union. The Indiana oolitic limestone, otherwise known as the Bedford Oolitic Limestone, the Salem Limestone, etc., has long been known among architects for its strength and durability. Within the past decade the demand for it has been rapidly increasing, and it is now in use in twenty-nine states, and three foreign countries. Four State capitol buildings, those of Indiana, Illinois, Georgia and New Jersey, have been constructed wholly or partly from it, as have also 31 court houses in Indiana, and numerous custom houses, postoffices, hotels and other public buildings throughout the United States. The Soldiers' and Sailors' Monument, at Indianapolis, with its magnificent carved groups of statuary, is composed wholly of it. In New York and other eastern cities it is also used extensively in the construction of the private residences of many of the more wealthy citizens. Its wide reputation is due to its general usefulness in masonry, ornamentation and monuments; its abundance; the ease with which it can be quarried and dressed, and its pleasing color and durability.

*For a detailed account and maps of the area containing the oolitic stone, and also full data relative to its production for the market, the reader is referred to the paper by Messrs. Hopkins and Siebenthal in the 21st (1896) Annual Report of this Department.

This stone is geologically a member of the Mississippian or Lower Carboniferous formation and occupies a strip of territory from two to 14 miles in width which extends from Greencastle, Putnam County, to the Ohio River. It occurs in a stratum varying from 25 to nearly 100 feet in thickness. This stratum is massive in many places, being without bedding or lamination planes from top to bottom, so that the size of the blocks which may be quarried is limited only by the capacity of the quarry machinery and transportation facilities. There are, however, in many quarries and all outcrops one or more systems of vertical or nearly vertical joint seams, which occur 20 to 40 feet apart. These and the presence of peculiar suture joints, known as "stylolites," "crow feet," "toe nails," etc., often cause a great deal of waste and annoyance in quarrying.

The principal working quarries of the oolitic stone are located near Romona, Owen County; Stinesville, Ellettsville, Bloomington and Sanders, Monroe County; Oolitic, Dark Hollow and Bedford, Lawrence County; Salem, Washington County and Corydon, Harrison County. Within the past five years many quarries have been opened along Clear Creek in the southern part of Monroe County, and this region has become one of the richest productive areas of oolitic stone in the State.

Few building stones are more accessible than the Indiana oolitic limestone. Occurring as it does in an almost horizontal position and in the driftless portion of the State, it outcrops over a comparatively large area, with either no covering at all or one so light that it can be readily removed.

The C. I. & L. (Monon) Railway traverses the area from north to south over its most productive part, and there are also three east-west railroads and a short line known as the Belt, which serves to connect many quarries around Bedford with the other roads. There are also short branch roads, making switch connections with one or more of these roads, running into each of the quarries. The Indianapolis Southern Division of the Illinois Central Railway recently completed, will soon construct a spur from Bloomington south into the main quarry district of Clear Creek Valley.

The oolitic stone is a granular limestone, or calcareous sand rock in which both grains and cementing principle are carbonate of lime. In the common sandstones of the State the grains are hard and nearly angular. In the oolitic stone they are always soft and either round or rounded. and the cement is harder than the grains. In color the stone is either buff or blue. Its specific gravity is about 2.47, and its weight about 152 pounds per cubic foot. In chemical composition it is nearly pure carbonate of lime, the *average* of eight analyses of specimens from eight of the leading quarries showing the following percentage composition: Calcium carbonate, 97.62; magnesium carbonate, .61; iron oxide and alumina, .36; insoluble residue, .91. The crushing strength of 50 specimens ranged between 4,500 and 13,200, with an average of 7,000 pounds per square inch.

The fire resisting properties of the oolitic stone are also very great, as a series of experiments on one-inch cubes by this Department has proven. Heated to 1,000° F., and plunged into cold water, the cubes were not affected. Heated to 1,200° F. and plunged into cold water, the cube crumbled slightly along the lower edges. Heated to 1,500° F. and cooled in air, the cubes retained their forms intact, but were calcined in a marked degree. This shows that the stone will withstand the effects of fire to the point of calcination.

On account of its softness when first quarried, the oolitic stone can be readily sawed or carved into any form desired, and the larger companies now operate one or more saw mills in connection with their quarries. The saws in use at the various mills are largely the common gang saw with long iron blades made to swing to and fro across the stone, sand and water being fed under each saw automatically. In a number of the mills what is known as the "diamond saw" is now used to do the cutting. A heavy steel blade 10 to 12 feet in length and a foot or more wide, has its lower edge set with steel blocks about an inch square and a little thicker than the blade. Attached to each of these blocks are small black diamonds that do the cutting. No sand or other abrasive is used with this saw, and it cuts at the rate of about 30 inches per hour, as against three to four inches by the ordinary gang saw.

The larger part of the oolitic stone which is quarried is used for fine dimension stone for buildings, both for face work and trimming. It is also much used for monumental purposes, either as bases for monuments or for the shafts or both. Large quantities are used for pavements, curbing, sewer piers, abutments, etc. It makes a strong and durable pavement, and does not wear slippery. Its use for curbing for cement walks is increasing year by year in many of the larger towns of Indiana and adjoining states. Large quantities of the spalls and waste pieces from the quarries are also used annually for railway ballast.

The oolitic stone is too soft for use as macadam material on roads which are much traveled or where heavy traffic is necessary. On such a road it grinds easily into a dust which is very disagreeable in summer and full of chuck holes in winter and spring. It is by far the most valuable stone in Indiana, and many good deposits are as yet undeveloped.

In the year 1905, the output of rough building limestone from the oolitic quarries was valued at $1,155,728, while the dressed building stone from the same quarries was valued at $1,337,232, making a total of $2,492,960 for the oolitic stone industry of the State.

The Niagara Limestone.—This limestone comprises 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 south and southwestward from Newcastle, Henry County, to the Ohio River near Jeffersonville. In the vicinity of Osgood, Ripley County; Westport, New Point and St. Paul, Decatur County, and Laurel, Franklin County, are important beds of Niagara limestone, which for many years have been extensively quarried. This is locally known as the Laurel limestone, since the stone is typically exposed and has been longer worked near the town of that name.

This stone can be quarried more easily and at less expense than any other stone of a similar nature in the State; the natural seams and even bedding doing away largely with the necessity for drilling and blasting. The stone occurs in natural slabs of a uniform thickness—two to 20 inches—and with the upper and lower surfaces very even, so that for many purposes tool dressing after quarrying is not necessary. It is of a handsome color, very hard and durable, and is used extensively for bridge abutments, flagging and curbing, and to a less extent for window sills, window caps, range stones, ashlar, doorsteps, foundations, street crossings, gutter stone, pier footings, etc. For many of these uses it is better suited and can be furnished more cheaply than either the Indiana oolitic limestone or the Berea (Ohio) sandstone, the two materials with which it comes in closest competition. Across Fall Creek at Indianapolis, some of the most handsome and durable bridges in the State have recently been constructed almost wholly of this stone.

A somewhat similar stone, well fitted for curbing, flagging and paving, and occurring, as does the Laurel limestone, in layers of variable thickness, has been quarried in the immediate vicinity of Wabash, Wabash County. The deposits are large, easily and cheaply quarried, and worthy of much more extensive development.

Macadam and Concrete Stone.—Limestone well adapted for macadam and concrete making purposes occurs in many localities in central, eastern and southern Indiana.* A large number of tests made in the U. S. Road Laboratory at Washington in 1905, show that, named in the order of their superiority, the Mitchell, Huron and Niagara limestones of the State rank best for road making purposes. The Devonian limestones are in many places too soft and, as already noted, the Indiana oolitic limestone should not be used for the same reason.

The Mitchell limestone is a heavy bed of compact limestone and chert, intercalated in places with thin layers of limey shales. It is one of the divisions of the Lower Carboniferous or Mississippian formation, and its exposures occur over an irregular area three to 25 miles in width, extending through the central part of southern Indiana from the Ohio River in Harrison County, north and northwestward to the southwestern corner of Montgomery County, where they disappear beneath the drift. Chemically it is a very pure carbonate of lime, one analysis of a sample from Monroe County showing 99.04 per cent. of that compound.

The Mitchell limestone is quarried in large quantities and used for road metal, wagon roads or railways, for flagstones, for paving and curbing, for burning to quicklime and for building stone. It is one of the best road metal stones in the State of Indiana, comparing favorably with the Niagara limestone of Silurian age in this respect, but it is harder and generally superior, since the Niagara in many places has thin layers of intercalary shale which, if not separated in the quarrying, will quickly form mud on the roads.

This limestone has been used quite extensively, especially during the last few years, in macadamizing the roads in the area where it occurs. Many small quarries have been opened from which the stone has been obtained for local use. A number of large railway quarries, where the stone is taken out extensively for railway ballast or road material, are also scattered throughout its area. Each of these quarries is capable of turning out from ten to 30 carloads of crushed limestone per day.

The Huron limestones lie just west of the Mitchell, and like it belong to the Mississippian formation. There are three of these limestones with two beds of sandstone intervening. The lower Huron limestone is a compact, smooth-grained, ash-gray to blue limestone, which runs five to eight feet in thickness. In structure it is a close, fine grained, non-crystalline stone, breaking with a subconchoidal fracture. This structure renders it well fitted for mac-

* For a detailed account of the macadam industry in Indiana, see the paper entitled "The Roads and Road Materials of Indiana," in the 30th (1905) Report of this Department.

adam stone, for which purpose it has been used locally in a number of places.

The middle Huron limestone is usually a close textured, semi-crystalline, gray fossiliferous limestone, which varies in thickness from five to 30 feet, averaging about 16 feet. It also has been recently used for road material in Orange, Martin and Greene counties.

The upper limestone averages about 15 feet in thickness, is more crystalline in structure, varies from dark to light gray in color and contains many crinoid stems and remains of bryozoa. It takes a fine polish and resembles marble when so treated, but does not hold the polish when exposed to the atmosphere. On account of its crystalline structure it is not so well suited for road material as the finer grained, harder rocks of the middle and lower beds. It, however, is far better than any sandstone for road purposes, though sandstone has been used in some localities where the upper limestone was available.

The Niagara limestone already mentioned has been used more extensively for road material than any other limestone in the State. This is on account of its wide distribution rather than for any special fitness which it possesses. Numerous tests show it to rank below the Mitchell limestone in resistance to wear, though its cementing qualities are better.

The use of crushed stone for macadam and concrete work is constantly growing, and the business of preparing the stone for such uses will, in the near future, become a more important industry in many localities of the State than at present, as there are many places where the limestones outcrop in quantity close to a railway and offer excellent sites for the investment of capital. In 1905 the value of crushed stone manufactured in Indiana was $336,812, divided as follows: for road making, $222,441; for railroad ballast, $84,007; for concrete, $30,364.

Large and permanent plants for preparing material for macadam concrete, and railway ballast from the Niagara and Mitchell limestones are already located at a number of places throughout the southern two-thirds of the State. Each of these plants is situated on a spur of some railway and the stone dumped directly into the cars from storage bins. The following list of companies, with location and kind of rock crushed, is given for the benefit of those interested:

A LIST OF THE PERMANENTLY LOCATED STONE CRUSHING PLANTS OF INDIANA.

Name of Firm.	Location.	Kind of Stone.
W. F. Goff Stone Co.	Kentland, Newton County	Niagara.
Edw. Hely	Monon, White County	Niagara.
Casparis Stone Co.	Kenneth, Cass County	Niagara.
Thos. Bridges' Sons	Wabash, Wabash County	Niagara.
Wabash Stone Co.	Wabash, Wabash County	Niagara.
Erie Stone Co.	Huntington, Huntington County	Niagara.
Keefer & Bailey	Huntington, Huntington County	Niagara.
F. A. Brickley	Markle, Huntington County	Niagara.
Shoemaker Bros.	Bluffton, Wells County	Niagara.
Meyer Stone Co.	Bluffton, Wells County	Niagara.
J. S. Bowers Co.	Decatur, Adams County	Niagara.
E. Woods & Co.	Pleasant Mills, Adams County	Niagara.
Portland Stone and Lime Co.	Portland, Jay County	Niagara.
Baltes Stone Co.	Montpelier, Blackford County	Niagara.
Marion Stone Co.	Marion, Grant County	Niagara.
Chaffin Bros. Stone Co.	Kokomo, Howard County	Niagara.
Leach & Co.	Kokomo, Howard County	Niagara.
Wilson Stone Co.	Kokomo, Howard County	Niagara.
Deffenbaugh & Co.	Kokomo, Howard County	Niagara.
Interurban Stone Co.	Kokomo, Howard County	Niagara.
Delphi Crushed Stone Co.	Delphi, Carroll County	Niagara.
Pierce Stone Co.	Delphi, Carroll County	Niagara.
Armfield & Cartwright	Ridgeville, Randolph County	Niagara.
Mock Stone Co.	Muncie, Delaware County	Niagara.
Eaton Stone Co.	Eaton Delaware County	Niagara.
L. C. Nicoson	Alexandria, Madison County	Niagara.
David V. Miller	Ingalls, Madison County	Niagara.
J. D. Torr	Oakalla, Putnam County	Mitchell.
A. & C. Stone & Lime Co.	Greencastle, Putnam County	Mitchell.
Big Four Stone Co.	New Point, Decatur County	Niagara.
Greensburg Limestone Co.	Greensburg, Decatur County	Niagara.
Westport Stone Co.	Westport, Decatur County	Niagara.
St. Paul Stone Quarry Co.	St. Paul, Decatur County	Niagara.
Spencer Stone Co.	Spencer, Owen County	Mitchell.
Southern Indiana Railway Co.	Williams, Lawrence County	Mitchell.
Mitchell Lime Co.	Mitchell, Lawrence County	Mitchell.
W. W. Franklin	West Franklin, Posey County	Carboniferous limetsone.
Marengo Manufacturing Co.	Marengo, Crawford County	Mitchell.
J. B. Speed & Co.	Milltown, Crawford County	Mitchell.
Eichel Lime & Stone Co.	Milltown, Crawford County	Mitchell

*Limestone for Lime Making.**—Indiana is rich in stone suitable for making high grades of lime. No purer forms of calcium carbonate occur anywhere than that furnished by the Mitchell and Bedford oolitic stone, while the Niagara limestone in places affords a magnesium-calcium carbonate which produces a lime rich in magnesium oxide.

The outcrops of Niagara limestone along the Wabash River in the vicinity of Huntington, Huntington County; Delphi, Carroll County, and Logansport, Cass County, have proven especially suitable for the production of lime for building and other purposes. At Huntington and Delphi extensive kilns are at present in active operation.

The lime made from this stone contains about 32 per cent. of magnesium oxide and is, when burned, a dirty brownish color; but

*For a full account of the lime industry in Indiana, see the 28th (1903) Report of this Department, pp. 211–257.

when slacked it bleaches out as white as any other. It is what is termed a "cool," slow setting lime. Where used in paper factories it does not gum the cylinders or clog the cloth or "felt," as does a lime made from pure calcium carbonate. Large deposits of this magnesian stone are yet available in Huntington, Wabash, Miami, Cass and Carroll counties and offer excellent sites for new kilns.

At Mitchell, Lawrence County, and Milltown, Crawford County, large plants are engaged in burning lime from the Mitchell limestone which is the purest form of calcium carbonate in the State. The lime from this stone runs from 97.7 to 98.2 calcium carbonate, and is a quick slacking, strong lime. On account of its purity, large quantities are sold for chemical use, caustic and soap manufacture, etc.

At Milltown a hydrated lime is made from ordinary quick lime 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. 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.

The Mitchell limestone outcrops in fifteen or more counties in this section of the State, and everywhere furnishes a very pure and easily obtained material for lime manufacture.

At Salem, Washington County, and near Bedford, Lawrence County, large kilns are burning lime from the Bedford oolitic stone, the spalls and waste stone from the oolitic quarries being mostly used. As it is burned from stone wholly free from dirt and in kilns so constructed as to separate it from all cinders, the lime made from the spalls of the oolitic stone is noted for its purity and is sold mostly to the chemical trade. For building purposes it 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.

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.

The total value of the lime manufactured in Indiana in 1905 was $366,866.

Limestone for Fluxes.—Large quantities of Indiana limestone are either crushed or ground fine and then sold for fluxes. The magnesium-calcium carbonate or dolomite, quarried at Kenneth, Cass County, is used extensively as a flux by the Illinois Steel Company at South Chicago.

At Mitchell, the Mitchell limestone is ground into a fine powder and sold in quantity for glass making, bringing $1.50 per ton in car load lots at the plant. Any one of the three main limestones of the State, viz., Mitchell, Oolitic and Niagara, can be used in making fluxes, and the growth of this industry will doubtless largely increase as soon as the new steel plants now being erected at Gary, Lake County, are in operation.

The value of the limestone fluxes sold in the State in 1905 was $117,790.

Limestone for Mineral Wool.—The upper layers of the Niagara limestone at Alexandria, Madison County, are being utilized by the Hoosier Rock Wool Company in the making of a mineral or "rock wool." The stone so used runs from three to ten feet in thickness, and is composed of a mixture of silica, alumina, lime, and magnesia in the right proportions to make it fibrous on being subjected to jets of superheated steam while in a melted condition. The result is a mineral fibre resembling cotton in appearance, and called rock wool, which is said to be much superior to the ordinary mineral wool made from steel slag. In the process of manufacture the material increases in bulk twelve times, which shows that the original stone has enmeshed a quantity of air equal to eleven times its own bulk. It is this that makes rock wool one of the most perfect non-conductors of heat and cold known, and it is also fire proof.

The uses of this material as shown from its nature are at once apparent. The covering of boilers and steam pipes in order to retain the heat; for fire proofing; for insulating and lining cold storage plants, refrigerator cars, packing houses, breweries, creameries, hotels and residences; in fact, for all purposes where perfect insulation is desired.

The utility of mineral wool in building as a deadener of sound and as a sheathing in place of building paper is now also generally recognized. The material is also manufactured in felt and board in thicknesses to meet the different requirements of the trade. The many valuable uses to which rock wool may be put and its comparative cheapness make it one of the future valuable mineral resources of the State.

The value of limestone produced in Indiana from 1900 to 1906 was as follows:

1900	$2,344,818	1903	$2,935,274
1901	2,993,186	1904	3,140,679
1902	2,865,691	1905	3,189,259

The following table shows the production of limestone in Indiana in 1905 and the uses to which it was put:

USES AND VALUE OF INDIANA LIMESTONE IN 1905.

Uses.	*Value.*
Rough building	$1,155,728
Dressed building	1,337,232
Flagging	29,699
Curbing	134,898
Paving	5,421
Lime burners, sold to	193
Road making	222,441
Railroad ballast	84,007
Concrete	30,364
Rubble and riprap	43,422
Flux	117,790
Miscellaneous	28,064
Total	$3,189,259

SANDSTONES.

Sandstones of good quality occur in great abundance at a number of localities in western and southwestern Indiana. On account of the wide distribution of excellent limestones in the State they have not as yet received the attention and development which their quality and availability merit. The Indiana sandstones may be classed under three heads, viz., the Mansfield sandstone, the Knobstone sandstones and the Coal Measure sandstones.*

The Mansfield Sandstone.—This is a bed of coarse-grained sandstone and conglomerate that lies at the base of the Coal Measures. It outcrops over a strip from two to 20 miles in width, extending from the north part of Warren County 175 miles in an east of south direction to and beyond the Ohio River. It thus forms a dividing belt between the Lower Carboniferous limestones on the east and the coal producing beds on the west. While the Mansfield sandstone when first quarried is soft, friable and easily worked, it

*For full information concerning Indiana sandstones, see the paper entitled "Carboniferous Sandstones of Western Indiana," by T. C. Hopkins, in the 20th (1895) Report of this Department.

hardens by exposure and becomes in time one of the most durable rocks in the State.

In this sandstone the mass of the rock is made up of white or colorless quartz grains embedded in a matrix or cementing substance consisting almost wholly of iron oxide. When this iron oxide is a hematite or anhydrous in its character, the stone is a handsome *dark brown* in color and is especially suited for business blocks, and for the lintels and cornices of buildings whose fronts are constructed of pressed brick. The rain never discolors small portions of such stone, and the brick walls are therefore permanently free from those unsightly, mouldy looking streaks which soon appear where limestone is used for finishings.

This brown variety of the Mansfield sandstone has been quarried at Hillsboro, Fountain County; near Green Hill, Warren County; Mansfield, Judson and Portland Mills, Parke County, and St. Anthony, Dubois County. Good brown stone in suitable position for quarrying, but not yet developed, occurs near Bloomfield, Greene County, and on Rocky Fork and Sugar Mill creeks in Parke County. Smaller outcrops of less importance occur elsewhere.

Specimens of this brown stone from six of the leading deposits in the State have been analyzed by this Department, and their *average* composition was found to be as follows:

	Per cent.
Insoluble residue (silica)	90.39
Alumina	.49
Iron oxide	7.41
Lime	.08
Carbonic acid	.09

When the iron oxide in the cementing material is a limonite or hydrous form, the color of the sandstone is a buff or gray. Ledges of such stone are more common than the brown variety, and are well fitted for bridges, foundations, retaining walls or, when of the best quality, for fronts of business blocks. These buff and gray varieties of the Mansfield sandstone have been quarried at and near Williamsport and Kickapoo, Warren County; Attica, Rob Roy, Stone Bluff, Hillsboro, Wallace and elsewhere in Fountain County; Guion, Judson, and several different localities along Raccoon and Sugar creeks in Parke County and at numerous small quarries throughout the area farther south. Where the Mansfield sandstone occurs of a homogeneous texture and free from impurities, it will furnish a stone of superior quality for building purposes.

Knobstone Sandstones.—The Knobstone rocks of Indiana comprise one of the uppermost members of the Mississippian or Lower Carboniferous formations. They form the surface rocks over a strip of territory three to 38 miles in width, extending from the Ohio River southwest of New Albany in a west of north direction to a point a few miles south of Rensselaer, Jasper County. In central and southern Indiana the group may be divided into (1) the New Providence shales at the base or eastern side, overlain by (2) the Upper Knobstone shale and (3) the Knobstone sandstone. The two shales will be mentioned on another page under the head of clays, to which they properly belong.

The sandstone of the Knobstone group has been extensively quarried at Riverside and Independence, near Attica, Fountain County. Small quarries to supply a local demand have been operated near Raccoon and Bainbridge, Putnam County, and at several points in Brown and western Jackson counties.

The stone at Riverside is very fine grained. It takes a smooth finish and is light blue or drab in color, and well adapted for delicate carving and ornamentation. It has a crushing strength of 6,000 pounds per square inch, and a chemical analysis shows its percentage composition to be: Silica, 93.16; alumina, 1.60; iron oxide, 2.69. It has been largely used at Lafayette and neighboring towns.

In general, the Knob sandstone is not a very durable building stone, especially in the presence of moisture, and hence is not well adapted to foundations and bridges, where it has been too frequently used. In the walls of buildings above the foundations, or as trimmings for brick or stone buildings, it is quite serviceable if quarried and selected with some care. It has a fine grain and generally uniform color, either yellowish buff, as generally found in the top layers, or a blue gray in the deeper unoxidized layers. The fineness and evenness of grain, the uniformity in color, the ease with which the stone can be cut and carved are all strong points in its favor as a building stone. If the stone is selected with care and quarried and dressed with proper precautions and laid in proper position in the wall, it can be used safely and with good architectural effects.

Coal Measure Sandstones.—In the upper Coal Measures, overlying or at a horizon above that of the Mansfield sandstone, are several beds of sandstone which are extensively quarried in the coal bearing counties of the State. In composition these Coal Measure sandstones are finer grained than the Mansfield sandstones, and the cementing matrix is more complex, being composed of a mixture of clay, silica, decaying feldspar and iron oxide. These stones are buff, blue or gray in color, and have proven durable wherever used. The largest quarries are at Worthy, Vermillion County, and Cannelton, Perry County. The stone from Worthy has been used extensively in Chicago for wall fronts and trimmings, and from it public buildings in several towns in Illinois have also been built.

The oldest and largest sandstone quarries in the State are those near Cannelton. The stone varies in color from a lemon yellow to a light or dark gray. Its percentage composition is as follows: Silica, 96.18; iron oxide, 1.56; alumina, .54; lime, .15. It has proven very durable but its color is not an attractive one for fine buildings, owing to the iron oxide weathering to a rusty yellow tint. It has been extensively used for building purposes at Cannelton; in the locks on the canals at Louisville, Kentucky, and on the Green River, Kentucky; and for wharves, retaining walls, etc., at many places along the Ohio River.

Other deposits of sandstone which have been quarried on a small scale, occur near Rockport, West Baden, Paoli, Brazil, Coxville and Covington. Some of these, as well as many hitherto undeveloped deposits, are sufficient in quantity and in quality suitable to merit the careful attention of capitalists in search of good investments.

*Sandstone for Whetstones and Grindstones.**—Certain sandstones in Orange and Martin counties have long been used in the manufacture of abrasive materials. Two grades of whetstone rock are used. One, known as the "coarse whetstone bed," is a portion of the upper Huron sandstone, which occurs in massive beds 20 to 35 feet thick. Of this, but five or six feet is suitable for whetstones. This is a white, coarse grained, friable sandstone, free from iron nodules and concretions, and which under the lens resembles loaf sugar. It occurs in quantity along the valley of French Lick Creek in Orange County. After being blasted out of the ledge in blocks, this coarse sandstone is sawed into slabs the thickness of the finished whetstone, usually by a gang saw operated by horse power. The whetstones made from it are well adapted to produce a harsh, coarse edge, and are largely used for shoemakers' and fishermen's knives.

The Hindoostan or fine-grained whetstone rock is found in a bed about 25 feet thick, which comprises a portion of the Mansfield sandstone and occurs from 60 to 100 feet above the base of that formation. It is found most abundantly northwest of French

*For a detailed account of the Whetstone and Grindstone rocks in Indiana see the paper by E. M. Kindle in the 20th (1895) report of this Department.

Lick in the northwestern part of Orange County, and along the southeastern margin of Martin County. All the operated quarries are in the former county. This stone varies much in color, the best grades being creamy white. It is composed of very fine quartz grains which average about .02 of a millimeter in diameter. Most of the whetstones from it are manufactured at small mills situated near the quarries and run by horse power, though one or two steam power mills are operated. Since the whetstone rock occurs in thin layers, these mills are chiefly used in grinding the whetstones smooth on a rub wheel. The whetstones made from it are chiefly "slips," axe stones, glass makers' files, hacker stones, etc. They bring a much higher price than those made from the coarse-grained whetstone rock.

But few grindstones are at present made in Indiana, although sandstones which are capable of making a fine quality of such stones occur at a number of localities in western Orange, northeastern Dubois and southeastern Martin counties. About 35 years ago grindstones were made extensively in this region and sold throughout Indiana and adjoining states. As the work was done by hand and there was great lack of transportation facilities, the industry gradually dwindled until only enough are made to supply the local demand. The Orange County stone is just as good, if not better, than that used at Berea and Amhurst, Ohio, where the leading grindstone industries of the world are located.

Both the Upper and Lower Huron sandstones, and also the Mansfield sandstone, afford an abundance of good grindstone "grit" at many localities in the three counties above mentioned. The French Lick and Jasper Railway now building will soon be completed, and will furnish the long needed transportation facilities. It runs through the center of the region furnishing the grit, and there is therefore no reason why several large steam plants for making both grindstones and whetstones would not prove a profitable investment in this region.

Clays and Clay Industries.*

The clays of Indiana rank in value next to coal and petroleum among the natural resources of the State. A dozen years ago the term "shale" was almost unknown among such resources. Those great beds of soft, blue-gray, thin-layered rock which occur over vast areas in the coal bearing counties were then looked upon as a

*For a detailed paper on the Clays and Clay Industries of Indiana, see pp. 13 to 657 of the 29th (1904) report of this Department.

wholly valueless nuisance, which had to be removed or tunneled through before the underlying veins of coal could be reached. To-day the smoke is pouring forth from hundreds of kilns where these shales are being burned into sewer pipe, hollow block, conduits, paving brick, pressed front and ordinary brick, drain tile, etc. It is only within the past ten years that capitalists have come to realize to some extent the vast possibilities which the clays and shales of western Indiana present for manufacturing purposes. Even yet but few of the main deposits are being worked, and there is room for five times as many factories as are now in operation. During the past five years all factories have had many more orders than they could fill and, on account of the rapid advance in the price of lumber, the future of the clay industry is a most promising one.

Not only have the Carboniferous shales been proven in the highest degree suitable for the best of vitrified wares, but the Knobstone shales, which were accounted even more valueless than those of the Carboniferous age, are in several places now being utilized for vitrified, pressed front and ordinary brick, and in three of the largest factories of the State as the clay ingredient of Portland cement. The factories now utilizing them are but the pioneers or forerunners of many yet to be; for these hitherto ignored Knob shales possess almost unlimited possibilities of service for practical use.

At the present time Brazil, Terre Haute, Clinton, Veedersburg, Crawfordsville, Montezuma. Cayuga, Hobart and Porter are the principal seats of clay industries in the central west and northwestern parts, while important factories are located at Brooklyn, Martinsville, New Albany, Huntingburg and Evansville in the center and southwest. In the eastern half of the State there are few, if any, clays suitable for other purposes than ordinary brick and drain tile.

Each of the principal classes of clay in the State will now be taken up in order, and its distribution and uses briefly stated.

Kaolin of Lawrence and Martin Counties.—The purest clay in Indiana is the kaolin of Lawrence and Martin counties. The best grades of it are pure white, and show a chemical analysis of 98.61 per cent. silicate of alumina, and but 1.47 per cent. of fluxes. The poorest grades are yellowish brown in color, but even they contain no more than three per cent. of iron oxide and but 5 or 6 per cent. of all impurities combined.

The great drawback to this kaolin is its lack of plasticity. Otherwise it would be in every way suitable for the best grades of porcelain ware. It is, however, suitable in the highest degree for the manufacture of alum salts for the sizing of the finer grades of wall and letter paper. Its refractory properties are also very great, and for that reason, if mixed with a small percentage of the underclays of the nearby Coal Measures to render it more plastic, it can be used for making the finer grades of refractory wares, such as retorts, glass pots, glass tanks, etc. Ground fine with a bond clay and pressed dry, it will make the highest grade of fire brick. The best flint clays of Ohio and Kentucky, from which the high grade refractory products of those states are made, are, like the Lawrence County kaolin, wholly non-plastic, and have to be mixed with a plastic under-clay before they can be burned into fire brick and similar products. Recent experiments have proven this kaolin also suitable for making a filler for furniture and buggies; for cosmetics and for ultramarine.

At the largest known deposit, four miles north of Huron, Lawrence County, thousands of tons of this purest of clays can be seen, comprising a stratum five to 11 feet in thickness; yet, since 1891, not a pound has been put to use. The deposit is not a local one, covering a few rods or acres, but square miles, as evinced by outcrops which are known. There is enough in sight in the mines at this one deposit to last an average factory a hundred years, and not one one-thousandth of it has been exposed to view. There it lies, a great mineral resource of untold value, unworked, unutilized, awaiting only the coming of energy and capital to make it up into many kinds of products which are now brought into our State from distant lands.

Fire-Clay of Vermillion County.—Next to the kaolin in purity is the fire-clay of Vermillion County, found just west of Montezuma and north of Hillsdale, in the hills bordering the Wabash River. It is a whitish, silicious under-clay, showing 98.24 per cent. of clay base and sand, and but 1.79 per cent. of fluxes.

From this it will be seen that the clay is of high refractory grade, and moreover, very pure. It contains less fluxes than any plastic under-clay so far discovered in Ohio, and lacks but .02 per cent. of being as pure as the Mineral Point flint clay of that State, which is largely used in making high grade refractory materials, such as glass pots and kindred products. The only objection to the fire brick made from this clay is that for some purposes they are too friable, or easily crumbled. This is due to the small amount of bonding material present, and can be readily overcome at any time by mixing with a small per cent. of a more plastic high grade under-clay, such as occurs at Mecca and many other points in the coal areas to the south. In Ohio, non-plastic flint clays constitute the body mixture of all the refractory wares made in the State, but it is necessary to use plastic under-clays with all of them to act as a bond material.

The Vermillion County fire-clay occurs in a stratum five to seven feet in thickness which underlies an area a mile or more wide, extending from Hillsdale almost to Newport. Coal of good quality both overlies and underlies the fire-clay, the latter outcropping on the sides of the ravines. It is at present worked by six companies whose plants are located along the C. & E. I. Railway, between the points mentioned. Four or five of these grind and ship large quantities of the under-clay, receiving therefor an average of $1.25 a ton on board the cars. This is used for making mortar for laying and setting the parts of kilns, for rock and adamant plaster, for lining ladles and making molds, and many other purposes.

Fire-brick made from this clay by the Burns & Hancock Company of West Montezuma have been used for years in the iron and steel furnaces at Birmingham, Alabama; Atlanta, Georgia, and as far west as Montana, and the Illinois Steel Company at South Chicago uses large quantities of both the brick and the unburned clay as a lining for their furnaces. The six-pound fire-brick sell for $12.00 per thousand, and other sizes by weight at the same proportion, on board the cars at the plant.

A number of sites are yet available where large plants can be located for the manufacture of this clay into many kinds of refractory products. Taking into consideration its quality and the facilities of fuel and transportation, there is room for an investment of large capital in its development, with the assurance of a handsome profit in the future.

Potters' Clays.—Potters' clays of good quality are found in a number of localities in the coal bearing counties; notably near Huntingburg, Dubois County; Cannelton, Perry County; Loogootee and Shoals, Martin County; Clay City, Poland and Brazil, Clay County; Coal Bluff, Vigo County; Annapolis, Parke County, and Stone Bluff, Fountain County. All of these deposits have been tested in a small way in manufacturing pottery for the local markets, and all have given excellent satisfaction.

The best known deposits and the ones heretofore most extensively worked are those at Huntingburg and Cannelton. The clays from these two points show the presence of 95.16 per cent. of clay base and sand, and 5.20 per cent. of fluxes. The average analyses of the clays used in the great potteries at Akron and Zanesville, Ohio, give 94.65 per cent. of clay base and sand, and 4.54 per cent. of fluxes. The potters' clays of Indiana are thus shown to be as good as those of Ohio, and the fuel supply and transportation facilities are, in many localities, better.

The deposit at Huntingburg is known to underlie an area one mile wide and three miles long between Huntingburg and Holland, and it also occurs in quantity north and northeast of the former place. It is a soft, light gray, plastic material, free from all grit and impurities, and a high grade clay in every particular. Besides stoneware, it can be made into terra cotta, sewer pipe, hollow brick and all kinds of hollow vitrified wares. For a number of years large quantities of it have been shipped to potters at Evansville, New Albany, Louisville and other points along the Southern Railway, and for twenty-seven years it has been used in a pottery at Huntingburg. The bed runs five to seven feet in thickness, and the clay at present brings $1.25 per ton on board the cars. The stoneware made from it at Huntingburg and Evansville is strong, durable, and takes an excellent glaze. It does not air-crack in drying or in cooling after being removed from the kilns.

A good slip clay for glazing pottery occurs in abundance along Rocky Run, four and a half miles west of Rockville, Parke County, and another deposit which has been recently put on the market is found along the St. Joseph River, just west of Elkhart.

Under-Clays and Shales of the Coal-bearing Counties.—Millions of tons of shales and under-clays, well fitted for making the best grades of vitrified products, exist in the coal bearing counties of Indiana. These clays lie in the closest proximity to the fuel necessary to burn them; the shales immediately overlying, and the under-clays, as their name denotes, underlying the veins of coal.

The relation of the *under-clays* to the coal shows plainly that the former may be regarded as having formed the soils of the ancient Carboniferous marshes, and that from them sprang that luxuriant vegetation which in time was changed into coal. The under-clays, then, are the mother soils of the coal seams. They are usually from one to six feet in thickness, and composed of a soft, homogenous clay, whitish or gray in color, highly plastic and, when sufficiently free from the fluxing elements, capable of withstanding in a remarkable degree the action of heat. These clays are best fitted for the making of sewer pipe, conduits, drain tile, flue linings, chimney tops, hollow building block, fireproofing, and all hollow products of similar grade. Of the wares mentioned, the sewer pipe, conduits and hollow building brick are vitrified in the making. The others are burned at a lower temperature, generally for a shorter time, and are not salt-glazed, as are the vitrified products. A number of large factories in the State are engaged in making these hollow wares, and have proven by years of practical experience that the under-clays of the Coal Measures furnish a raw material which can not be excelled for that purpose.

The blue, drab and gray *shales* comprise the greater part of the Coal Measure rocks of Indiana, and, taken as a whole, are the most valuable clay deposits occurring in the State. They are not closely related to the strata found above or below them, and their thickness and composition varies exceedingly and is dependent entirely upon the character and source of those streams of water which flowed into the old lakes in which the shales were formed.

When freshly exposed these clay shales are usually hard and tough and more or less massive, requiring to be blasted or worked much as the seemingly harder rocks. As soon as exposed to the weather they soften and crumble into a mass of more or less plastic clay. This is commonly called "slacking," more properly "slaking." Some shales, when weathered, divide into thin flakes or leaves, when they are called "fissile shales." Others break up more or less into little cubes. Of these two, the latter are generally more suitable for making clay wares. The very plastic shales, other things being equal, are best adapted for making stoneware and sewer pipe; those of moderate plasticity find their application in the manufacture of paving brick, while the lean or sandy ones are used mostly for dry pressed and common brick.

The argillaceous or clayey shales, in which clayey material (silicate of alumina) largely predominates, are usually drab or blue in color, though yellow and buff shades are not of uncommon occurrence. They are almost free from "grit" and are often soft and unctuous or greasy to the touch. In the country they are almost universally known as "soapstones," but this term rightfully belongs to the mineral steatite or talc, a magnesian silicate which does not occur in Indiana. Sometimes, however, the shales are quite hard and tough, yielding but little to the pick and requiring the use of explosives for their removal. But whatever their character when first mined, upon exposure to air, rain and frost, they quickly disintegrate into soft, plastic, fine-grained clays of large, commercial importance.

These shales are most useful for the making of vitrified and other brick. No more durable material for the making of pavements can be used than vitrified brick, provided sufficient care be taken in the structure of the foundation upon which the brick are placed. Such a pavement comes nearer than any other to a typically perfect pavement, i. e., one which is reasonable in first cost; low in cost of maintenance, and easy of repair; durable under heavy traffic with reasonable freedom from noise and dust; free from decay, water-proof and non-absorptive; of low tractive resistance and furnishing a good foothold for horses. The making of paving brick is an industry yet in its infancy in Indiana, for the time will come, and that before many years, when not only the streets of every town of two thousand or more inhabitants within our State will be paved with brick, but also many of our country roadways in those regions devoid of gravel and other road material.

On January 1, 1907, there were in Indiana six large factories using Carboniferous shales for making paving brick, while 13 others, among which are the largest clay-working industries in the State, were making hollow wares from either the shales or the under-clays of the Coal Measures. These do not include numerous factories making stoneware, drain tile, building brick and many other products from the shales which a dozen years ago were practically unused and despised.

Undeveloped deposits of shale and under-clay which offer promising sites for great factories are so numerous in the coal-bearing counties that space can not here be taken for their enumeration, and parties interested are referred to the Twenty-ninth (1904) Report of this Department, where the advantages of each are set forth in detail.

Shales of the Knobstone Area.—As already mentioned, the Knobstone area comprises a strip of territory three to 38 miles in width, extending from northwest to southeast near the center of the State. Its eastern or basal division, known as the New Providence or Lower Knobstone shale will, wherever it is exposed, be found suitable for paving brick, pressed front and ordinary brick and the clay ingredient of Portland cement. When properly ground it becomes plastic enough to form a good sewer pipe clay, but when utilized for that purpose, some difficulty is experienced in glazing the product. Otherwise it is of excellent quality. It is already being utilized on a large scale at New Albany for the making of both ordinary stiff mud and dry pressed brick.

The middle division of the Knobstone, known as the "Upper Knobstone shale," consists of a series of soft, light gray or greenish shales, which vary in composition from soft clay shale towards the bottom to an impure, fine-grained sandstone at the top. It has a thickness of 200 to 250 feet, and extends from the East Fork of White River in Jackson County north to Rensselaer. At Blue Lick, Jackson County, this Upper Knobstone shale is quarried in quantity and shipped to Mitchell, where it is used as the clay ingredient of Portland cement at the two large factories of the Lehigh Portland Cement Company.

That the same shale is in every way suitable for brick making is proven by the practical use of it at the large plant of the Adams Brick Company, at Martinsville, Morgan County, where 40,000 ordinary soft mud brick are made from it each working day in the year; and at Crawfordsville, Montgomery County, where from it the same number of stiff mud paving blocks are made daily. It is probable that this upper Knobstone shale will in many places be found too "lean" to be made into sewer pipe and drain tile, though at Brooklyn, Morgan County, a large factory for making drain tile from it has been in successful operation since 1904. By mixing two parts of the shale with one of a more plastic clay, such as one of the under-clays of the Coal Measures, it will, without doubt, make the best of such products.

In locating a large factory for clay products in any part of the Knobstone area care should, of course, be taken to select a locality where the shale is not too sandy and has the proper composition. Then with a man in charge who is experienced in manipulating and burning clay wares, as good, if not better, products can be made from the Knobstone shales as from the more widely known Carboniferous shales which have come into such extensive use during the past decade.

Clays for Terra Cotta Lumber.—In the northern third of the State, near Brook, Newton County; Hammond and Hobart, Lake County; Chesterton, Porter County; Michigan City, South Bend and other points, are extensive deposits of a silty or marly clay, which is peculiarly fitted for the making of terra cotta lumber. These clays were deposited in bays, lakes or harbors, in still water. Much "rock flour" containing a large percentage of kaolin was produced by the passing of the glaciers over beds of shale. This was held in suspension by the glacial streams and finally deposited in the bays and lakes of that epoch. These marly clays are, in general, composed of very fine grains, and are usually in thin layers, separated by a coating of sand. They contain a large percentage of finely disseminated lime and magnesium carbonates, and for that reason products burned from them are usually cream colored or whitish in hue.

The terra cotta lumber for which they are principally used is made by mixing one part of sawdust with three parts of clay, and then forming a hollow brick a foot square and two, four or six inches in thickness. After burning, the ware is left very light and porous, but strong and wholly fire-proof. It can be sawed like a pine board, is easily penetrated by nails, and on it plaster can be spread without intervening laths, or to it wooden finishing can be readily united. It is coming into rapid demand for wall partitions in fire-proof buildings. Floor arching, wall furring, column and girder covering and under-roofing to which slate or roofing tile can be nailed, can also be made of this same porous material. One factory has been making these products at Hobart for 20 years, and the average profits of the owner have been $20,000 or more per annum. Capital invested at any of the points mentioned will realize a handsome profit in the making of porous fire-proof products, the demand for which is increasing every year.

Clays for Ordinary Brick and Drain Tile.—Clays suitable for burning ordinary building brick and drain tile occur in quantity in almost every county in Indiana. In the northern and eastern parts of the State they are largely of drift origin, and some care has to be taken to choose those free from limestone pebbles. The surface of a large area in southwestern Indiana is covered with a very fine grained, clayey buff or brown silt, known as "common loess." It contains but a small percentage of lime, rarely effervescing with acid. Lime pebbles are very scarce, and where found are generally of small size. Other pebbles do not occur except where the sheet of loess is so thin that roots penetrate to the underlying drift and, on the felling of the tree, pull the pebbles up into the loess. Being very uniform in composition, and free from foreign impurities, these common loess clays are much better suited for ordinary brick making than the pebbly drift clays of other sections of the State.

Within the past few years large factories have been erected near Cayuga, Martinsville, Montezuma and Brazil, for making ordinary brick from shale. These factories have been successful from the start, and in 1906 could not supply the demand for their output.

The following table, extracted from the Annual Report of the Mineral Resources of the United States for 1905, shows the value of the clay products of Indiana for the six years, 1900 to 1905, inclusive:

CLAY PRODUCTS OF INDIANA, 1900–1905.

PRODUCT.	1900.	1901.	1902.	1903.	1904.	1905.
Brick.						
Common—						
Quantity	274,383,000	315,966,000	305,233,000	294,890,000	294,409,500	279,073,000
Value	$1,391,873	$1,624,133	$1,710,385	$1,697,190	$1,725,162	$1,630,072
Average per M.	$5.08	$5.14	$5.60	$5.76	$5.86	$5.84
Pressed—						
Quantity	19,084,000	27,293,000	24,866,000	24,742,000	29,606,000	22,212,000
Value	$172,752	$234,775	$215,202	$232,487	$240,670	$231,353
Average per M	$9.05	$8.60	$8.65	$9.36	$8.03	$10.42
Vitrified—						
Quantity	30,326,000	31,468,000	45,933,000	47,864,000	49,305,000	43,573,000
Value	$331,276	$320,221	$441,494	$482,967	$545,721	$474,600
Average per M.	$10.92	$10.18	$9.61	$10.09	$11.06	$10.89
Fancy or ornamental, value	$7,310	$8,160	$10,398	*	*	$15,520
Fire, value	$40,976	$51,526	$66,725	$115,526	$128,760	$163,728
Drain tile, value	$674,602	$772,241	$807,516	1,014,706	$1,023,571	$1,267,691
Sewer pipe, value	$279,719	$253,626	$311,223	$363,212	$417,260	$430,680
Fireproofing, value	$116,581	$91,081	$342,854	....	$165,000	$393,985
Tile, not drain, value	$343,985	$478,130	$579,896	$463,082	$450,000	*
Earthenware and stoneware, value	$48,544	$54,371	$28,780	$73,160	$88,780	$74,462
Miscellaneous*, value	$450,732	$578,190	$769,260	$1,252,295	$1,300,500	$1,817,482
Total value	$3,858,350	$4,466,454	$5,283,733	$5,694,625	$6,085,424	$6,499,573

*Included in miscellaneous are ornamental terra cotta, yellow and Rockingham ware, C. C. white graniteware, sanitary ware, porcelain electrical wares, glass pots, hollow building block, conduits, and all products not otherwise classified.

Although the above table shows a steady growth in the annual value of the clay products of Indiana, yet, taking into consideration the clay resources, the cheapness of fuel and the transportation facilities of the State, the output is not what it should be. There is room for five times as many clay factories as now exist without over-crowding or overdoing the business, for the number and variety of clay products is increasing at a marvelous rate, while the growth of the country and the rapid disappearance of the forests is ever widening the demand and opening up new markets.

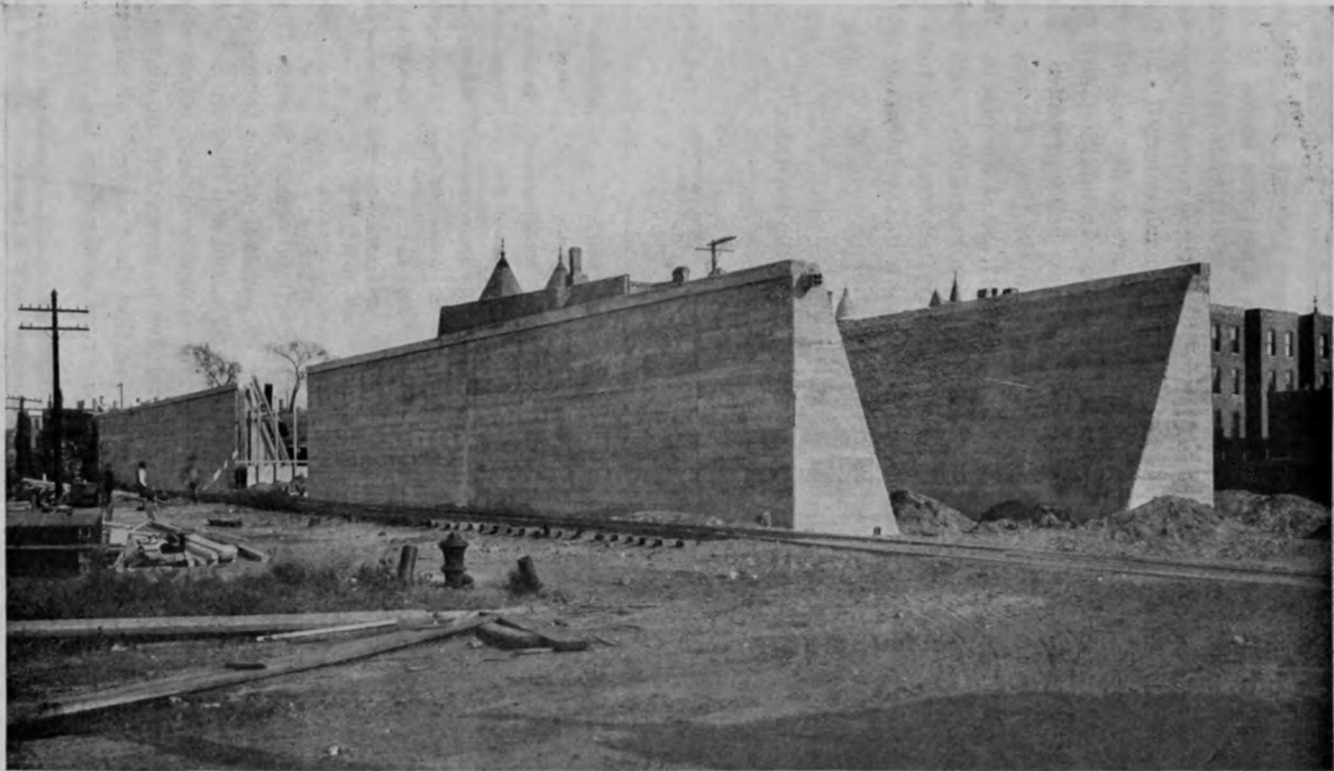
CEMENT RESOURCES.

Portland Cement.

No mineral industry in the United States has grown more rapidly during the last fifteen years than that of the manufacture of Portland cement. In 1890 there were but sixteen plants making such cement in the United States. Their output was but 335,600 barrels, while 1,940,186 barrels were imported. In 1905 the number of plants in the United States had increased to 89 while their output reached the enormous total of 35,246,872 barrels for the year.

Portland Cement Industry in Indiana.—While the making of

Plate II.



Illustrating the Use of Portland Cement in Elevating Railways.

Portland cement has not reached the prominence it should assume in Indiana, the industry is increasing year by year, and promises much for the future. In 1901,* when a report was issued by this Department showing the location of the raw materials suitable for such cement in many portions of the State, there were but two factories in operation. These have since been much enlarged and four additional ones have been erected, which are to-day actively engaged in turning out the finished product. In addition, two factories were built during 1906, while others are being promoted. The total output of the operating factories in the State for the year 1906 was 3,867,427 barrels, valued at $4,947,180 at the plants. The factories now in operation or which will soon be installed, with their location, number of kilns, daily capacity in barrels and form of carbonate of lime and clay used, are shown in the following table. The first seven are now in active operation.

PORTLAND CEMENT FACTORIES OF INDIANA.

	NAME OF FIRM.	Location.	Number of Kilns.	Daily Capacity, Barrels.	Form of Carbonate of Lime.	Form of Clay.
1	Sandusky Portland Cement Co.	Syracuse, Kosciusko County.	14	1,800	Marl	Silty clay.
2	Wabash Portland Cement Co.	Stroh, Lagrange County.	10	1,500	Marl...............	Drift clay.
3	Lehigh Portland Cement Co.	Mitchell, Lawrence County.	18	5,000	Mitchell limestone...	Knobstone shale.
4	United States Cement Co.	Bedford, Lawrence County.	6	1,200	Bedford Oölitic limestone.	Knobstone shale.
5	Universal Portland Cement Co.	Buffington, Lake County.	16	4,500	Niagara limestone...	Slag from Steel Works.
6	Louisville Cement Co......	Speeds, Clark County	2	700	Jeffersonville limestone.	Knobstone shale.
7	Art Portland Cement Co.	Kimmel, Noble County.	1	250	Marl...............	Carboniferous shale.
8	Standard Portland Cement Co	Charlestown, Clark County.	1	300	Jeffersonville limestone.	Knobstone shale

Ingredients of Portland Cement.—Portland cement is made from carbonate of lime and clay—about 78 per cent of the former and 22 of the latter—intimately ground and mixed and then burned into a clinker and reground. The burning is mostly done in rotary steel kilns, 60 to 80 feet in length and five to seven feet in diameter, which are set at a slight incline, so that the "slurry" or mixture of carbonate of lime and clay will pass slowly from the upper or

*The 25th report, issued in June, 1901, contained the following articles relative to the subject: "Portland Cement; Its Manufacture and Use," by W. S. Blatchley; "Lakes and Marl Deposits of Northern Indiana," by W. S. Blatchley and Geo. H. Ashley; "Oolite and Oolitic Stone for Portland Cement Manufacture," by W. S. Blatchley.

stack end to the lower or fire end. Into the latter end the fuel—now mostly dried and powdered bituminous coal—is forced with a blower and burns with a very hot flame similar to that produced by natural or other gas. From the lower end the clinker, the size of a walnut or smaller, emerges. This is then ground to a fine powder in either the Griffin or other ball and tube mills, from which it emerges as the cement of commerce. A plant with an output of 500 barrels daily, complete with machinery up to date, will cost approximately $200,000, while one with a capacity of 2,000 barrels costs $550,000 or more.

The carbonate of lime used in the production of Portland cement is either marl or limestone. Both of these forms occur in great abundance in Indiana; marl of excellent quality being found only in the northern third of the State, while the limestones abound in the southern half.

Marl for Portland Cement.—Marl, or "merl" as it is commonly called in the country, is a soft, earthy material, composed principally of an amorphous form of carbonate of lime. It occurs only in or about the margins of lakes or marshes, either present or extinct. In color it varies with the percentage of impurities which it contains. In the wet or damp state in which it occurs in lakes or marshes, it ranges from a milky white through varying shades of brownish-yellow to a dark brown, which may finally grade over or merge into the overlying or adjacent muck. After exposure to the air a short time a wet marl that at first may seem almost white turns a bluish or drab color, on account of some chemical change which takes place. In drying, the color of marl tends to lighten again, but seldom gets beyond a light dove color, and is generally a decided drab, running from a light drab to a slate color. The purer forms, however, when dry, are white or slightly cream color. The grains or particles composing the dry mass cohere very loosely and vary in size from coarsely granular to fine powder.

A careful study of the deposits of marl in northern Indiana, made by this Department in 1899 and 1900, led to the following conclusions regarding its origin:

First.—That the marl deposits of Indiana have been formed in the still waters of lakes now in existence, or in former lakes, now extinct.

Second.—That the original source of the marl material is the glacial clay in the region surrounding the lakes.

Third.—That the deposition of the marl is caused by the loss of carbon di-oxide from the sub-aqueous spring waters which bear the marl material into the lakes.

Fourth.—That the loss of this carbon di-oxide is for the most part caused in three ways, viz.:

(a) By the increase in temperature of the incoming spring water.

(b) By the decrease in pressure as the spring water rises to the surface of the lake.

(c) By the action of different aquatic plants in abstracting the carbon di-oxide for food.

In the Portland cement industry, a cubic yard of marsh marl, of the consistency of soft putty, is used in making two barrels of cement. Where the marl is dredged from a lake, and contains much water, this proportion is necessarily greater. Careful estimates go to show that an acre of marl three feet in thickness will make 10,000 barrels of cement. From this data the length of time necessary to exhaust any deposit can be readily computed. At the present time a factory with an output of 500 barrels of cement each 24 hours is considered of only medium size. As the process is a continuous one, with no stop for Sundays or holidays, such a factory will use a bed of marl nine acres in area and six feet in thickness each year.

The following table gives approximately the length of time which deposits of varying thickness and area will last a factory whose output is 500 barrels of cement daily:

Area in Acres.	*Thickness in Feet.*	*Barrels of Cement.*	*Time*
1	3	10,000	20 days.
1	6	20,000	40 days.
1	12	40,000	80 days.
1	18	60,000	120 days.
9	6	180,000	1 year.
40	12	1,600,000	8.9 years.
120	12	4,800,000	26.5 years.
135	12	5,400,000	30 years.
160	10	5,333,000	29.6 years.
200	10	6,666,000	36.5 years.
90	18	5,400,000	30 years.
270	6	5,400,000	30 years.

Since a modern cement factory with a capacity of 500 barrels daily costs in the neighborhood of $200,000, the company erecting it wish a deposit of marl in sight which will last at least 30 years. From the table we note that a deposit equal to 160 acres ten feet in thickness will last almost 30 years.

During the investigations made by this Department, 32 deposits of the size mentioned were located in northern Indiana, and fully described in the report for 1900. Of these but three are as yet utilized for the making of cement.

In quality the marls of Indiana rank up with those of Michigan and Ohio, where they are being put to much more extensive use. The following analyses made for the report of 1900 are herewith given, that persons interested may know where the best deposits occur:

ANALYSES OF INDIANA MARLS.

Origin of Sample. Lake.	Origin of Sample. County.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Alumina (Al_2O_3).	Ferric Oxide (Fe_2O_3).	Calcium Sulphate ($CaSO_4$).	Insoluble Inorganic (Silica, etc.).	Organic Matter.	Total.	Authority.
Hog Lake	Steuben	90.42	2.88	.14	.28	......	.68	4.13	98.53	W. A. Noyes.
Lime	Steuben	86.00	9.42	......	1.16	......	1.08	2.32	99.98	Chas. R. Dryer.
Deep and Shallow	Steuben	93.29	2.67	.04	.12	......	.47	1.56	98.15	W. A. Noyes.
James	Steuben	92.41	2.38	......	.29	.15	1.16	1.97	98.36	W. A. Noyes.
Silver	Steuben	84.00	6.46	......	1.34	......	4.52	3.68	100.00	Chas. R. Dryer.
Turkey Lakes	Lagrange	91.14	2.75	.61	.25	......	.85	......	95.60	W. R. Oglesbey.
Loon	Whitley and Noble	82.07	2.63	.41	.42	.22	5.95	6.71	98.41	W. A. Noyes.
Mud	Elkhart	82.89	2.04	.41	.23	......	7.94	3.67	97.18	Osborn Engineering Co.
Cooley	Elkhart	88.21	4.78	.52	.36	......	1.42	2.58	97.87	Osborn Engineering Co.
Syracuse	Kosciusko	88.49	2.71	.90	.31	1.58	1.78	4.23	100.00	S. B. Newberry.
Dewart	Kosciusko	92.35	3.54	.37	.16	......	2.00	2.12	100.54	A. W. Burwell.
Dewart	Kosciusko	84.24	2.85	.18	.30	......	4.52	5.02	97.11	W. A. Noyes.
Tippecanoe (James Basin)	Kosciusko	90.67	2.42	.06	.26	......	2.48	2.87	98.76	W. A. Noyes.
Tippecanoe	Kosciusko	91.02	2.28	......	.29	.05	2.92	2.10	98.66	W. A. Noyes.
Little Eagle	Kosciusko	84.75	2.84	.15	.35	.07	4.61	5.69	98.46	W. A. Noyes.
Manitou	Fulton	87.65	2.60	.19	.30	......	6.39	2.88	100.01	W. A. Noyes.
Maxinkuckee	Marshall	85.02	3.85	.12	.33	.17	5.67	3.21	98.37	W. A. Noyes.
Maxinkuckee	Marshall	85.38	3.50	.05	.33	.17	6.40	3.15	98.98	W. A. Noyes.
Houghton and Moore	Marshall	89.22	2.73	.04	.20	......	2.02	4.15	98.36	W. A. Noyes.
Notre Dame	St. Joseph	91.62	4.02	.05	.07	.14	.19	2.25	98.34	W. A. Noyes.
Chain and Bass	St. Joseph	87.92	2.64	.10	.20	.23	3.10	4.18	98.37	W A. Noyes.
Kankakee Marsh Deposit	St. Joseph	91.30	2.90	......	.08	.22	.82	3.88	99.20	W A. Noyes.
North Judson Marsh Deposit	Starke	89.92	2.46	.45	.74	......	1.56	4.51	99.64	W. A. Noyes.

In addition to the deposits mentioned in the table of analyses the following were included among the workable deposits investigated by the Department:*

Gage and Lime lakes, Steuben County; Shipshewanna, Cedar, Grass, Libey and Fish lakes, Lagrange County; Waldron, Jones, Steinbarger, Eagle and Deer lakes, Noble County; Crooked Lake, Whitley County; Indiana and Long lakes, Elkhart County; Turkey, Barbee, Center, Pike, Eagle or Winona lakes, Kosciusko County; Hudson and Fish lakes, Laporte County.

Limestones of Indiana for Portland Cement Manufacture.—The Oolitic and Mitchell limestones of Owen, Lawrence, Monroe, Washington, Crawford and Harrison counties have been found to make Portland cement of a superior quality. The oolitic stone contains from 93 to 98 per cent. carbonate of lime, and is almost free from magnesia, the element most harmful in the manufacture of cement. Millions of tons of spalls and refuse pieces of this stone, unfit for building purposes but in every way suited for cement manufacture, are thrown aside yearly from the leading quarries. The stone, when first quarried, is soft and much more easily ground than is generally supposed. At Bedford, Lawrence County, this stone is being used in the large plant of the United States Cement Company.

The Mitchell limestone has been in use three or more years at the largest cement plants in the State, namely, those of the Lehigh Portland Cement Company, at Mitchell, Lawrence County, and their product has everywhere given the best of satisfaction. This stone occurs in quantity in a dozen or more counties, and runs from 96 to 99 per cent. carbonate of lime. Large beds of oolite, which is whiter and much softer than oolitic limestone, occur as component strata of the Mitchell limestone at Milltown and Marengo, Crawford County, right by the side of the Southern Railway. The bed at Milltown as exposed is 13 feet thick and 1,500 feet in length, when it disappears in the bluffs of Blue River. An analysis showed the oolite to contain 99.18 per cent. carbonate of lime. It is, therefore, purer than oolitic limestone and, being softer, the expense of the preparatory grinding will not be so great.

Clays for Portland Cement Making.—In the northern part of the State beds of drift clay of sufficient purity to utilize with the marl occur in many of the counties. A full account of their distribution, extent and properties will be found in the Twenty-ninth (1904) report of this Department.

*In a number of instances the marl in two or three lakes, lying close together, was treated as one deposit.

At both the Bedford and Mitchell plants in southern Indiana Knobstone shale from Jackson County is utilized as the clay ingredient, and has proven highly fitted for that purpose. There is no apparent reason why this same shale from numerous other parts of the Knobstone area should not be used for the same purpose. Points that should lead to the increased use of the Knobstone shale in cement making are (1) its proximity to the excellent limestone beds overlying it, and its short distance from the coal fields; (2) uniformity in composition, and (3) ease of quarrying and preparation. The shales may be a little harder to pulverize and mix with the lime ingredients than the softer clays that are sometimes used, but this is more than counterbalanced by the greater uniformity of composition and great thickness of the beds. The clay at Huntingburg, mentioned above under the head of "Potters' Clays," will furnish an abundance of the best of material for use with any deposit of limestone which may be utilized along the Southern Railway. The Coal Measure shales at Loogootee and other points are also well fitted for the purpose.

Lying, as it does, adjacent to fuel and the shales and other clays of the Knobstone and coal bearing counties, there is no reason why this Mitchell and Ooolitic stone region should not become the center of the Portland cement industry in Indiana.

A large Portland cement plant was erected by the Illinois Steel Company at Buffington, Lake County, in 1904, and was started up in January, 1905. It has 16 rotary kilns, each 80 feet long by 7 feet high at the fire end, and 5 feet 6 inches at the stack end, capable of turning out sufficient clinker to make 4,500 barrels of Portland cement per day. Power for the electric motors is supplied from the South Chicago works, 10 miles distant, at less than a 4 per cent. loss. The current is supplied by two 2,000-kilowatt generators, and steam is furnished by boilers fired with waste gases from the blast furnaces in South Chicago. As in the company's slag-cement factory at North Chicago, Illinois, and its Portland cement plant at South Chicago, Illinois, the raw materials used are obtained in the State of Illinois, the same quarry furnishing limestone for all three of the plants. Slag from the steel funaces at South Chicago is used with the limestone in place of clay or shale. The output of this factory in 1906 was 1,529,000 barrels, valued at $2,140,600. The product is now sold under the name of Universal Portland cement.

The building of the Panama Canal, which will require more than 12,000,000 barrels of cement; the re-building of the cities of Balti-

Illustrating the Use of Portland Cement in Viaduct Building.

more and San Francisco, especially along their water fronts; the enormous increase in the consumption of cement caused by its use in the various forms of concrete construction, and the increasing demand throughout this country for cement sidewalks, point toward a bright outlook for the Portland cement industry in the future.

Hydraulic or Natural Rock Cement.*

The manufacture of natural rock cement, which is the oldest cement industry known, has for a half century or longer been carried on in southern Indiana. In the manufacture of such cement there is no artificial mixing of ingredients, but the rock as quarried is crushed to small pieces, then burned in ordinary continuous up-draft kilns, and then ground into the cement of commerce. This simple process lessens the cost of manufacture very greatly, so that the cement is much cheaper than Portland cement, the ingredients of which must be artificially mixed in certain proportions. The hydraulic cement is well suited for lining cisterns and cellars, and for all underground work which is protected from frost, but will not stand freezing as will Portland cement.

In southern Indiana the rock used in its manufacture is the Silver Creek Hydraulic Limestone, one of the formations of the Devonian age. This rock outcrops in Clark and Scott counties, but is utilized for cement making only in the former, where it occurs in great quantity. It is a homogeneous, fine grained, bluish to drab clayey magnesian limestone, five to 16 feet in thickness, the calcined form of which has the property of *hydraulicity*, or setting or hardening when in contact with water. Its average chemical analysis shows about as follows: Calcium carbonate, 53 per cent.; magnesium carbonate, 31 per cent.; silica, 10 per cent.; iron oxide and alumina, 5 per cent.

There are 13 mills with 116 kilns in this district which were built to make cement from this hydraulic limestone. For several years most of them have been idle, owing to the formation of a company to control the manufacture and the selling of the cement, and to regulate the quota assigned to each mill. In many cases the quota of smaller factories is made for them by one of the large plants, in which event the small place is not started up at all.

For a number of years, between 1895 and 1900, the Indiana plants made two to three million barrels of natural rock cement yearly,

*For a full account of the hydraulic cement industry in Indiana, see the paper entitled "The Silver Creek Hydraulic Limestone of Southeastern Indiana," by C. E. Siebenthal, in the 25th (1900) Report of this Department, pp. 331–389.

but on account of the great activity in the Portland cement industry, that of the hydraulic cement has dwindled until in 1905 but 527,600 barrels, valued at $211,040, were produced. The deposits of limestone are as abundant, and the transportation facilities better than ever, yet it is very doubtful if the industry soon again reaches the proportions it held a decade and more ago.

Mineral Waters.

The mineral waters occurring in Indiana comprise one of the important natural resources of the State which, in the future, will be much more appreciated than in the past. In the report of this Department for 1901, 80 springs and 86 wells which yield mineral waters within the State were fully described and, in many instances, chemical analyses of the waters were given.

These wells and springs are distributed among 52 of the 92 counties of the State. At a number of them large hotels and bath houses have been erected for the accommodation of guests. Those of two or three localities have already become so noted as to attract many thousands of visitors each year from all parts of the United States. A number of other springs and wells of the State have waters which are as valuable and worthy of increased public patronage as those of these better known resorts.

Among those little known which will well repay the investment of capital in their development are (*a*) the Lodi well near Silverwood, Fountain County, drilled in 1865 to a depth of 1,155 feet. It has an output of 30,000 barrels of saline-sulphuretted water per day. This water is fully equal in medicinal properties to that at French Lick and West Baden; (*b*) King's, Payne's and other mineral springs in Clark County; (*c*) the artesian well at Worthington, and (*d*) those at Spencer; (*e*) the mineral spring near Corydon; (*f*) the Zorn and Blair mineral wells near Michigan City; (*g*) the Feldun Fields wells near Avoca, Lawrence County; (*h*) the artesian well at Shoals, and (*i*) the one at Winamac; (*j*) the Mudge artesian well near Medarysville, and (*k*) Snowden Springs, near Bainbridge. At the most of these the surroundings are or can be easily made picturesque, while facilities for recreation can be readily established.

It is the writer's opinion, based on personal experience, that the change of surroundings and diet, the increased amount of recreation and exercise, obtained by a few weeks spent at the sanitariums and resorts, have quite as much to do with bringing about a cure of many patients as does the water itself. There are many ordinary springs of pure water, i. e., water containing only a few grains of lime or iron salts per gallon, located near villages in this State, which are claimed by the inhabitants to possess remarkable curative properties. Old persons who seldom get ten rods from their homes, and business men who are kept indoors most of their time, begin to visit such springs, and once or twice a week walk or drive quite a distance to bring home a jug full of the water. The increased amount of exercise thus obtained, as well as the change of scenery, however limited, and perhaps the drinking of an extra amount of water each day, are the causes of the improved health rather than any curative properties possessed by the water.

From 23 of the more important and best known mineral springs and wells in the State the water is bottled and sold. This industry is constantly increasing, the sales for 1905 amounting to $435,182 as against $376,485 in 1904. The water of several of these springs is not at all mineral in character, yet they have been utilized for medicinal purposes and are highly recommended by some physicians. Many of the so-called "potable water" or "pure water" springs of the State are as worthy of development for medicinal purposes as those better known as real "medicinal springs." Proper advertising and the expenditure of some capital in furnishing means of recreation is about all that is necessary to make of them "noted health resorts."

Iron Ores.

Limonite or brown hematite, siderite and pyrites are the ores of iron occurring in Indiana.*

Limonite.—Limonite or brown hematite, commonly called bog iron ore, is found in largest quantities in Green, Martin, Monroe and Perry counties in the south, and in the swamps of Lake, Porter and St. Joseph counties in the northwest. In general, it is too siliceous to compete with the richer hematites of the Lake Superior, Missouri, Tennessee and Georgia iron regions. As a proof of this it is only necessary to state that of fourteen blast furnaces which were erected in the State in the past to use these bog and other iron ores, not one is in operation at the present. Most of them have long since gone to ruin, and of those still standing, the last one went out of blast in 1893.

The most extensive deposits of limonite are those in Martin and

*For a detailed account of the distribution, extent and character of the principal deposits see the paper by Chas. W. Shannon in another part of this volume.

Greene counties. An average analysis of seven samples from these counties, made by Dr. Lyons for this report, showed the presence of 45.1 per cent. metallic iron; the range being between 36.6 and 51.5 per cent.

The old Richland furnace, which was located two miles southeast of Bloomfield, was used in reducing the ores of Greene County between the years 1841 and 1858. About nine tons of pig iron were produced daily. The closing down of the old Wabash and Erie canal left the furnace thirty miles from the nearest transportation point, and so caused its final abandonment. A semi-block coal of good quality is found in veins two to three and a half feet thick in the immediate vicinity of this iron ore. The Bloomfield branch of the C., I. & L. (Monon) Railway is distant to the southward about two miles, while the Indianapolis Southern division of the Illinois Central passes close to the principal deposits.

In Martin County extensive deposits are found within one to four miles of the B. & O. S. W. Railway. Within the past two years about 50 carloads of the ore have been shipped from Martin County to Jackson, Ohio. This brought $2.00 per ton on board cars at the point of loading. The unprecedented demand for manufactured iron and the use of slag as a by-product in making cement has caused a demand for a low grade iron ore formerly considered worthless. If this demand continues, the deposits of Greene and Martin counties will have a commercial value which will yield a fair profit to those who may undertake their development and shipment.

Present conditions of transportation and demand for pig iron would doubtless justify the erection of two or three good blast furnaces in the vicinity of the principal iron ore deposits of Greene and Martin counties. Limestone for fluxing is abundant in the near vicinity, and the Indiana block coal, which can be used without coking, would furnish a cheap and easily obtained fuel.

Siderite.—Siderite, or carbonate of iron, often called kidney iron ore, is found associated with the overlying shales in most of the coal bearing counties. In western Vigo and Vermillion counties it is especially common in the shales overlying coal VII. Large quantities were formerly used in the blast furnace at Terre Haute, and in the old Indiana furnace on Brouillet's Creek, about eight miles to the northwest. It is a low grade ore, yielding usually about 35 per cent. of iron. At the present price of iron ores it would doubtless pay for collecting and shipping.

Pyrites.—Pyrites, or iron sulphide, known also as "fools' gold," is the most widely distributed ore of iron in the State. Where free from rock or other impurities its constituents are iron, 46.7 per cent.; sulphur, 53.3 per cent. It is probably to be found in greater or less quantities in every county. It occurs most abundantly associated with coals V and VI, the thickest veins of bituminous coal mined in the State. Hundreds of thousands of tons of pyrites have been thrown out on the dumps of the mines of these veins of coal between Edwardsport, Knox County, and Coxville, Parke County. Within the past few years this pyrites has greatly increased in value on account of the rapid rise in the price of sulphur. The pyrites is used mainly in the manufacture of copperas, or iron sulphate, and sulphuric acid; 100 tons of the pyrites being used in making 50 tons of the acid. It is also used in the manufacture of fertilizers and in the wood pulp industry. The deposits in the United States do not begin to supply the demand, and there is annually a greater quantity imported from Spain, Portugal and New Foundland than is produced in this country.

As usually thrown on the dumps, the pyrites is mixed too largely with coal and other impurities for use. A plant or separator for freeing it from impurities can be erected for about $2,500, and the pyrites will then bring $3.75 or more per ton. In 1905, 253,000 tons of pyrites, valued at $938,492, were produced in the United States, while 511,946 tons, valued at $1,774,379, were imported. The value of that produced in Indiana for the year was $11,491.

Sulphuric acid is by far the most important chemical compound known to man. Sodium nitrate and pyrites are the two ingredients used in its making. The nitrate for any factory in the United States has to be imported from South America. With the pyrites and fuel present in large quantity, western Indiana offers a most excellent site for a great sulphuric acid factory.

Tripoli.

Tripoli or infusorial earth occurs at a few localities in Indiana. A large deposit which was formerly somewhat extensively worked occurs near Ferdinand, Dubois County, on the land of Joseph Brinkman. It is a fine grained, highly siliceous product of excellent quality, but lack of capital and transportation facilities have put a stop to its development. Another extensive deposit, darker in color and showing the presence of 83.71 per cent. of silica, 8.92 per cent. of alumina, and 1.54 per cent. of iron oxide, is found on the farm of A. H. Harbaugh, near Freetown, Jackson County. Other deposits occur near Mooney, Jackson County, on the land of Mrs. Elizabeth Clampett; in Lawrence County, on the farm of Hugh S. Bass of Bedford; near Merom, Sullivan County, on the land of W. P. Sparks, and near Bartle, Washington County.

Tripoli is formed from the siliceous shells of diatoms and other minute species. It is used mainly as a polishing powder for brass, silver and other metal work; also as an absorbent of nitroglycerine in the manufacture of dynamite, as a protective packing about steam boilers, as a base for fire and heat retarding cements, and in the manufacture of scouring soap and filters. It brings about $6.00 per ton on the market. Ten thousand nine hundred and seventy-seven tons, valued at $64,637, were produced in the United States in 1905.

"Drift marl," a very fine grained, silty clay containing 40 per cent. or more of calcium carbonate, and valuable as a polishing powder, occurs in quantity on the farms of M. W. McCann, near Rushville, and D. B. Wilson, Carbon, Clay County; also near Gosport, Owen County, and Boone Grove, Porter County.

Mineral Paints.

Minerals suitable for making paints are found in quantity in several places in southern Indiana.

In section 6, Pierson Township, Vigo County, there is a large deposit of very fine grained, grayish shale, known as the "Paint Mine." For a number of years this was ground and shipped in barrels to be used as a body for paints. It served the purpose admirably, and a lack of capital and transportation facilities have alone prevented the development of the industry on a larger scale.

On the land of Chas. Grimes, Section 20 (9 N., 5 W.), Jefferson Township, Owen County, three miles east of the E. & I. Railway, is a large deposit of iron oxide suitable for a mineral paint. A similar deposit of finer texture occurs near Worthington, Greene County.

One mile west of Dover Hill, Martin County, is a bed of ferruginous shale and clay, 15 and more feet thick, which furnishes umber and red and yellow sienna of excellent quality. When Dover Hill was the county seat of Martin County, this deposit was extensively worked, but on account of a lack of transportation facilities it has, for many years, remained untouched.

Near Ferdinand, Dubois County, in the south half of section 34 (3 S., 4 W.), are extensive beds of red oxide of iron and clay, which, about 1870, were worked on a large scale. Paints of a dozen or more different colors were made which were highly esteemed for their beauty and durability. A lack of capital and shipping facilities, however, in time put a stop to the enterprise. Large deposits of ochre and other paint clays are found farther south in the same region.

Deposits of a ferruginous clay suitable for umber also occur in quantity on the land of W. C. Stevenson, near Dillsboro, Dearborn County.

Glass Sands.

Sand suitable for glass making occurs in quantity at a number of localities in Indiana. Extensive deposits near Pendleton, Madison County; Montpelier, Blackford County, and Lapel, Hamilton County, were formerly largely used by the glass factories in the gas belt. A large deposit near Wolcott, White County, has been used for some years by the American Window Glass Company.

On section 15 (14 N., 8 W.), one-half mile east of Coxville, Parke County, is also a large deposit which in the past few years has been shipped in quantity for use in window and bottle glass making at Terre Haute, Muncie, Orestes, and other points. A switch from the T. H. & L. Railway is laid to the deposit, and a branch of the C. & E. I. runs within a half mile. At the point where produced, this sand is 40 feet thick. The deposit extends a mile or more along the bluffs of Raccoon Creek and is, in most places, underlain with a four-foot vein of good coal.

On the northwest quarter of section 20 (21 N., 7 W.), near the station of Rob Roy, Fountain County, there is a valuable deposit of glass sand which, for several years has been extensively worked by the Western Silica Company. A switch from the C. & E. I. Railway has been laid to the plant, erected on the banks of Shawnee Creek. The stratum of sandstone which is crushed and washed, reaches a thickness of 16 feet. This sand has had a large sale to points west and north.

Other noteworthy deposits of glass sand occur near Hillsboro, Fountain County; Johnstown, Greene County, and Loogootee, Martin County.

The manufacture of glass requires a purer sand than that used for any other purpose, and glass sand is, therefore, higher priced than other sands. The chief impurities are iron, alumina and clay, which color the glass or give it a cloudy appearance. These impurities are removed by washing and sometimes, in the case of iron, with a magnet. The purity of the sand used is regulated by the quality of the glass desired. Glass sand is mined in a more or less pure state from deposits of sand, and it is also obtained as a rock easily disintegrated when exposed to the air, or from hard sandstones, which have to be crushed before being used.

The following table shows the chemical composition of a number of the sands above mentioned:

ANALYSES OF INDIANA GLASS SANDS.

Location.	Silica (SiO_2).	Alumina (Al_2O_3).	Iron Oxide (Fe_2O_3).	Lime (CaO).	Magnesium (MgO).	Loss by Ignition.
Wolcott, White County	99.08	.59	.23	.10	trace.	....
Hillsboro, Fountain County	97.25	1.35	1.38	trace.	trace.	....
Rob Roy, Fountain County	97.84	1.38	.10	....	.03	.32
Coxville, Parke County	98.77	....	.68	.43	.11	....
Johnstown, Greene County	97.38	1.81	.16	.06	....	.57
Loogootee, Martin County	96.26	2.50	.92	....	.16	....

Molding Sand.

Molding sand for use in foundries occurs in a number of places in northern and central Indiana. The best known and most widely used deposit is on the land of the Bradford Sand Mining Company, near Centerton, Morgan County. A switch from the I. & V. Railway extends to a screening and loading plant near the principal beds, and during the year 1906, 16,100 tons, valued at $12,825, were shipped, principally to points in Indiana and Illinois. The sand is graded as per long established foundry rules and usages, into grades Nos. 0, 1, 2, 3, etc., which mean very fine, fine, medium and coarse. Each grade is then divided into three or more grades (as for instance, No. 0 strong, No. 0 medium, No. 0 open), thus making 20 or more grades. As almost every foundry makes a special kind of work, each requires a different kind or grade of sand suitable to their work, according to the mode of molding, kind of iron or metal used, etc.

Other beds of molding sand which are extensively used in Chicago, are located near McCool, Porter County, and four miles southeast of Valparaiso, in the same county. Near Hobart, Lake County, is a fine deposit eight and a half feet thick and covering a large area, which is, as yet, unworked. Other good deposits are found near Gosport, Owen County; Salem, Washington County, and Rockport, Spencer County. A large deposit has also been recently discovered on the land of Lewis Taylor, near Newburgh, Warrick County.

Sand Lime Brick.

The manufacture of brick from a mixture of sand and lime is a rapidly growing industry in Indiana. Four large factories are already in operation in the State, 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 usually 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. The sand-lime brick industry will grow most rapidly in northern Indiana, where sand is plentiful and good clay for ordinary brick making scarce. The Lake Michigan sand deposits of Lake, Porter and Laporte counties offer an abundance of material, and the pioneer plants in Indiana were located at Michigan City. The value of the sand lime brick produced in Indiana in 1905 was $65,905.

Gold and Diamonds.

For a half century or longer it has been known that free gold in the form of minute grains and flakes occurs in a number of Indiana counties. Moreover, the natives of Brown and Morgan counties have, while washing gold, happened upon a dozen or more small diamonds, most of which have been found in the past ten years. This gold and the diamonds have from time to time been the subject of numerous articles in the newspapers, and public curiosity and attention have therefore been drawn to them. Many letters and inquiries relative to them have been received at the office of the State Geologist, and a large number of persons have called there tc secure information regarding the distribution and quantity of gold in the State.

*For a detailed paper on the occurrence of gold and diamonds in Indiana, see pp. 11 to 47, inclusive, of the 27th (1902) Report of this Department.

Gold.—All gold found in the State up to the present time is "free" or "placer" gold, the particles ranging in size from those too small to be seen with the naked eye up to nuggets whose value was five to six dollars. Occasionally a piece of quartz or other igneous rock is found which contains particles of gold, but in each instance this quartz is a pebble or boulder of drift origin. In one or two places, horizontal strata of a conglomerate occur, which have been said to show gold upon assay. This gold, if present, has found its way into the conglomerate through interstices in the overlying strata, or was a component part of the sedimentary material which originally formed the conglomerate. The rocks underlying the surface of Indiana are all of them sedimentary limestones, shales or sandstones. No igneous dikes or vertical veins are known in the State, and no quartz, slate, schist, granite, gneiss, mica or other igneous rock with which native gold is found associated, occurs except in the form of boulder or pebble of glacial origin. Taking into consideration the above facts, there remains but one conclusion as to the origin of the gold, namely: *It was brought in by one or more slow moving glaciers from some point far to the north or northeast and deposited by the melting of those glaciers on or near the places where it now lies.*

Although this placer gold is known to occur in twenty or more of the drift covered counties of the State, especially in those which are just within or along the border of the drift-covered area, it has as yet been found in commercial quantities only in Brown, Morgan, western Johnson and northern Jackson counties. Here, along the lowlands of the stream valleys, it is found associated with a black magnetic iron ore sand, numerous minute garnets, and a mineral known as menaccanite. The quality of the gold found is of the best, as it will average 22 or more carats, as against 16 to 18 for California gold, and 14 to 16 for Klondike gold.

Along each side of the streams in the counties mentioned is a strip of bottom land of varying width, composed of gravel, clay and soil, the gravel resting upon the bed rock, which is the blue Knobstone shale. It is this gravel, next to the bed rock, that is richest in gold. Most of the surface of these strips is cultivated, and the owners will not allow the "gold hunters" to pan except in the beds of the streams. These beds have most of them been washed many times in succession, a new supply of gold being eroded during each freshet from the gravel beds along the banks. These beds, which form the base of the lowlands or cultivated bottom lands of the valleys, were formed during the melting of the glacier, when the streams flowing through the valleys were much wider and stronger than now. The gravel and sand composing them was then deposited and the soil, for the most part, has been formed since then by decaying vegetation and annual overflow.

After every freshet the children of the vicinity seek gold along the rocky bottom of each rill and stream and often find pieces worth 25 to 40 cents. Much of this is found lodged in minute crevices at the bottoms of small waterfalls. A few of the natives do little else than pan gold for a livelihood. One of them, Uncle John Merriman, of Brown County, has panned more or less every year for 53 years, and has done little else for the last quarter century. The largest nugget he ever found was taken on Bear Creek, and weighed 132 grains, valued at $5.50. He has found a number of pieces which ran as high as $1.00 to $1.25 in value; but most of what he secures is in the form of "colors" or minute flattish particles. He estimates that the gravel beneath the soil of the lowlands will average 25 cents per cubic yard in gold.

On two different occasions Mr. Merriman has kept a careful account of the results of a month's work—Sundays excluded. One month yielded him $34.00, the other $40.00. He claims that he can average $1.25 a day during the panning season, which runs from March to November, except in time of summer drought. During his panning he has found several small diamonds.

Practical tests have been made of the lowland material in a number of places in northern Morgan County. These have proven that it runs from 30 to 80 cents per cubic yard in gold. The most thorough of these tests was made on the land of Dr. Clark Cook, section 30 (13 N. 1 E.), just north of the postoffice of Brey. Here 25 holes were dug through a strip of lowland to bed rock, the average depth being three feet, nine inches. From each of these holes 75 pounds of gravel was carefully panned, one-third being taken from the top, one-third from the middle and one-third from the bottom of the gravel stratum. In addition, miscellaneous gravel from the holes was added to bring the total up to 2,000 pounds. From this, gold to the value of $1.54 was secured. Allowing 3,000 pounds as the weight of a cubic yard of gravel, and deducting two-thirds for soil and clay, which were barren of gold but must be handled, the tests showed 77 cents per cubic yard for the matter composing the lowland. There is probably an aggregate of ten to twelve square miles of the gold-bearing lowlands in the four counties above mentioned.

The most serious problem to be solved in the working of these placer deposits on a large scale is that of a permanent water supply, as most of the streams are dry several months in summer. By constructing permanent dams in several of the valleys enough water could probably be conserved to tide over the dry season. There is no doubt but that large quantities of gold exist in the area mentioned. Only a person experienced in hydraulic and placer mining who is conversant with the latest improved machinery for that purpose, will be able to state whether the process of its separation can be made a profitable one. One company with a large amount of capital at its disposal could, with a plentiful supply of water and machinery, which would save 90 per cent. of the gold, perhaps make money in the thorough washing of these placer deposits, but everyone is warned against investing money in small stock companies, several of which have been promoted for that purpose in the last few years.

Diamonds.—While panning gold from the gravel and sand in the beds of the streams of Brown and Morgan counties, a number of small diamonds have been found by the gold seekers. Their discovery, however, is only of scientific interest, as they are far distant from their original home. It is only by chance, at long intervals, that one is happened upon, and a search for one would be like seeking the proverbial "needle in the haystack."

I have seen nine of these diamonds and have credible information concerning several others. The ones which have come to my notice were small stones, one-eighth to five carats in weight. The colors were variable, brown, yellow, pink or bluish. Most of the stones were clear and flawless, their gem value running from \$5.00 to \$200.00.

Source of the Gold and Diamonds.—From a careful study of the minerals found associated with the Indiana gold and diamonds, and from what is known regarding the source of the glaciers which brought them into our State, it is believed that their original home was somewhere in British America, probably to the west or southwest of James Bay. The Director of the Geological Survey of Canada has become interested in the subject, and has begun the mapping of the Canadian wilderness in this region, in order to determine more definitely the source and direction of the ice movement. The new National Transcontinental Railway, from Quebec to Winnipeg and the great wheat region of Manitoba, will traverse much of the country whence the gold and diamonds have probably come, and the Canadian Government is also sending out numerous survey parties for exploration along its route. It is not improbable that within the next quarter century a real El Dorado will be discovered among the igneous rocks of this far northern region, which will be as rich in gold and precious stones as any heretofore known to man.

Other Minerals and Ores.—With the exception of the placer gold above mentioned, no gold, silver or other precious metal occurs in the State. Much money has been foolishly spent and time wasted by people who have thought otherwise; but they have ever had their labor for their pains.

In many of the northern counties small pieces of "black jack" or zinc blende, galena or lead sulphide, and native copper ore, are occasionally found, and give rise to much local excitement and speculation. It is needless to say that the specimens of copper and lead were also brought in by the drift or by the Indians; and the blende, while possibly of native origin, is, on account of its small quantity, utterly valueless. In almost every county one also hears tales of reputed silver and lead mines, which in the days of long ago were secretly worked by the Indians. Many well informed people yet believe these tales, and have spent days in fruitlessly searching after imaginary mines, where enough silver may be had to pave the streets of their native towns, or where lead ore exists without limit.

While Indiana is thus lacking in the precious and other useful metals, her deposits of coal, clay, stone, petroleum and cement resources are far more valuable, and are bringing more wealth into the State than if, instead of them, rich mines of gold and silver had been found within her bounds. Higher grades of labor, and more stable industries are based upon such resources, for few, if any, large factories utilize gold and silver in quantity as a manufacturing resource.

THE PEAT DEPOSITS OF NORTHERN INDIANA.

By Arthur E. Taylor

The area treated in this paper comprises about 7,500 square miles of northern Indiana, embracing the three northern tiers of counties. At the present, no greater economic problem presents itself to the people of this section of Indiana than that of a cheap and abundant fuel supply. Until twenty years ago the farmer had little concern as to where his winter fuel would come from. Axes, crosscut saws, mauls and wedges were in his woodshed, and at his back door, the woods, where fuel could be obtained in abundance by merely cutting it. The cost was practically nothing, since he did this kind of work after grain, hay and other crops had been either stored away or sold; the fall wheat had been sown; and there was little else that could be done about the farm.

What a pronounced change has taken place. The large forests that once covered northern Indiana are now only a dream of the past. What, at one time, seemed to be an inexhaustible source of fuel, has become largely obliterated; and what remains is used little for such purpose, since the repeated advances in the prices of timber have made it much more valuable as lumber. This depletion in a native fuel means much to the farmer, and to the citizens of the many small towns that are several miles from a railroad.

Today the farmer, in numerous localities, hauls his coal from 5 to 12 miles. The coal, at the switch or coal yard, costs him from four to eight dollars per ton. Suppose he only hauls for 5 miles over an improved road, and at a time of the year when the roads are in a good condition. A load of two tons is about as much as the average farm team should haul under such circumstances, and two loads per day will make a good day's work. Considering a team and man worth three dollars per day, and the cost of the coal four dollars per ton, the cost of his coal in his bin is five and one-half dollars per ton. But these are the most favorable circumstances, and, furthermore, do not coincide with the facts. The farmer is very busy with his crops when the roads are at their best; and generally, for some of the distance, he hauls over dirt roads, which are frequently very sandy, the hills little graded, the side ditching and repairing sorely neglected. With such obstacles to contend with, his loads must be much lighter, and his team will travel more slowly. Is there any remedy for these conditions? Will it be possible for the farmer to obtain a fuel at a lower cost?

It is true that there are no workable beds of coal in northern Indiana. The only coal found occurs in irregular masses in the glacial drift. This was picked up by the ice, while passing over some of the coal beds of Michigan, and carried into the various localities and dumped. The nearest coal beds of any economic importance occur near the western-central part of the State.

However, there is a fuel in this seemingly barren territory that is sure to come into domestic use, especially with those living so far from the railroad switches. This fuel has been used by the people of the Old World for centuries, and today is used in Canada and many places in the United States. It is frequently found in large quantities, in the very localities where the people are hauling their coal for ten miles. The name of this fuel is "peat," commonly known as "muck" by the people of northern Indiana.

All of the larger peat beds in the northern part of the State were inspected during the spring, summer and fall of 1906, in order that an estimate might be made as to the economic importance of this material as a future fuel for northern Indiana. The purpose of this report is, first, to give reliable information regarding the location, extent and value of the principal deposits; second, to make known the best methods of determining in the field something of the fuel value of peat; and third, to point out various physical and chemical changes that are taking place in these peat beds, as well as certain topographical phenomena, that will be of interest to those who enjoy the study of nature.

Definition.—Peat is a moist, spongy and partially carbonized vegetable matter, ranging in color from a light chocolate brown to a black. When it has remained, for some time, in a state of imperfect decomposition in the presence of water, it forms a soft, slimy mass, which is sufficiently tenacious to be molded into almost any form. When dried this mass becomes hard and somewhat darkened on the surface, from oxidation. It shows an earthy fracture, and reminds one of a black carbonaceous clay. Where the peat has only been in this state of partial decay for a brief period it is very fibrous, incompact and often contains the roots of the plants which afford the material from which it is derived. It is lighter in color and has a lower specific gravity than the first variety. In any marsh where the process of peat formation is going on, we find these two varieties, the former comprising the lower and medium portions of the bed, while the latter lies near the surface. Between these two varieties the peat is found in various intermediate stages of incomplete preservation. Peat in many localities is commonly known by the terms "muck," "turf" and "bog."

Distribution.—The deposits of peat are widespread and extensive. Russia alone has 67,000 square miles of peat land; Ireland contains 1,576,000 acres of "flat bog," and 1,254,000 acres of "mountain bog;" while the beds of Germany will also cover several millions of acres. There are likely half a million acres in Sweden and Norway, and numerous deposits in Holland and France. Large deposits also occur in China, the southern part of Africa, southern South America, Mexico, Canada, and the United States. Professor Lyell states, "it has seldom, if ever, been discovered in the tropics." Darwin says, "in the southern hemisphere peat does not occur nearer to the equator than latitude 45 degrees."

The distribution of peat deposits shows that they are not governed by luxuriant growth of vegetation, like in the tropics, but rather by conditions that make accumulation of vegetation possible. These conditions are climate and topography. Excessive heat, like that of the tropics, promotes decomposition. Both the work of oxidation and that of the bacteria is much more pronounced than in a cooler climate. Close to the Arctic Circle, the summers are too short for a large accumulation; but in the moist regions found between latitudes 40 and 60 degrees north, the climatic conditions seem most suitable. Here it is that the sphagnum mosses, which are the most important of the peat producers, grow most abundantly.

The topographical features are even a greater factor in the geographical position of the peat deposits of North America, than the climatic conditions. The main developments are limited to the region occupied by the late continental ice sheet of the Pleistocene period, and occur in old glacial lake basins. These basins, filled with peat, are very common in the northern part of the United States, in New Jersey, New York, Pennsylvania, Indiana, Michigan, Wisconsin and Minnesota, and adjacent portions of Canada. Their development was brought about by the gouging out of the bed rock by the advance of the great ice lobes, and the deposition of their heterogeneous loads of clay, gravel and bowlders at the time of receding. These irregular masses gave a hummocky surface, which necessarily contained hundreds of thousands of undrained depressions. The deeper of these had part of their basins beneath the ground-water level and became lakes.

It* has been around the shores of these small glacial lakes, where the waves were too small to disturb greatly the plant growth, that the water loving vegetation found its way out upon the surface of the water. Here it would die, and sink beneath the water surface; other plants of the same species would grow upon it; and this process would continue until the vegetal growth would cover the entire lake, and the successive layers would fill its basin.

Although the swamps that mark the locations of old glacial lake basins, contain the most important sources of peat fuel in North America, yet there are many other swamps and marshes that contain vegetation in the presence of water. The condition necessary for the development of any of these vegetal accumulations is a sufficient amount of water present to prevent entire decomposition†. Swamp formation is also governed by the relation existing between humidity, temperature and gradient. Where the dry season is long, the vegetal accumulation, although considerable, may be dried out and entirely oxidized; and the higher the temperature the more rapid the oxidation. Even a very level surface in a climate of this kind would be sufficient to stand off marshes; while in other places where the climatic conditions are favorable, heavy vegetable accumulations occur on grades of five degrees. N. S. Shaler has given the most comprehensive classification‡ and discussion of marshes and swamps, known by the writer, in the 10th Annual Report of the United States Geological Survey. His classification is as follows:

CLASSIFICATION OF MARSHES.

Marine marshes	Above mean tide.	Grass marshes.
		Mangrove marshes.
	Below mean tide.	Mud banks.
		Eel grass areas.
Fresh-water swamps	River swamps	Terrace.
		Estuarine.
	Lake swamps	Lake margins.
		Quaking bogs.
	Upland swamps. Ablation swamps	Wet woods.
		Climbing bogs.

*See page 81.

†See page 82 for an explanation of this partial development.

‡See 10th Ann. Rept. U. S. Geol. Sur., pp. 261–339

The marine marshes are of little importance as peat producers. Those of the eel grass type lie in bays, where the slackened currents deposit the fine silt that they carry, forming a bed, on which the eel grass grows readily. These marshes* are generally covered with 3 or 4 feet of water at half tide, when the tidal current is greatest. The heavy growth of vegetation almost stops the tidal current, which bears in more fine silt for deposition; thus increasing the thickness of the bed, until it is dry at low tide. At this stage the eel grass ceases to grow, and the accumulation depends entirely upon the sediment borne in by the tide. The result of this accumulation is the mud flat.

On the higher part of this mud flat phenogamous grasses begin to grow, which ultimately form a bed of such thickness that only the highest tides overflow it. The mud flats, existing between the eel grass marshes and grass marshes, sometimes attain widths of one mile. The peat of the eel grass marshes is unsuitable for fuel, and the grass peat seldom contains 50 per cent. of carbon.

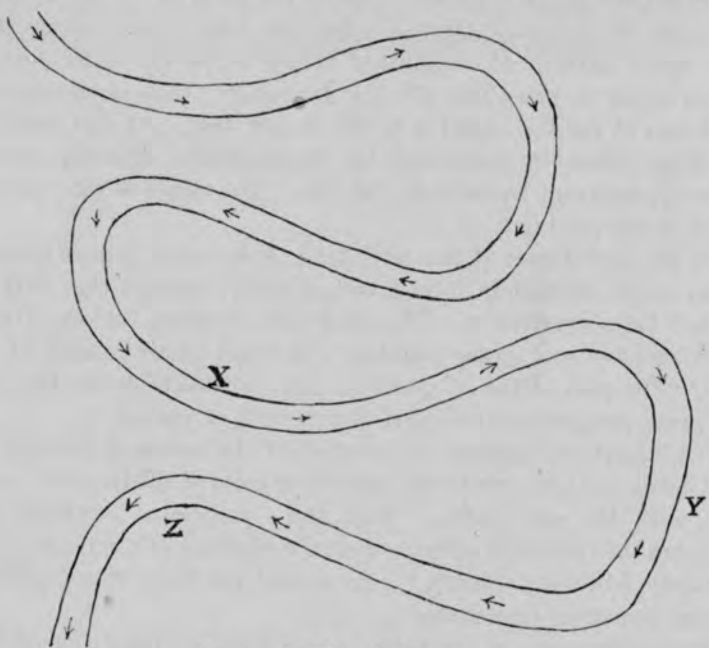
The Mangrove marshes, so common on the coasts of Florida, are well developed only where the branching roots of the tree are in contact with the salt water. With the "successive runners† and branches the trees may advance over the sea-floor at a rate of twenty or thirty feet in a century." As a peat producer this vegetation has no economic importance.

Terrace swamps are developed in two ways. At the time of flood a stream is heavily laden with sediment, and when the current leaves the channel and flows out over the banks, the velocity is suddenly reduced. Since the draught on a stream's energy of a particle carried in suspension is measured by its mass into the distance it would fall in a unit of time in still water, this immediate slackening of the current causes part of the load to be abruptly dropped, where the main channel is abandoned. A repeated deposition of this kind forms a dike, which dams off a portion of the water of the flood plain or first terrace, so it cannot return to the stream channel after the subsidence of the flood. Thus sloughs or small lakes are frequently developed, whose still waters and silty shores make an excellent soil for the growth of some aqueous mosses, grasses, sedges, rushes, etc. These encroach upon the water limits, in a manner similar to which they do upon the glacial lakes‡, and fianlly replace the water entirely. These deposits, however, are generally more or

*See 23d Rept. of the New York State Museum, p. 22.
†See 10th Ann. Rept. U. S Geol. Sur, p. 293.
‡See page 81.

less silty, and can not compare from a commercial standpoint with those of the glacial lakes.

The second manner in which the terrace deposits are developed is



Course of a Meandering Stream.

by the meandering of a stream. When the current of a stream has a low velocity it requires very little to turn it away from its course, and since the banks of a stream are always weaker in some portions than in others, it is certain to meander. At these weaker places curves are started, and since the current readily finds these, they are developed rapidly. When the development has reached an advanced stage, as is shown in the figure, the position of the channel becomes unstable, and there is a strong tendency for straightening. While the channel follows the course x to z by way of y, at time of flood, when the banks are overflown, the currents may find their way, by the much shorter route, from x to z. The steeper gradient from x to z increases the velocity of the current, which begins to wear a new channel. As this channel deepens a larger and larger volume of water is admitted, which accelerates the velocity and eroding. In this way the channel may be worn so deeply that a new channel is cut during a large flood. Upon the subsidence of the water the old channel has been abandoned. If its bottom is beneath the ground-water level a lake is formed, which is known as a "bayou" or "ox-bow lake." These, in a manner similar to that of the slough*, become covered with vegetation and take on the form of swamps, which may develop into peat beds.

Estuarine swamps are developed when a stream forms a delta at its mouth. The delta necessitates several outlet channels, between which the surface is often lower than the banks of the stream. Over these low flat surfaces, which contain many little lakes and ponds, aqueous vegetation grows rapidly, thus producing the swampy conditions suitable for the partial preservation of mosses, grasses and sedges in the presence of water. The deposition of silt at flood time, makes deposits of this type generally impure.

Wet Woods.—When the surface is very level a small accumulation of vegetation will retard the surface drainage, and soak up the water, which would otherwise flow away. If the evaporation is retarded, as is the case in the forests, some water may be held throughout the year. This will prevent the complete perishing of the vegetable matter, which may be accumulated upon it, and thus develop the swampy conditions.

Climbing bogs frequently occur in Ireland, but in North America are rare. Where the climate is very humid the sphagnum, starting on the lake borders, will extend upward over slopes of as much as five degrees. The interstitial spaces between the dense mass of branches of this plant make excellent reservoirs for water. This water preserves, in part, the vegetable matters and a swamp is eventually developed. These bogs furnish large quantities of peat for commercial purposes in parts of Europe.

The ablation swamps are of little importance as sources of peat. They are formed by the dissolving away of the $CaCO_3$, or other salts, which result in sinks. These basins are undrained, and may have their bottoms beneath the ground-water level. In the latter case, marshy conditions are certain to result.

VARIETIES OF PEAT.

There are two kinds of peat found in this State that occur in workable quantities. The most important of these is the moss peat. It has originated mainly from the water-loving mosses, but somewhat from the ferns, grasses and sedges. The moss figuring most prominently in the forming of this peat is known as *Sphagnum cymbifolium.* Probably 90 per cent. of a peat derived solely from

*See page 77.

the mosses, would come from this source. Go into any tamarack or huckleberry marsh of northern Indiana, where the ground is quite moist, and one will find this species growing on the surface. Frequently it looks like a great carpet, covering several acres. Always associated with this form is the one which holds the next place of importance as a source of the moss peat, namely, *Sphagnum acuminatum*. In addition to these two sources, the mosses *Climacium americanum, Cylindrothecium seductrix, Dicranum scoparium*, and other mosses, various species of ferns, and a few other plants play a small part as sources of origin for a real moss peat in this State. Most of the deposits, however, for reasons that will become obvious in subsequent pages, contain some of the grasses, sedges and other vegetation.

The grass and sedge variety, which has a lower fuel value than the moss peat, is derived from a great number of grasses, sedges, reeds, rushes, etc.

Occurrence of Peat.

Peat is found to some extent in all of the area covered by the late Wisconsin drift, which has its terminal moraines in the central part of the State, but occurs in workable quantities only in the three northern tiers of counties. The peat beds appear in the sites of old glacial lake basins, in lake basins that have been developed between sand dunes, and in "bayous" or "ox-bow" lake basins, which have been left in the meandering of streams. The first topographical position is most prominent in the northern and northeastern part of the peat region; the second is very noticeable in Lake and Porter counties, in the northwestern part of the State, and the third is found especially in the Kankakee and Little Calument River Valleys.

Origin of Peat.

The largest and most important of these peat deposits are those which occupy the sites of old glacial lake basins. Almost all of the moss peat of Indiana, and 70 per cent of the grass and sedge variety have this topographical position. Since all of the workable deposits of the State are limited to the counties found in the lake region, and most of the beds have had their development in these lakes, a brief history of the lakes and their origin will be helpful in understanding the forming of the peat deposits.

Without question, the most beautiful and picturesque portion of the State of Indiana is that found in the lake region. These lakes were well known in prehistoric times to those true children of nature, the Indians, who built their wigwams nearby, hunted about the shores and fished in the quiet waters. The pioneers were no less acquainted with them, since it was here that all the birds and animals of the forests came to quench their thirst, and the bass and pickerel were always waiting for their bait. Today the shores are lined with cottages and tents, where the busy sons and daughters of the Hoosier State go for rest and pleasure during the hot summer weeks.

These lakes and the topographical features surrounding them are the monuments of the last continental ice sheet. They belong to the very latest moraines of the glacial period. Their origin took place when the great ice lobes began their recession, dropping their heterogeneous loads of clay, sand, gravel and bowlders in irregular masses, which gave rise to a hummocky topography, without any drainage. Consequently almost an innumerable number of depressions, technically called "kettle basins," were present, which became occupied by lakes or ponds wherever the bottoms were below the ground-water level. Today only a small percentage of these lakes and ponds are left.

In brief, those factors that have been most important in the destruction of the lakes have been* (1) the development of a natural drainage; (2) the filling up by the "carrying in of debris or foreign matter by streams and springs"; (3) the lowering of the ground-water level by the cutting away of the timber, dredging and tiling; (4) and the filling up brought about by the partial decaying and accumulation of vegetation. In the first case the streams and their tributaries worked their heads back into the hummocky surface, tapping many of the lakes and lowering the ground-water level. Probably the carrying in through springs of the calcium bicarbonate, which, upon losing carbon dioxide, was precipitated in the form of the mono-carbonate, or "marl," is the most important of the second case. In the third division, the cutting away of the forests has permitted a complete oxidation and hardening of the surface, so that the water passes over the surface readily, and into the streams, where formerly the soft vegetal mold formed a sort of a sponge, which retained it, keeping the ground-water level at a greater altitude. Dredging and tiling has also lowered the ground-water level, draining many of the smaller lakes and ponds, and has lowered the water level in the larger lakes. The most important

*Twenty-fifth Ann. Rep. Geol. Sur. of Indiana, 1900, p. 36.

factor in the extinction of the larger lakes and those that continued to remain beneath the ground-water level is the last. In almost every township of these northern tiers of counties are old glacial lake basins filled up by partially decayed vegetation.

The filling of some of these lakes by vegetation undoubtedly began as soon as the ice receded, and is today going on, in greater or less degree, at almost all of the lakes. Vegetation, in the larger lakes, generally grows most abundantly on the southern and western shores. This is due to the prevailing winds coming from a southwesterly or westerly direction, and thus developing higher waves on the northern and eastern shores. Because of the minuteness of the waves, the small lakes are not so noticeably affected in this way. The more narrow portions of the lakes, and the bays are found to be suitable for a heavy growth of vegetation.

"*Where muck meadows—former portions of the water area—border a lake the transition from the species of vegetation covering their surface to those growing in the water on the outer edge of the muck beds is a gradual one. In the water 8 or 12 feet in depth are pond weeds (Potamogeton), water shield (Brasenia), bladderwort (Utricularia), and water-millfoil (Myriophyllum). As the water decreases in depth, first the white water lilies (Castalia) and then the spatterdock or yellow water lily (Nymphoea), appear. With the latter are usually pickerel weed (Pontederia) and often the green arrow-arum (Peltandra). A little higher up and growing in the muck which reaches to or nearly to the surface of the water is usually a thick bed of cat-tails (Typha) and arrow-head (Sagittaria), while farther back are the sedges and grasses of the typical muck meadow."

The partially decayed vegetation underlying the cat-tails and arrow-heads is of no practicable use as a fuel, because of its very incompact condition. It is really a mass of fibers floating in the water. Even the surface of the bêd at this stage will seldom bear the weight of a man; and it is not until a sufficient vegetal covering has blanketed the water surface, and the grasses and sedges begin to grow, that the bed even begins to become sufficiently compact and decomposed to be considered a peat bed. By far the major portion of the accumulation takes place subsequent to the beginning of the growth of the grasses and sedges upon the surface. The peat beds resulting from the accumulations of this sort, are alluded to in this report as grass and sedge deposits. Not that the grasses and sedges

*Twenty-fifth Ann. Rep. Geol. Sur. of Indiana, 1900, p. 38.

are the only sources, because even while these are growing on the surface there are reeds, rushes, ferns, mosses, and other forms of vegetation, but because they seem to be the most important of any of the vegetation in the origin.

Instead of being filled up by the grasses, sedges, etc., other lakes are replaced by the mosses; and in such deposits the sphagnum mosses play a much more important part than the grasses and sedges do in the development of the grass and sedge beds. These mosses form a lodgment about the margin of the lake wherever the waves are not sufficient to break them up. This covering of moss spreads out and floats on the surface. It gradually thickens, and the decayed peaty matter falls off from the lower side of this raft and accumulates on the bottom of the lake. At first this moss covering is very thin and will sustain little weight, but as it becomes heavier and advances over the surface of the lake, a man can walk out for a short distance on its quaking surface. At this stage it is known as a "quaking bog." If the growth and accumulation continues for a sufficient period, the lake may become entirely filled with this peaty substance, and the resulting deposit would be termed a peat bed, if sufficient decomposition beneath the ground-water level had ensued. However, if the material was yet in a very fibrous condition and not enough decomposed for peat, a "peat-moss litter" bed would be a more applicable term.

As has already been mentioned, peat is formed from the partial decaying of vegetation in the presence of water. This water does not have to be held in a lake, but may be in the interstices of living and dead vegetation. In Indiana we have some good examples of peat being formed entirely above the ground-water level. If we will walk through an ordinarily dry forest we will note that the vegetation soon becomes blackened and decomposed, the carbon passing off as carbon-dioxide and the inorganic matter being left as a residue. As we approach a lake we may find the vegetation decaying much more slowly in the presence of water; and the accumulation gaining on the decomposition. This accumulation is due to the fact that where the water is present the air can not come into free contact with the carbon, and this element is largely retained, while much of the inflammable substance is given off. Consequently the fuel quality of the vegetation is becoming improved. Further, because of the aqueous condition, various microscopical organisms are shut off that are very effective in producing decay. In short, vegetation in the presence of water loses very little, if any, of its fixed carbon, although some light, combustible gases are given off. In this condition will remain indefinitely, until possibly a change in the elevation of the land will permit the deposit to be submerged and covered by other formations, thus leaving it buried in the strata, where it will ultimately become a coal bed.

Quality.

The quality of peat is dependent upon (1) the kind of vegetation from which it originated; (2) the length of time since the formation took place, and the amount of decomposition beneath the ground-water level that has ensued; (3) whether it is above or below the ground-water level and how long it has been in this position; and (4) the amount of impurities. The fuel determinations* made by Dr. R. E. Lyons of the State University, show the moss peats to have a higher value than the grass and sedge variety. The same fact has been corroborated by numerous other tests that have been made throughout the world.

If the vegetation has been submerged only a brief period the slow decomposition that takes place in the presence of water has not had time to dispel the inflammable gases. Peat in this condition has a low fuel value, and is generally very fibrous and incompact. Frequently underlying this sort of material is a less fibrous, more compact, and decomposed substance, which will make a much better fuel.

From an economic point of view, nothing is more important than the relation of the bed to the ground-water level. When the material once gets above the ground-water level, and becomes dried out by the atmosphere, decomposition takes place very rapidly. It is nothing unusual to see the surface of a peat bed, which has been cultivated for a few years, changed to a black sandy loam. This is merely due to the fact that the material has been stirred so that the oxidizing work of the air has been complete. The organic material has been given off in the form of carbon-dioxide and other gases, and the inorganic substance has remained as a black sandy loam. So we find the peat beds in general that are above the ground-water level, of a lower fuel value; and thus rapidly decreasing. The peat beneath the ground-water level will remain, almost indefinitely, in a fresh and undecomposed condition, the fuel value constantly improving as the decomposition continues.

The lower portion of a peat bed is generally somewhat mingled with the underlying formation. The importance of this impure condition is largely dependent upon the thickness of the bed, the

*See page 93.

per cent. of impurity being less as the thickness of the bed is greater.

USES.

As a fuel, peat has been known since prior to the Christian Era. Pliny, in his Natural History relates that "the Chauci pressed together with their hands a kind of mossy earth, which they dried by the wind rather than by the sun, and which they used not only for cooking their victuals, but also for warming their bodies." At present, in Europe, peat is burned extensively when coal is not available. Great quantities are used in Ireland, Scotland, England, Norway, The Netherlands, Denmark, Poland, Bavaria, Switzerland and France. Russia alone produces 4,000,000 tons annually, Germany 2,000,000, Holland 1,000,000 and Sweden 1,000,000.

In America, the exhaustion of the coal fields is bringing peat more and more into use as a fuel, especially in those places that are rather remote from the coal regions. Probably its most extensive utilization has been in the provinces of Ontario and Quebec, Canada. The briquettes are being burned more or less in all of the large cities of the eastern part of the United States. Peat works are already operating in the New England States, New Jersey, New York, Michigan, Illinois, Wisconsin, Florida, Quebec, Ontario and Manitoba, and the crude process of digging out the green material, stacking it up and drying it, is carried on somewhat in the rural districts of all of the states in which peat is found.

As compared with coal, peat contains less carbon and hydrogen, more oxygen and ash, and has a lower fuel value and specific gravity. In Percy's Metallurgy we find the following table, which compares some of the chemical and physical properties.

Substance.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.	Specific Gravity.
Peat	54.02	5.21	28.18	2.30	.56	9.73	.850
Lignite	66.31	5.63	22.86	.57	2.36	2.27	1.129
Bituminous Coal	78.69	6.00	10.07	2 37	1.51	1.36	1.259
Anthracite Coal	90 39	3.28	2.98	.83	.91	1.61	1.392

The following table, giving the comparative heat values, has been taken from Thurston's Elements of Engineering:

Fuel.	Calorific Power. Relative.	Absolute.
Anthracite coal	1.020	14.833
Bituminous coal	1.017	14.796
Lignite, dry	.700	10.150
Peat, kiln dried	.700	10.150
Peat, air dried	.526	7.650
Wood, kiln dried	.551	8.029
Wood, air dried	.439	6.385

Because of its low fuel value, peat is used very little in factories, but for domestic purposes it is growing in importance. This growth is largely due to its cleanliness.

Ordinary coal or wood stoves and furnaces are not suitable for the burning of peat. The fire boxes are too large, and the drafts are too strong. In Europe much attention has been given to specially constructed stoves for burning peat. T. H. Leavitt, who operated peat works at Lexington, Massachusetts, relates his experience as follows: "During four years I ran a 14 horse-power tubular boiler; (the fire-box, fitted for coal, was originally 32x42 inches, with grate bars ¾ of an inch apart and 15 inches below the boiler). I burned nothing but condensed peat of my own manufacture, and, finding that the heat generated was far in excess of what was required, the area of the grate was reduced by laying fire-bricks at the sides and rear end, to 16x36 inches—less than one-half the original area. The fuel was never more than six inches deep on the grate, generally less; the amount of gas generated produced a constant flame which filled the entire space under the boiler, showing that if a larger quantity was used it would probably generate an amount of gas in excess of what could be consumed, and must therefore be wasted. It burned with a very light draft, gave quick and intense heat, and at the close of the fourth year the grate bars were entirely uninjured and as good as when new."

Manufacturing of Peat Fuel.

Extraction of Peat.—The most common manner of extraction is by means of a slane, which is a spade with sharp edges, the one edge being at right angles to the blade. With this instrument it is reputed that a strong man can cut 50 tons of the crude peat in a day of 10 hours. Another instrument that is very common in Prussia is the Browsowsky. With this peat can be obtained from beneath a considerable depth of water, without the expense of draining. The cutting device is made like the four sides of a box, with oblique edges. The lower edges are kept sharp for the cutting. When the machine is sunken to the desired depth, which might be 20 feet, a blade, worked by means of levers, cuts under the prism of peat, which can then be lifted. The prism, which is from 1 to 2½ feet thick, and 20 feet long, is cut up into convenient sizes. A machine of this sort is operated along the side of a trench that has been already cut, by the labor of two men. The output is 3,000 cubic feet in 10 hours. Various dredging machines are also used in the very wet peat bogs.

The question of getting rid of the moisture is a most important one in the digging of peat. Sometimes a large amount of water can be drained off by ditching, but this is often impracticable, since freezing makes the peat brittle and difficult to work. When the person extracting can stand on the dry ground and do his digging beneath the water level, he finds that his peats cut most easily and conform best. They can then be stacked in the air for their first drying, and afterwards be put in a drying kiln. Another method of drying is to harrow and rake the surface of the bed, after taking off the undecomposed vegetation. This exposes a thin layer of peat to the action of the wind and sun, reducing the amount of moisture from 75 to 40 or 50 per cent. In this condition the material is submitted to the dryer, where the water content may be reduced to 10 or 15 per cent.

In Holland there is a process where irregular pieces of wet peat are thrown into a vat and there trodden by men and women, or horses or oxen. This developes a kind of compact pulp, which can be readily moulded into the desired form and dried. Sometimes this pulp is spread out on a floor and then gone over with a roller until it has become much more compact and has taken the shape of a rectangular solid. It is then cut into suitable sized brick and removed to the drying floor.

The most successful processes have been those where machinery is used for tearing up the fiber and giving a homogeneous mixture of the mass. These processes might be discussed under two headings, the wet and dry.

Up until recently the wet process has not been considered successful by operators of the United States, but is said to be used extensively in Continental Europe. At Trent Valley, Canada, hydraulic presses were built and operated from 1900 to 1902. The crude peat was put on trucks between perforated trays, covered with filter cloth. In this condition it was subjected to the pressure. Nineteen pressings were made in 10 hours. The amount of water in the peat upon entering this press amounted to 77.71 per cent., but after being submitted to pressure it was reduced to 63.48 per cent. Upon leaving the press the peat was put through a drier, which consists of a long rotary cylinder. This apparatus evaporates 6,000 pounds of water in one hour, and reduces the amount of water to 23.41 per cent.

Another peat plant of the wet process type is situated a short distance north of Toledo, in southern Michigan. The equipment and method of handling the material are described as follows: "The peat is dug by a dipper dredge, loaded onto scows, these are floated to the wharf, then unloaded by a bucket and scraper elevator, carried to the second floor of the factory building, and there dumped into the hopper of the peat-mill, containing all its original moisture—about 85 per cent. In this mill the peat is thoroughly ground, macerated and kneaded, so much so that after emerging from the mouth-piece there is no loose moisture discernible, the water and peat having formed a perfect amalgamation, which, after it is taken to the drying sheds, where within 24 hours it loses about 40 per cent. of moisture through natural evaporation.

The condensing process has begun and when dry it has assumed a black, hard, tile-like appearance, burning freely without smoke, depositing no soot and no clinkers. It has been found adaptable for steam boilers, heating and cooking stoves, for brick kilns, and in fact wherever a clean, intense, heat-producing fuel is wanted."

The general opinion of the peat producers of the United States is that the most practicable process is the dry. In this the material is gotten into a very dry condition before it is introduced into the press. At Beavertown, Canada, is a peat plant, using this dry process, that has been operated successfully for 5 years. The material is dug by an electric scraper, and the fragments are thrown before a paddle wheel*, which tosses them from 30 to 50 feet, thus scattering the substance, so that within 2 or 3 hours it will have lost 40 per cent. of its moisture. The product next goes into a breaker, where it is torn up and broken; and thence into the drying cylinder, which is 30 feet long and 3 feet in diameter. It rotates in 3-5 of a minute and has a pitch of 14 inches. The peat in 20 to 30 minutes comes out at the lower end of this cylinder as a dry powder. This powder is delivered to the briquetting press. The capacity of

*Parmelee, Peat Deposits of N. J. Ann. Geol. Rept. for 1905 the plant is 12 to 15 tons, and the cost is $1.80 per ton. A number of other presses are used, but the general characteristics are set forth in the above description.

Numerous plants, mostly of a low capacity, are found in Europe. In Russia 70 can be seen in one locality and from one viewpoint, each requiring the labor of 30 men. Plants of the United States* are being operated at Lincoln Park, N. J.; Rochelle, N. Y.; Orlando, Fla.; Vicksburg, Mich.; Copac, Mich.; Boston, Mass.; Eaton Rapids, Mich.; Chelsea, Mich.; Chicago, Ill.; and partly operating or organizing at Aurora, Ill.; Detroit, Mich.; Tyner, Ind.; Willmar, Minn.; Mankato, Minn.; Minneapolis, Minn.; Portland, Me.; Gobleville, Mich.; Marshall, Wis.; Madison, Wis.; William Street, N. Y.

Peat Coke.—In the Freyburg smelting works, coked peat is said to have been used in 1360; and for a similar purpose it was used in England in the early part of the seventeenth century. It is recorded that in 1735 peat charcoal was made in the Harz and successfully applied on a large scale. Peat coke has been manufactured in Ireland, Scotland, Norway, Sweden, Holland, Germany, Bohemia, Bavaria, and during the last few years the Russian Government has erected a plant between St. Petersburg and Moscow, to supply railway locomotives.

The intensity of heat, freedom from smoke, odor without sulphur, absence of those properties deleterious to metals and its cleanliness, places coked peat as one of the foremost of fuels. G. L. Fowler, in "The Engineer" of April, 1903, says: "The temperature to be obtained by the combustion of coke is considerably in excess of that possible with any of the grades of coal. With a forced draft, such, for example, as that existing in a fire box of a locomotive, a temperature of 4,700 degrees F. can be obtained. The corresponding maximum temperatures for high grade bituminous coal, such as Pocahontas and Anthracite, are about 4,000 degrees and 4,500 degrees, respectively."

The processes of coking peat are varied. Probably the most simple is in the form of heaps, as charcoal is made. In this, part of the charge is burned. Another form is the permanent kiln, and belonging to this would be the open kiln, pit and oven. The most successful method has been the retort. In this the charge is encased within the retort, and the fire does not come in contact with it. Thus there is no loss by combustion, and all of the by-products can

*Parmelee, Peat Deposits of N. J., Ann. Geol. Rept for 1905.

be obtained. Plants of this kind are operating successfully at Oldenburg, and Beuerberg, Germany, and Ridkino, Russia.

In the Consular Report, 1615*, we find the following description of the Zeigler method:

"Concisely stated, the Zeigler method consists in carbonizing peat in closed ovens, heated by burning under them the gases generated by the coking process itself. Such a plant is therefore self-sustaining, the only fuel required being coal or wood sufficient to heat the oven for the first charge, when the gases generated by the coking process become available and enable the operation to be repeated and continued indefinitely. Not only this, but the off-heat from the retort furnaces passes on and heats the drying chambers, in which the raw, wet peat is prepared for the ovens by drying to the point of economical carbonization. There is transmitted to the department as an exhibit with this report, a sample of 1 kilogram of raw peat, and the several products derived therefrom by the Ziegler process, each in its due proportion, as follows: Three hundred and fifty grams of coke, 40 grams of tar, and 400 grams of gas liquor, from which last is derived 6 grams of methyl alcohol, 6 grams of acetate of lime, and 4 grams of sulphate of ammonia. If this sample be multiplied a thousand fold to a metric ton, and the value of each product given at its present market price in Germany, the demonstration would be as follows:

Description.	*Marks.*	*Value.*
One ton of peat costing, dried, 5 marks ($1.19), produces:		
350 kilograms (771.6 lbs.) of peat coke	15.75	$3 75
40 kilograms (88.2 lbs.) of tar	2.20	52
6 kilograms (13.2 lbs.) of methyl alcohol.	4.20	1 00
6 kilograms (13.2 lbs.) of acetate of lime.	.72	17
4 kilograms (8.8 lbs.) of sulphate of ammonia	.88	21
Total	23.75	$5 65

The peat coke produced as the primary product of this process is jet black, resonant, firm, and columnar in structure, pure as charcoal from phosphorus or sulphur, and having a thermal value of from 6776 to 7042 calories. It is so highly prized as a fuel for smelting foundry iron, copper refining, and other metallurgical purposes that it readily commands from 40 to 50 marks ($9.52 to $11.90) per ton. It is also a high-class fuel for smelting iron ores, but, as the process is comparatively new and the output limited, it is as

*U. S. Dept. of State, Consular Rept. 1615, Ap. 8, 1903, pp. 6, 7.

yet too scarce and expensive for blast furnace purposes. Crushed and graded to chestnut size, it forms a splendid substitute for anthracite in base-burning stoves. In larger lumps, as it comes from the oven, it fulfills substantially all the various uses of wood charcoal as a clean, smokeless fuel. The cost of a four-oven plant, with all apparatus for cutting and drying the peat, distilling the gas liquor and extracting paraffin from the tar, is given at $95,200. Such a plant is reckoned capable of working up annually 15,000 tons of peat, the various products of which would sell, at present wholesale market prices, for 494,100 marks ($117,596). A plant of 12 ovens, with all appurtenances complete, would cost $261,800 in Germany, and should produce annually products worth $350,000, from which, deducting the carefully estimated cost of peat labor, depreciation of property and other expenses—$179,200—there would remain a profit on the year's operation of $170,800. This process is in successful operation at Redkino in Russia, and the German government has evinced its practical interest in the subject by placing at the disposal of the company a large tract of peat-moor lands, the property of the state, on which extensive works will be erected during the coming year."

The by-products of this process are ammonia, naptha, aniline colors, ethyl, alcohol, methyl alcohol, acetic acid, benzol, illuminating oils, creosote, paraffin, tar and heavy lubricating oils.

Peat Gas.—Although the gas procured from peat is more expensive than coal gas, yet there is considerable advantage in its containing no sulphur or phosphorus. From 13,000 to 16,000 cubic yards of peat are consumed annually at the Notala Steel Works, Sweden, for its gas. Dr. A. A. Hayes, who was once the State Geologist of Massachusetts, wrote: "There are only two or three cannel coals known which afford so much illuminating material, placing peat in the first class of gas materials. It exceeds all common channels, and, of course, is far above the bituminous coal; can be worked with poor coal to make good gas." The following table gives a comparison of gases obtained from peat, lignite and bituminous coal:*

	Peat.	*Lignite.*	*Bituminous Coal.*
Carbon monoxide	21%	22%	22%
Hydrogen	8%	8%	9%
Hydrocarbons	2%	2%	2%
Nitrogen	60%	62%	61%
Carbon dioxide	9%	6%	6%

*Hausding, Verwertung des Torfes, p. 415.

Absorptive.—As an absorptive, the fibrous quality is used somewhat in surgery, and is found, in some respects, to be superior to cotton, being more gradual, having antiseptic qualities, and absorbing largely the serum and blood. The power of absorption is very high, being from 4 to 10½ times its own weight of water. One can pour a bottle of ink in the clear water taken from the peat moss deposit, 1½ miles south of Garret, Indiana, and in a few days it will again be colorless. This is probably due to the absorption by the innumerable microscopical filaments of peat, which are floating in the water.

As an antiseptic and preservative.—Many of the men that work in the peat bogs are well acquainted with the healing qualities of this material. Repeatedly the writer has heard these affirm, that are in the habit of using it on flesh wounds, that it is equal to any salve they know of. However, peat beds differ greatly in their healing qualities, since in some there is a large amount of poisonous vegetation that has a tendency to irritate instead of soothe. Bodies of human beings and animals are frequently found in a well-preserved condition, which have been imbedded for several centuries. "In the year 1747, in Lincolnshire, England, the body of a woman was found in a bog at a depth of seven feet. The only change that the flesh had suffered was a brownish discoloration. The sandals on her feet and her clothing bore unmistakable evidence of the centuries that had passed since her body had sunk into the bog." Perishable goods, packed in peat moss, are often sent on long journeys, and arrive in a perfectly preserved condition.

As a disinfectant and deodorizing agent.—The power of the fibrous variety to take up odors is very great, and this, with its antiseptic and absorbing qualities, makes it very valuable in vaults, drains and other receptacles of filth, stables, henhouses and pig pens. Frequently we find it sold in drug stores as a deodorizing powder.

Peat alcohol.—During the past few years numerous experiments have been made to determine the amount and quality of alcohol that can be obtained from peat. Although, to the knowledge of the writer, none of the processes have come into commercial use; yet it is claimed that two tons of peat will yield 65 quarts of alcohol.

Among other uses of peat is its value in agriculture and as a peat moss litter, both of which are considered in another portion of this report.

Paper and card board of fair quality have been made from peat, but its competition with straw and wood has been too great to make it of any economic importance. As a non-conductor of heat, peat has been found to take the place of sawdust in icehouses. The manufacture of paving material, and substitutes for carpets, celluloid and various fabrics, from fibrous peat, have been carried on slightly, but with little commercial success. As a filtering agent peat charcoal is excellent. The charcoal is also used extensively in the manufacture of gunpowder and fireworks. T. H. Leavitt says, "I have seen the black peat of Massachusetts so perfectly prepared and granulated, without any explosive admixture, that it was impossible to distinguish it from the best rifle powder." Its rapid combustion and brilliant flame makes it very valuable in fireworks. As a tanning agent it has been used slightly. By mixing peat and coal dust a fair fuel has been produced at a moderate cost. In Europe, certain brown dyes are separated from the peat.

COMPOSITION AND VALUATION OF INDIANA PEATS.

By Robert E. Lyons.

Twenty-nine samples of Indiana Peats collected by the department assistant, A. E. Taylor, were submitted for chemical examination.

Description of Peats.

Lab. No.	*Description.*	
1.	Marshall Co. No. 31.	
2.	St. Joseph Co. No. 15.	
3.	St. Joseph Co. No. 32.	
4.	Dekalb Co. No. 25.	
5.	Elkhart Co. No. 26.	
6.	Noble Co. No. 76.	
7.	Lagrange Co. No. 15.	
8.	St. Joseph Co. No. 5.	
9.	Lagrange Co. No. 18.	
10.	Kosciusko Co. No. 9.	
11.	St. Joseph Co No. 11.	Sec. 16 (37 N.; 2 E.).
12.	Elkhart Co. No. 1.	
13.	Marshall Co. No. —.	
14.	St. Joseph Co. No. 11.	15 N.E. & N.W.; 10 S.W. & 9 S.E.; 16 N.W., S.W., N.E. & S.E.; 21 N.W. & 17 S.W. and S.E.; 20 N.W., S.W., N.E., S.E.; 29 N.W. (37 N., 2 E.).

Lab. No.	*Description.*
15.	Whitley Co. No. 13.
16.	Noble Co. No. 29.
17.	Kosciusko Co. No. 32.
18.	Elkhart Co. No. 14.
19.	Steuben Co. No. 45.
20.	Elkhart Co. No. 12.
21.	Stark Co. No. 15.
22.	Pulaski Co. No. 4.
23.	Jasper Co. Nos. 1 and 2.
24.	Porter Co. No. 3.
25.	Lake Co. No. 3.
26.	Pulaski Co. No. 2.
27.	Marshall Co. No. 22.
28.	Pulaski Co. No. 25.
29.	Newton Co. No. 1.

The relative fuel value of each of the twenty-nine samples was determined by calorimetric test. To obtain data of value for certain specific purposes, five typical specimens, Nos. 1, 2, 3, 4 and 21, were subjected to a more complete chemical analysis, including the determination of the percentage of moisture, volatile combustible matter, coke, fixed carbon, ash, sulphur, phosphoric acid, potassium, nitrogen and absorbing power. Three samples of fibrous, absorbent peat, free from lumps and suitable for litter, Nos. 5, 6 and 22, were also examined as to power of absorbing water and urine.*

Methods of Analysis.

Preparation of the sample.—Peat when taken from the bog contains a large amount of water, frequently as high as 85 to 90%. When the cut peat is exposed to the air a large portion of this water evaporates, but after prolonged drying there still remains some water which can not be expelled except at a high temperature, e. g. 100° C. or higher.

The method used in this laboratory was to air dry the samples by spreading them out in thin layers and exposing them for about fourteen days to room temperature (20° to 22° C). An average sample of the air-dried peat was ground in a Weatherhead steel mortar to such fineness that all would pass through a 100 mesh sieve.

Moisture.—Five grms. of the powdered, air-dried sample were placed in a previously weighed glass weighing bottle equipped with a good-fitting ground stopper. The open bottle was placed in a

*I hereby acknowledge the valuable assistance of Mr. C. C. Carpenter in executing these analyses.

small toluene bath which was kept at a temperature of 105° C. At the end of 48 hours the bottle was removed from the oven, stoppered, placed in a desiccator over fused calcium chloride for 30 minutes and then weighed. The drying for periods of 2 to 3 hours, cooling and weighing were repeated until no further loss of moisture was found, i. e., until the weight became constant. The weighings were always undertaken with the bottle securely stoppered because of the extremely hygroscopic nature of the powdered and oven-dried peat. The operation generally required 72 to 90 hours.

Calorimetric Test.—The method of operation is to burn complete ly a small sample of the peat under such conditions that the heat generated will be absorbed by a known volume of water. The rise in temperature of the water is observed and made the basis of calculation.

The unit of heat used in reporting the results may be the Calorie or the British Thermal Unit.

Calorie (kilo-calorie)=the heat necessary to raise 1 kilogram (2.2 lbs.) of water 1° C.

B. T. U.=the heat necessary to raise 1 lb. of water 1° Fahr.

The fuel value test was made on samples of peat dried at 105° C., which give a slightly higher thermal effect than would be obtainable in practice with air-dried peat, because of the moisture held by peat even after prolonged air drying. The advantage in using oven-dried peat in this test is that all samples may be accurately compared as to heating effect, since the amount of moisture remaining after air drying is dependent upon local conditions.

The calorimetric test was executed with the Parr or Standard Calorimeter, equipped for electrical ignition. The bomb of the instrument was charged with a small quantity of the powdered, oven-dried sample, sodium peroxide and potassium chlorate which furnished oxygen for the combustion. The completeness of the combustion of the peat in the presence of these oxidizing chemicals was noteworthy.

Procedure.—Weigh accurately 1 grm. of chlorate mixture upon a watch glass and brush into the bomb. From a stoppered test-tube, or weighing bottle, weigh accurately by difference 0.5 to 0.7 grm.* of finely powdered oven-dried peat directly into the bomb; without delay add 1 measure of sodium peroxide, close the bomb with the head on which the ignition wire has been adjusted and mix the contents of the bomb by rolling and gently tapping.

*The charge of peat should not exceed 0.8 grms. on account of the violence of the reaction.

The bomb is now immersed in a nickel-plated copper beaker containing 2000 cc. of distilled water and the beaker placed in the fibre bucket. Adjust the bucket cover, connect the belt from the wheel of the stirring device with a small electric motor and place in position a thermometer graduated to 1-100th degrees Fahrenheit. Read the thermometer when the mercury thread becomes stationary, ignite the charge by making electrical contact with the device on the lid and observe the maximum temperature registered by the thermometer.

Calculation: The factor for this instrument using 0.5 grm. coal is 3115. The correction for 1 grm. chlorate mixture, electric ignition was 0.012° Fahr. Hence, degrees rise in temperature —0.012 × .5 ÷ grams of peat = B. T. U. To convert B. T. U. into Calories divide by 1.8.

Evaporative Effect.—To convert one kilogram of water into one kilogram of steam, from and at 212° F., requires 536 calories of heat. If the heating effect expressed in calories is divided by 536, therefore, we obtain the evaporative effect in kilograms of water per kilogram of peat or in pounds of water per pound of peat.

Sulphur.—The sulphur was determined in the bomb residue from the calorimetric test by a modification of the method of Andrews for determining sulphuric acid in mixtures, containing less than 2 per cent. The fusion was dissolved in water, acidified with hydrochloric acid, boiled, neutralized with ammonium hydrate, 15 cc. acid solution of barium chromate added, boiled two minutes, diluted with water to 200 cc., made alkaline with ammonium hydrate, boiled vigorously, filtered and washed with 80 cc. of hot water. The filtrate was approximately neutralized with hydrochloric acid and then 5 cc. conc. hydrochloric acid and a lump of ice added. To the cold solution about 1 grm. potassium iodide was added, the mixture well stirred and the liberated iodine titrated with n/10 sodium hyposulphite.

1 cc. n/10 hyposulphite equals 0.00107 gm. sulphur.

*Volatile Matter, Fixed Carbon, Coke and Ash**—One gram of powdered air-dried peat was placed in a weighed platinum crucible, 37 mm. in diameter and 40 mm. high, having a tightly fitting lid, and heated, in a place free from draught, over the full flame of a Bunsen burner for seven minutes. The crucible was supported on a platinum triangle with its bottom 7 cm. above the top of the

*The volatile matter, fixed carbon, and ash were determined by the methods recommended in the Report of the Committee on Coal Analysis to the American Chemical Society, Journal Amer. Chem. Soc., vol. 21, page 1116.

Bunsen burner. The flame, when burning free, was 25 cm. high. After the ignition the crucible was placed in a desiccator over calcium chloride for 30 minutes and then weighed.†

Volatile Combustible Matter: The loss of weight incurred during the seven minutes' heating, less the moisture contained in one gram (previously determined in another portion), gives the volatile combustible matter.

Coke or Charcoal: The weight of the material left in the crucible after expelling the volatile matter is "coke," i. e., the fixed carbon plus the ash.

Ash: The open crucible containing the coke was supported on a platinum triangle and heated over a Bunsen burner, at first with a low flame, till the carbon was completely burned. After 30 minutes in a desiccator the crucible was weighed. The operation is hastened by placing the crucible in an inclined position on the triangle, or by tilting the lid on the top of the crucible.

Fixed Carbon: The weight of coke less the weight of ash gives the weight of the fixed carbon.

Total Combustible Matter: The volatile combustible matter plus the fixed carbon gives the total combustible matter.

Partial Analysis of the Ash.—The potash and phosphoric acid were determined.

The ash for this purpose was obtained by incinerating about 20 gms. of peat in an open platinum dish, at a low temperature, over a free flame.

Estimation of Potassium: One gram of ash was treated according to the Lawrence Smith‡ method and the potassium finally separated as potassium platinic chloride. The double salt was decomposed by heating gently in a weighed platinum dish with a few crystals of oxalic acid; the platinum residue was washed with water, dried, ignited and weighed.

The weight of metallic platinum multiplied by the factor 0.48125 gives the weight of potassium oxide.

Estimation of Phosphoric Acid: 0.5 to 1 grm. of ash was weighed from a test tube into a No. 4 beaker, treated with 25 cc. hydrochloric acid and digested on the hot plate. After expulsion of the excess of hydrochloric acid, 2 cc. of nitric acid was added, the mixture boiled, filtered and washed. A drop of ferric chloride solution was added and the whole neutralized with ammonium hydrate. Nitric acid was cautiously added, shaking the solution, until a faint

†This detailed description of the method is given because the methods used by different chemists are not the same, and the results depend, to a considerable extent, on the method used.

‡Fresenius Quantitative Analysis.

amber color was shown. The solution was warmed to 70° C., 25 cc. of ammonium molybdate solution added, vigorously shaken, allowed to stand thirty minutes and filtered. The residue is well washed with 1% nitric acid and then with 1.5% potassium nitrate. The filter and contents was placed in the precipitation flask, a known amount of standard sodium hydrate solution added to dissolve the precipitate and the excess of sodium hydrate was determined by titrating with standard nitric acid, using phenolphtalein as indicator.

23 parts of sodium compound to 1 part phosphorus (P).

Nitrogen.—The total nitrogen was determined by the method of Kjeldahl slightly modified. Three grams of powdered, air-dried peat were placed in a long-necked Kjeldahl digestion flask of 200 cc. capacity, 25 cc. of pure concentrated sulphuric acid and 10 grams of potassium bi-sulphate added. The flask was supported at an angle of 45° on a wire gauge and heated cautiously with a small flame. After the first violent action ceased 1 to 1.5 grams C.P. copper sulphate was added and heating continued more vigorously. The oxidation of the three-gram portion was complete in 1 to 1¼ hours.

When cool the digested mixture was transferred to a 700 cc. Erlenmeyer flask, equipped with a three-hole rubber stopper bearing a separatory funnel, a glass tube of sufficient length to almost touch the bottom of the flask and a potash safety bulb, which connected with a long Liebig's condenser. After tying down the rubber stopper and placing 25 cc. of normal hydrochloric acid in a receiving flask (cap. 500) at the end of the cooler, a strong solution of caustic soda was run in through the separating funnel to alkaline reaction and distillation with steam maintained until the distillate attained a volume of almost 400 cc. Titration of the distillate in the presence of methyl-orange with normal sodium hydroxide gave the amount of standard acid neutralized by the ammonia. One cc. normal hydrochloric acid corresponds to .014 grams of nitrogen.

Absorption of Water.—Attempts to make small briquettes of the coarse or natural peat by moistening and pressing in an assay cupel mould were usually unsatisfactory in the case of the fibrous varieties of peat. An approximate determination of the water-absorbing power was made in the following manner:

Three grams of coarse air-dried peat were placed in a beaker glass, covered with distilled water, and stirred occasionally during 12 hours. A folded filter paper supported in a funnel was filled with distilled water and allowed to drain five minutes. The moist paper was then carefully removed to a small plain beaker and weighed (to second decimal place) under watch-glass cover. The paper was again placed in position in the funnel, the peat collected upon it, and after 10 minutes' drainage, was removed to the beaker and weighed. The results are expressed as pounds of water absorbed by one pound of air-dried peat.

ANALYTICAL DATA FROM THE ANALYSES OF PEAT.

Laboratory No. of Sample.	Moisture, Air Dry.	Volatile Comb. Matter, Air Dry.	Fixed Carbon, Air Dry.	Coke, Air Dry.	Ash, Air Dry.	Nitrogen, Air Dry.	Sulphur, Oven Dry.	Calories, Oven Dry.	B. T. U., Oven Dry.	E. E., Oven Dry.	Absorption Water, Air Dry.
1	8.99	61.98	19.08	29.09	10.01	3.91	0.83	5525.6	9946.19	10.3	4.84
2	12.24	57.97	23.45	29.78	6.33	2.22	0.87	5466.8	9840.28	10.1	7.23
3	11.40	54.12	20.65	34.47	13.82	3.31	1.33	5013.4	9024.15	9.3	4.18
4	17.16	56.15	22.53	26.67	4.14	2.56	0.74	5684.8	10232.77	10.6	7.25
21	10.20	52.23	24.30	37.55	13.25	2.96	0.96	5503.1	9905.70	10.2	2.15
5	......	......	......	......	......	......	......	......	......	......	8.28
6	......	......	......	......	......	......	......	......	......	......	7.25
22	......	......	......	......	......	......	......	......	......	......	6.12

PARTIAL ANALYSIS OF THE PEAT ASH.

Laboratory Number.	Potash, K_2O. %	Phosphoric Acid, P_2O_5. %
1.	1.53	1.26
2.	1.35	1.51
3.	0.96	1.17
4.	1.56	1.90
21.	0.82	0.96

Laboratory Number of Sample.	B. T. U., Oven Dry.	Calories, Oven Dry.	Evap. Effect, Oven Dry.
5.	9628.78	5349.3	9.9
6.	10335.57	5741.9	10.7
7.	8924.47	4958.0	9.2
8.	8503.95	4724.4	8.8
9.	8513.29	4729.5	8.8
10.	6129.32	3405.1	6.3
11.	8236.06	4584.4	8.5
12.	7613.06	4229.4	7.8
13.	8497.72	4720.9	8.8
14.	8491.49	4717.5	8.8
15.	4541.67	2523.1	4.7
16.	9217.28	5120.7	9.5
17.	9715.68	5397.6	10.0
18.	7211.22	4006.0	7.4
19.	9422.87	5234.3	9.7
20.	8637.89	4799.4	8.9
22.	9774.87	5430.4	10.2
23.	8273 44	4596.3	8.0
24.	5635.03	3130.5	5.8
25.	8731.34	4850.7	9.0
26.	8472.80	4707.1	8.7
27.	10466.40	5814.6	10.8
28.	9064.65	5035.9	9.3
29.	9033.50	5018.9	9.3

Relation of Peat to Other Fuels.—Composition: The relation of peat to various fuels is shown in the following table,* which also indicates the progressive changes peat might undergo in a possible conversion to anthracite coal:

	Wood.	Peat.	Lignite.	Bituminous Coal.	Anthracite Coal.
Carbon	50	60	70	82	94
Hydrogen	6	6	5	5	3
Oxygen	43	32	24	12	3
Nitrogen	1	2	1	1	Trace.

Calorimetric Test: The value of any fuel depends upon the quantity of heat generated and the temperature which can be obtained. The determination of the quantity of heat a fuel can furnish is called the calorimetric test, and the results furnish a very accurate means of comparison of the relative value of different kinds of combustibles.†

Effect of Ash and Moisture on the Heating Power of Peat: The influence of moisture and ash upon the heating power of peat is well shown in the following table:

	Calories.
Dry peat without ash	6500
Dry peat with 4% ash	6300
Dry peat with 12% ash	5800
Dry peat with 30% ash	4500
Same peat with 25% water	4700
Same peat with 30% water	4100
Same peat with 50% water	2700
Same peat with 0% water and 15% ash	5500
Same peat with 25% water and 0% ash	4700
Same peat with 30% water and 10% ash	3700

It will be noticed that the difference between two samples of peat having a different content of moisture is greater than that due merely to the displacement of combustible matter. The explanation for this difference is that the loss represents the amount of heat consumed in vaporizing the moisture. This demonstrates the necessity of preparing peat for use as fuel so as to contain the least possible amount of moisture.

*Ost, Technische Chemie, 1903, p. 12.

†Hausding, Handbuch der Torfgewinnung 1904, p. 333.

Heating Power of Peat and Other Fuels: A comparison of various fuels is given in the following tables:*

	Water, Chem. Comb. Per Cent.	*Water, Mechanically Held. Per Cent.*	*Ash. Per Cent.*	*Calories.*
Anthracite coal	2	3	2	8305
Charcoal, air dry	0	12	3	6868
Charcoal, kiln dry	0	0	3	7837
Wood, air dry	39	20	1	3232
Wood, kiln dry	49	0	1	4040
Peat	26	25	5	3950
Peat, manufactured	30	18	2	4430

	B. T. U.	*Evaporative Effect.*
Coal, anthracite	14833	14.98
Coal, bituminous	14796	14.95
Coal, lignite, dry	10150	10.25
Peat, kiln dried	10150	10.25
Peat, air dried	7650	7.73
Wood, kiln dried	8029	8.10
Wood, air dried	6385	6.45

From these tables it will be seen that unprepared peat has a higher heating value than wood, but is inferior to coal.

The calorific value of fuels furnishes the data for their comparison, but in practical operations it is not possible to realize the full theoretical value, because of imperfect combustion, radiation, etc. In use under boilers, for instance, it must be considered as very successful practice if 60 or 70% of the theoretical evaporative effect is secured. In the majority of cases the efficiency of boilers is below 50%.

The following claims have been made for peat:†

1 pound of pressed peat will vaporize 5 to 6 pounds of water in a boiler.

250 lbs. will melt 100 lbs. of glass batch.

6 to 7 cwt. are required to burn 1000 brick.

100 lbs. are required to burn 80 to 100 lbs. of lime.

Hausding:

1 ko. of air-dried wood evaporates 3 to 3-4/10 ko. water.

1 ko. of hand-cut peat evaporates 2.8 to 4 ko. water.

1 ko. of machine-cut peat evaporates 4.5 to 5 ko. water.

1 ko. of best coal evaporates 7 to 8 ko. water.

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*First table from Hausding. Second table from Thurston's Elements of Engineering.

†Jour. Soc. Chem. Industry, 1899, p. 1113.

Roberts Austin says that for equal evaporative effect the bulk of the peat would be 8 to 18 times that of coal.

The American Society of Mechanical Engineers estimate 1 ton of anthracite coal to possess equivalent heating power to 1.8 tons of ordinary air-dried peat and to 2.5 tons of pine wood.

Comparison of Indiana Bituminous Coals and Indiana Peats.—Composition: (A) The extreme percentages of the constituents considered in connection with the fuel value of 20 samples of Indiana coal, analyzed for the department by Dr. W. A. Noyes:†

	Moisture, 105°.	*Volatile Combust. Matter.*	*Fixed Carbon.*	*Coke.*	*Ash.*	*Nitrogen.*	*Sulphur.*
Maximum	13.82	45.16	52.77	57.22	9.76	....	4.01
Minimum	6.08	35.22	41.80	49.62	1.06	....	0.34

(B) Similar data from the analyses of Indiana Peats.

	Moisture, 105°.	*Volatile Combust. Matter.*	*Fixed Carbon.*	*Coke.*	*Ash.*	*Nitrogen.*	*Sulphur*
Maximum	17.16	61.98	24.30	37.55	13.82	3.91	1.33
Minimum	8.99	52.23	19.08	26.67	4.14	2.22	0.74

2. Heating and Evaporating Effect as shown by calorimetric test:

(A) Twenty samples of Indiana Coal (analyzed by W. A. Noyes):

	B. T. U.	*Calories.*	*Evap. Effect.*
Maximum	13219.2	7344	13.4
Minimum	11691.0	6495	12.1

(B) Twenty-nine samples of Indiana Peat (oven dried):

	B. T. U.	*Calories.*	*Evap. Effect.*
Maximum	10466.28	5814.6	10.8
Minimum	4541.67	2523.1	4.7

	Calories.	*Evap. Effect.*
1 lb. best of 20 samples Indiana coal tested yields......	7344	13.4
1 lb. best of 29 Indiana peat tested (oven dry).........	5814.6	10.8
1.26 lbs. best Indiana peat (No. 27) equals in thermal effect 1 lb. of the best Indiana coal (No. 17, Report 21, p. 106).		
1 lb. oven dry peat, average of 29 samples yields.......	4288	8.0
1 lb. coal, average of 20 samples yields................	6860.8	12.8
1.6 lbs. average peat (oven dry) equals in thermal effect 1 lb. of average Indiana coal.		

†Twenty-first Annual Report of this Department, p. 105

Peat as a Litter.

According to Wollny, a fibrous, absorbent peat, free from lumps, ranks first as a litter for animals. A good peat will absorb eight times its own weight of urine, straw only three times. Peat litter not only prevents the waste but conserves the fertilizing value of the urine.

The peats best suited for litter are Nos. 2, 4, 5 and 6. No. 5 air dry will absorb 8.28 times its own weight of distilled water.

Considerable peat is imported into this country for use in the stables of large industrial establishments. It sells in New York for $14.00 to $16.00 per ton. The one factory in this country engaged in the manufacture of this product is located at Garret, Indiana. The litter is sold at $1.40 per bale of 225 lbs.

Agricultural Value of Peat.

In determining the value of peat as a fertilizer it is doubtful whether any of the analyses are of value, as the benefit derived from peat depends not so much on the chemical composition as on the mechanical effect of the peat on the soil, its effect in promoting disintegration and solution of mineral matters, and its property of absorbing ammonia. The value of peat as a direct fertilizer depends on the nitrogenous organic matter present and particularly upon the ammonia, potash, phosphoric acid and lime. As these direct fertilizing ingredients rarely form 2% of the mass free from water, it can not be a significant source of mineral fertilizer. The quantity of potash (K_2O) in the ash of the peats examined varies from 0.96 to 1.56%; the quantity of phosphoric acid (P_2O_5) from 1.17 to 1.90%.

Peat Charcoal.

Peat charcoal made as wood charcoal is so friable and porous as to be of limited use. It takes fire readily and scintillates in a remarkable degree. It is a superior filtering agent and is unsurpassed in the manufacture of powder for fireworks.

Peat coke made in kilns is jet black, resonant, firm and has an application as a fuel in metallurgical operations. Its heating effect ranges from 6776 to 7042 calories.

The by-products from retort coke are worth as much or more than the coke.

100 ko. of dry peat yield approximately 350 ko. of coke, 40 ko. of tar, 6 ko. of wood alcohol, 6 ko. of calcium acetate, and 4 ko. of ammonium sulphate.

Peat as a Source of Producer Gas.

In ordinary direct firing the object is to effect complete combustion in proximity to the fuel bed. Within the same chamber the fuel elements are vaporized, distilled, gasified and completely burned. The first two processes absorb heat only and there are advantages in separating them from the point where combustion of the gases occurs and where high temperatures are developed by the heat evolved. The gas producer or generator accomplishes this. Within it vaporization, distillation and gasification result in a combustible gas, which, led away to a separate combustion chamber, is there burned under conditions favoring a fuller realization of the fuel value and the attainment of temperatures otherwise impossible.

Even with a close connection of producer to the furnace, and consequent utilization of the sensible heat of the gas, there is a loss of energy, but it should not exceed 15 to 18% of the calorific value of the fuel. Notwithstanding this loss, experience has demonstrated that producer gas accomplishes the same result with less fuel. It has made possible metallurgical operations which were impractical with direct firing, and materials quite unsuited for heating operations are made available by previous gasification in a producer. This is true of combustible substances containing much moisture, as wood, sawdust, peat, etc. The water may be removed from the gases, which can then be applied to operations requiring high temperature.

The yield of producer gas from different fuels varies within wide limits.*

Material.	*Gas Yield per Poun[d] in Cubic Feet.*
Coke or charcoal	104
Bituminous coals	75
Brown coal	55
Turf	45
Wood	35

It has been demonstrated by test at the United States coal testing station in St. Louis that Indiana bituminous coal can be converted into producer gas and that when this gas is burned in a gas engine it yields 2 to 2½ times as much energy as could be obtained from burning the same coal under a boiler.

The advantages of burning coal gas pertain equally to using peat as a gaseous fuel. The use of solid peat fuel involves a loss of more

*R. D. Wood, Industrial application of Producer Gas, p. 26.

than 25% of heat, which loss may be reduced to about 15% by first converting the peat into gas and then burning the gas.

Peat gas is valued above coal gas in the steel industry on account of its greater freedom from sulphur and phosphorus.

R. D. Wood & Co. of Philadelphia have made experiments on the application of Texas Lignite in gas producers and have demonstrated its value as a basis of gas production. This lignite is not far removed in its chemical composition from peat. Lignite showed moisture 21.86, volatile matter 31.81, fixed carbon 36.85, ash 9.48. The gas made from it is high in hydrocarbons, and, as a consequence, its flame produces an intense heat.*

A test of "machine peat" from Taunton, Mass., gave 4 cu. ft. of gas with a calorific power of 654 B. T. U. per cu. ft. from each pound of peat.† Gas from "cut peat" averages about 135 B. T. U.

‡One ton of compressed peat analyzing: mosture 15, ash 7, fixed carbon 21, volatile matter 57, will yield not less than 100,000 cubic feet of gas of not less than 150 B. T. U. per cubic foot.

Data concerning producer gas made from Indiana peat is not available at the present time. There is, however, no apparent reason why it should not be as satisfactorily used.

In the opinion of the writer, the greatest development of the peat fuel industry in Indiana will doubtless be as a source of producer gas.

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*R. D. Wood, Industrial Applications of Producer Gas, p. 25.

†Norton: Report XV, Bog Fuel.

‡Twelfth Report Ontario Bureau of Mines, p. 231.

ANALYSES OF PEATS FROM VARIOUS STATES AND AUTHORITIES.

SOURCES. State.	SOURCES. Part of State.	H_2O.	Ash.	Vegetable Matter.	SiO_2.	Fe_2O_3. Al_2O_3.	CaO.	MgO.	K_2O_2. loss.	Authority.
Rhode Island	Cranston		13	87	8	2.2	2.8		tr.	
Rhode Island	Block Island	25.25	6.35	63.4	4.5	.75	1.1			
Rhode Island	Bristol		13.9	86.1						Light and porous.
Rhode Island	Cumberland		76	24	69.3	3.2	.5	.3		
Rhode Island	Cumberland Hill		2.15	97.85	.45	.25	1.3		1.5	Light, flaky and fibrous.
Rhode Island	N. Kingston		25.6	74.4	21.2	2.4	1.5		.5	Compact, red brown.
Rhode Island	S. Kingston		62.5	37.5						Ashes mostly silica.
Rhode Island	S. Kingston		48.4	51.6	41.35	4.2	1.2	.3		Gravelly, heavy and fine.
Rhode Island	Cranston		7.9	92.1	6.3	.9	.7			
Rhode Island	Pawtucket		11.4	88.6	9.5	1.9				
Rhode Island	Wickford	15.9	11.5	72.6	8.9	1.5	1.1	.2		
Rhode Island	Woonsocket	10	1.8	88.2	.5	.3	.6			
Rhode Island	Warwick	13.5	49	37.5	40.7	5.1	3.2			
Rhode Island	Warwick		4	96						
Rhode Island	Wickford		12	88						
Rhode Island	S. Kingston		17.5	82.5	12	2.1	2.5	.5	.4	
Massachusetts	Lexington	26	69	69	.1	.6			tr.	3 Phosphate of lime.
New Hampshire	Bedford		7	93						Geology and mineralogy of the State of New Hampshire, 1844, by Charles T. Jackson.
New Hampshire	Bedford	5.8	4.6	89.6						
New Hampshire	Canterbury		6.2	93.8						
New Hampshire	Canterbury	13.7	23.4	62.9						
New Hampshire	Lyndeborough	21	12.3	66.7						
New Hampshire	Franconia		26.3	73.7						
New Hampshire	Merideth		5.1	94.9						
New Hampshire	Bedford		24.3	76						
New York	Rochester	14.47	2.15	83.38						Edward Hirshfield, analyst.
New York	Rochester	14.51	5.08	80.41						
New York	Rochester	14.13	3.05	82.72						
Canada	St. Dominique		7.27	92.73						Geology of Canada, 1863.
Canada	St. Dominique		6.75	93.25						
France	Ardennes	30.5	8.3	61.2						M. Diday, analyst.
Connecticut	Goshen	12.37	35.21	52.42						Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Goshen	20.33	8	71.67						Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Goshen	15.13	4.52	80.35						Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Milford	19.67	3.23	77.1						Fresh water swamp, E.H.Trainning, Anl.

Connecticut	Plainville	18.7	29.2	52.1	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Griswold	12.85	34.7	52.45	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Berlin	17.41	13.59	69	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Colebrook	33.88	4.57	57.05	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	West Cornwall	19.71	14.89	65.4	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	North Granby	11.6	47.24	41.16	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Poquonnock	18.05	5.92	76.03	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Brooklyn	15.88	7.67	76.45	....	....	....	....	....	Fresh water swamp, E.H.Trainning, Anl.
Connecticut	Brooklyn	8.35	67.77	23.88	....	....	....	....	....	Eresh water swamp, F.H.Trainning, Anl.
Connecticut	Collinsville	11.19	57.78	31.03	....	....	....	....	....	Fresh water swamp, R. A. Fisher, Anl
Connecticut	New Haven	11.46	36.52	52.02	....	....	....	....	....	Salt marsh, R. A. Fisher, Analyst.
Connecticut	New Canaan	7.29	68.9	23.81	....	....	....	....	....	Fresh water swamp, R.A.Fisher, Analyst
Connecticut	New Canaan	6.66	66.9	26.44	....	....	....	....	....	Fresh water swamp,R.A.Fisher, Analyst.

ANALYSES OF PEATS FROM VARIOUS STATES AND AUTHORITIES.

SOURCES. State.	Part of State.	Org.	H_2O.	Fe_2O_3. and Al_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	SO_3.	CO_2.	SiO_2.	Cl.	Ins.	Authority.
California	Mowry's Sta., Ala. Co.	67.16	17.44						.41					15.4	
Michigan	Meare near Bridgewater	97.78		.436	$CaCo_3$ .855	.144	.131	.065	.053	.051		.403			Mich. Agr. Rept., 1865; p. 208.
New Jersey	Black Brook Meadows, Columbia turnpike, Morris Co.	65.61	16.16	3.19	3.86	.37	.31		.93	.89	.09	8.64			Geol. of N. J., 1868; p. 481.
New Jersey	Peat cut for fuel at Columbia, Morris Co., 2 to 3 feet below surface	66.87	15.15	3.97	3.17	.39	.27		.1	2.46		7.63			Geol. of N. J., 1868; p. 481.
New Jersey	Allandale bog in Bergen Co.	83.8	11.7	.42	1.46	.17	.08		.05	.74	.04	1.07			Geol. of N. J., 1868; p. 481.
New Jersey	Beavertown, Morris Co.	69.8	16.8	2.92	3.34	.27	.02		.19	.76	.43	5.36			Geol. of N. J., 1868; p. 481.
New Jersey	Haddonfield, Camden Co. compact, well formed	57.1	11.6	12.02	.14				.27	.21		18.59			Geol. of N. J., 1868; p. 482.
New Jersey	Haddonfield, Camden Co., fibrous, very light	34.8	7.1	5.26	.39	.14		.07	.2	.18		51.88			Geol. of N. J., 1868; pag. 482.
Ohio	Salem		91.31	Fe_2O_3 .33	1.24		1.26					5.86			Ohio Agr. Exp. Sta. Rept. 5; p. 281.
Ohio	Brimfield		85.99	Fe_2O_3 1.99	.54	.09						11.04			Ohio Agr. Exp. Sta. Rept. 6; p. 269.
Ohio	Frankfort, Ross Co.		73.38		5.47	.44						16.47			Ohio Agr. Exp. Sta. Rept. 6; p. 269.
Wisconsin	Peat soil, first foot	75.81					.09		.3			17.8			Wis. Agr. Exp. Sta. 13th Rept.; p. 304.
Wisconsin	Peat soil, 2d and 3d foot	10.09			.34		.07		.03			92.08			Wis. Agr. Exp. Sta. 13th Rept.; p. 304.
Wisconsin	Baraboo, 1st foot	84.28			2.16		.11		.28			8.68			
Wisconsin	Baraboo, 2d and 3d foot	92.			1.5		.04		.1			5.39			

PEATS FROM ONTARIO.

LOCALITY.	H_2O in Original Sample.	Calculated on 15% Water Content.			Authority.
		Volatile Combustibles.	Fixed Carbon.	Ash.	
Welland	82.2	59.27	21.66	4.07	Carter, Peat Fuel, Its Manufacture and Use.
	87.48	56.78	21.05	7.17	" " " " " "
Beaverton	62.98	57.13	11.67	16.2	Ont. Bureau Mines, Bulletin May 18, 1903.
	83.31	67.58	10.39	7.03	Ont. Bureau Mines, Bulletin May 18, 1903.
	84.86	73.6	4.72	6.68	Ont. Bureau Mines, Bulletin May 18, 1903.
Perth	....	54.72	19.85	10.43	Ont. Bureau Mines, Bulletin May 18, 1903.
	....	57.81	18.92	8.27	Ont. Bureau Mines, Bulletin May 18, 1903.
Brunner	....	60.1	15.7	9.2	Ont. Bureau Mines, Bulletin May 18, 1903.
Rondeau	....	58.56	23.29	3.15	Ont. Bureau Mines, Bulletin May 18, 1903.
Newington	87.94	56.74	27.21	1.05	Ont. Bureau Mines, Bulletin May 18, 1903.
	86.66	54.42	28.61	1.97	Ont. Bureau Mines, Bulletin May 18, 1903.

PEATS FROM IRELAND.*

SOURCE.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Remarks.
Philipstown	53.694	6.971	32.883	1.4514	Surface peat.
"	60.476	6.097	32.546	.8806	Dense peat.
Bog of Allen	59.92	6.614	32.207	1.2588	Surface peat.
" " "	61.022	5.771	32.4	.807	Dense peat.
Twichneven	60.102	6.723	31.288	1.8866	Surface peat.
Shannon	60.018	5.875	33.152	.9545	Surface peat.
"	61.247	5.616	31.446	1.6904	Dense peat.

*Dublin Journal of Industrial Progress. Ash and moisture not given.

Criteria for Determining the Economic Importance of a Peat Bed in the Field.

The writer, upon visiting a new deposit, would, in the first place, attempt to get some idea as to the extent, and about where in the bed would be the best places to make soundings and procure samples, so as to obtain a definite idea as to the average depth and quality. Since many of the best peat beds were covered with tamarack and heavy heaths, it was often necessary to climb one of the tallest trees to obtain this preliminary information. Before descending, he would get his bearings by means of a compass, his sectional location from a county map, and then draw an outline map of the marsh, putting in the boundaries, high ground, and points where soundings would be made. After descending from the tree the various points at which soundings were to be made were visited, observing, meanwhile, the changes in vegetation, since this helps one greatly in determining the quality of the material, and the thickness of the bed. Upon arriving at one of these points, the sounding augur, which is a common $1\frac{1}{4}$-inch wood augur welded to a joint of $\frac{1}{2}$-inch gas pipe, was pushed down into the peat bed to a depth of 2 or $2\frac{1}{2}$ feet. Then, by turning the augur, the material that would get into it when it was forced through the surface would be turned out, and the material at the depth of $2\frac{1}{2}$ feet turned in. The augur would then be withdrawn and the material examined. Notice would be taken as to whether it came from above or below the ground-water level, the coarseness of its fibers, the color, the origin and the stage of decomposition. The sounding augur would be again thrust down, treated in a similar manner and like characteristics to those described in the preceding sentence carefully noted. The soundings would be continued until the thickness of the bed and its quality at several different levels would be ascertained. The thrusting down of the augur is generally done with ease in a peat bed, where foreign material is not present, but when clay or sand is once met it is impossible to go down farther by hand. However, if marl be encountered, it will be with difficulty that one will decide where he leaves the peat and passes into the marl, unless he frequently pulls out the augur and examines its contents.

After all of the points mapped out for soundings have been visited, and any others that may seem advisable, another viewpoint may be hunted, and a revised map drawn. Notes can be taken as to the extent, thickness, color, stripping, amount of material above the ground-water level, the derivation, the underlying formation, the topographical position, the quality of the material, the possibilities of drainage, the distance from a railroad switch, the condition of the wagon roads in the neighborhood, the need of a fuel in the vicinity, the possible demand, whether the deposit would justify the erection of a peat plant, and any other matters of interest that might arise. Every peat bed has its individual characteristics, in which it differs from all others.

Chemical Tests of the Indiana Peats.

Twenty-nine samples, obtained from the better peat beds of the leading peat counties of the State, were sent to Dr. R. E. Lyons, Professor of Chemistry at the State University, for determination of their fuel value, etc. These were oven-dried by Dr. Lyons to permit of a more satisfactory comparison of the peats with one another. The oven-dried peat, of course, gives a slightly higher thermal effect than would be obtainable in the practice with air-dried peat, because of the moisture which is held by peat even after prolonged air drying under favorable conditions. The results of the tests made by Dr. Lyons were as follows:

TABLE SHOWING THE FUEL VALUE OF TWENTY-NINE SAMPLES OF PEAT FROM NORTHERN INDIANA.

No.	County, Township, Range and Section.	B. T. U., Oven Dried 105°C.	Calories, Oven Dried 105°C.	Evaporative Effect (Oven Dried).
1	Dekalb, Sec. 9 (33 N., 12 E.)	10232.77	5684.8	10.6
2	Steuben, Sec. 34 (37 N., 12 E.)	9422.87	5234.3	9.7
3	LaGrange, Sections 2, 11 and 12 (36 N., 8 E.)	8513.29	4729.5	8.8
4	LaGrange, Sections 4 and 9 (37 N., 9 E.)	8924.47	4958.0	9.2
5	Noble, Sections 28 and 29 (33 N., 9 E.)	10335.57	5741.9	10.7
6	Noble, Sec. 18 (33 N., 11 E.)	9217.28	5120.7	9.5
7	Whitley, Sec. 30 (31 N., 10 E.)	4541.67	2523.1	4.7
8	Kosciusko, Sections 11, 12 and 13 (31 N., 6 E.)	9715.68	5397.6	10.0
9	Kosciusko, Sections 32 and 33 (33 N., 6 E.)	6129.32	3405.1	6.3
10	Elkhart, Sec. 4 (36 N., 5 E.)	8637.89	4799.4	8.9
11	Elkhart, Sections 10 and 11 (36 N., 6 E.)	7211.22	4006.0	7.4
12	Elkhart, Sections 26 and 27 (35 N., 5 E.)	7613.06	4229.4	7.8
13	Elkhart, Sec. 18 (38 N., 6 E.)	9628.78	5349.3	9.9
14	St. Joseph, Sections 28, 33 and 34 (36 N., 2 E.)	9840.28	5466.8	10.1
15	St. Joseph, Sec. 3 (36 N., 1 E.)	9024.15	5013.4	9.3
16	St. Joseph, Sections 11 and 12 (37 N., 1 E.)	8503.95	4724.4	8.8
17	St. Joseph, Sec. 16 (37 N., 2 E)	8236.06	4584.4	8.5
18	St. Joseph, Sec. 20 (37 N., 2 E.	8491.49	4717.5	8.8
19	Marshall, Sections 10 and 11 (33 N., 1 E.)	9946.19	5525.6	10.3
20	Marshall, Sec. 1 (34 N., 2 E.)	8497.72	4720.9	8.8
21	Marshall, Sec. 10 (34 N., 1 E.)	10466.40	5814.6	10.8
22	Starke, Sec. 10 (32 N., 3 E.)	9905.70	5503.1	10.2
23	Pulaski, Sec. 9 (31 N., 1 W.)	9774.87	5430.4	10.2
24	Pulaski, Sections 7, 8, and 9 (31 N., 3 W.)	9064.65	5035.9	9.3
25	Pulaski, Sections 3, 9, 10 and 11 (31 N., 4 W.)	8472.80	4707.1	8.7
26	Porter, Sections 1, 2 and 3 (37 N., 5 W.)	5635.03	3130.5	5.8
27	Jasper, Sections 12, 13 and 14 (30 N., 6 W.)	8273.44	4596.3	8.0
28	Newton, Sections 32 and 33 (31 N., 8 W.)	9033.50	5018.9	9.3
29	Lake, Sections 34, 35 and 36 (35 N., 9 W.)	8731.24	4850.7	9.0

Five of the samples sent to Dr. Lyons were subjected to a more complete chemical analysis, including the determination of the percentage of moisture, volatile combustible matter, fixed carbon, ash, sulphur, phosphoric acid, potash, nitrogen, absorbing power, etc. The results of these analyses are as follows:

CHEMICAL ANALYSES OF FIVE SAMPLES OF PEAT FROM NORTHERN INDIANA.

County, Township, Range and Section.	Moisture 105°C.	Volatile Air Dried.	Fixed Carbon, Air Dried.	Coke Air Dried.	Ash Air Dried.	Nitrogen Air Dried.	Sulphur, OvenDried	Per cent of P_2O_5 in Ash.	Per cent. of K_2O in Ash.
Dekalb, Sec. 9 (33 N., 12 E.).....	17.16	73.31	22.53	26.67	4.14	2.56	0.74	1.90	1.56
St. Joseph, Secs. 28, 33 and 34, (36 N., 2 E.)................	12.24	70.21	23.45	29.78	6.33	2.22	0.87	1.51	1.35
St. Joseph, Sec. 3 (36 N., 1 E.)...	11.40	65.52	20.65	34.47	13.82	3.31	1.33	1.17	0.96
Marshall, Secs. 10 and 11 (33 N., 1 E.)......................	8.99	70.97	19.08	29.09	10.01	3.91	0.83	1.26	1.53
Starke, Sec. 10 (33 N., 3 E.).....	10.20	62.43	24.30	37.55	13.25	2.96	0.96	0.96	0.82

A workable peat deposit, as referred to in this report, will mean a bed covering an area of at least 60 acres, having an average thickness of 4 or more feet, and being more than half beneath the groundwater level. A deposit of this kind would justify the erection of a large peat plant for compressing the peat into briquettes, providing the transportation facilities were good. Large plants have daily outputs ranging from 75 to 250 tons. For a small peat plant, with an output of 30 tons per day, a bed over half beneath the groundwater level, containing 20 acres, with an average thickness of 4 feet, would be of sufficient size.

The operating expenses for a small peat plant of 30 tons capacity have been estimated by the Indiana Peat Company of North Judson, Starke County, as follows:

1 foreman	$3 00
1 engineer	2 75
2 peat men at $2.00................................	4 00
1 boy at...	1 25
1 man hoisting engine..............................	1 50
2 men at press at $2.00............................	4 00
3 boys at $1.25....................................	3 75
1 night man..	1 50
Office expenses	5 00
Total	$26 75

Not considering the wear and tear on the machinery and buildings, this estimate will place the manufacturing of peat into briquettes at a rate of 86 cents per ton.

In the way of building and equipment such a plant would need:

Building to cover machinery, 41x65 feet.
35 H. P. engine and boiler.
Disintegrator machine.

Receiving platform and dump.
Press and cutting table.
Elevator from pit to press.
Cars and 250 feet of track from press to drying shed.
300 feet of track to peat bog.
Turntables.
Cars to peat bed.
Transfer equipment.
Line shaft and pulleys.
Transmission rope, belting, etc.
Building containing 16 drying tunnels.
Three cars for drying tunnel.
Steam coil and fan.
Rails and hot air flues for tunnels.
Transfer tables, rails, etc.

History of Peat Deposits in the State of Indiana.

At present, no peat plant is operating in the State of Indiana. Operations in a crude way are being carried on by C. F. Brown of Tyner City, in a very successful manner. The Brethren of St. Mary's at one time took out the crude material where the southwestern portion of the city of South Bend now stands. About 40 years ago peat was spaded out and stacked up to dry near the town of Ross, in Lake County. A very fibrous form of peat known as "peat moss litter" is being taken out 1½ miles south of Garrett, in Dekalb County. The material is pressed into bales and shipped away as a litter for stables, kennels, etc.

Where Peat Fuel Would Now be of Economic Importance.

The peat deposits of Indiana will likely never become the more important sources of fuel for the large factories because such are located on the railroads or Lake Michigan, where the transportation facilities from the coal fields are the best; the calorific value of peat is only from 7-13 to 10-13 that of coal; a dollar's worth of coal will give off considerable more heat than a dollar's worth of peat; and there are so few large beds of peat where the railway transportation is good. So the old saying, "coal is king," will continue to be true as far as the large factories of northern Indiana are concerned. But it is bound to become the leading fuel of those people who are rather remote from railway facilities.

The fact that it is so widely distributed throughout northern Indiana places it within easy reach of some of the farmers of almost every township, and in numerous cases all of the farmers and townsmen of a township could be conveniently supplied. Of course, most of the deposits are small, possibly of only one or two acres, and could not afford sufficient material to pay for building even a very small factory; yet this material can, very successfully, be taken out and used in the crude condition. An excellent process for taking the peat from the deposit, drying and using it in the crude form is described on a subsequent page. By this process, with scarcely any expense outside of a week's labor, and a large part of this can be attended to when there is little else to do, a farmer can spade out and stack up his fuel for the entire year. The fire is very easily kindled, burns rapidly and gives an intense heat. There is very little odor and smoke, and no soot or clinkers. A very light, fine and soft ash is left. By covering the fire with ashes it can be kept throughout the night. The cleanliness of this fuel will give it a place in the home, as long as it is obtainable, in preference to coal.

STEUBEN COUNTY.

This county, which occupies the extreme northeastern corner of the State of Indiana, is covered by glacial drift to a depth of 300 to 600 feet. This heavy morainic deposit has given rise to numerous kettle and lake basins, many of which have been filled up by the developing of peat beds, while in others peat deposits are now forming.

The main deposits of the county are found between the townships of Hudson and Pleasant Lake, at Cedar Lake, 2½ miles east of Fremont, and between Hog Back and Golden Lakes.

As in southeastern Dekalb County, the eastern portion of the county is well drained by streams and the peat deposits have had no lakes in which to form, or were drained so long ago that a complete oxidation has taken place and only the inorganic parts of the peat and muck remain.

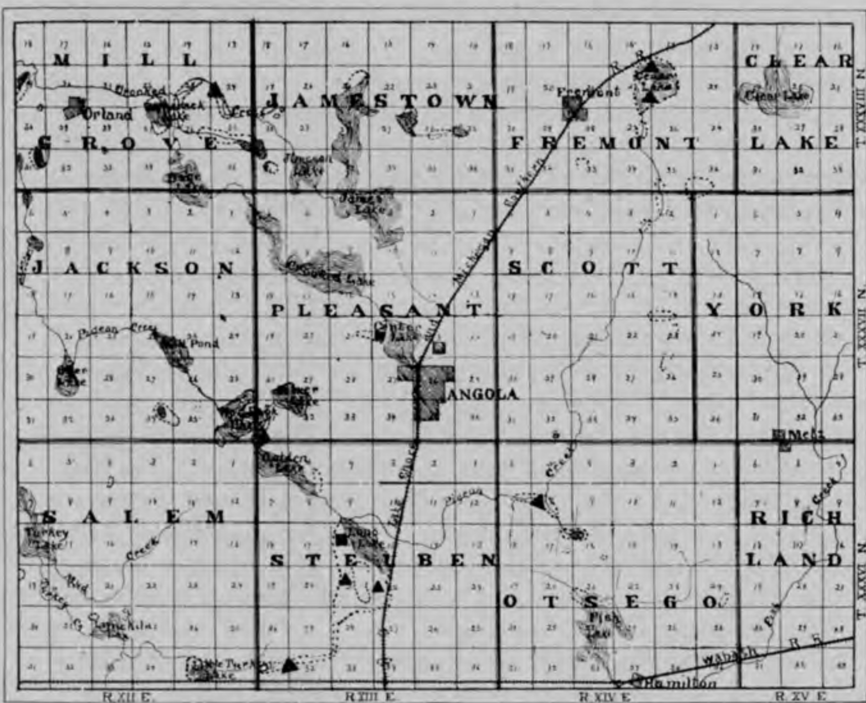
TOWNSHIP 36 NORTH, RANGES 12, 13, 14 AND PART OF 15 EAST.

Otsego Township (36 N., 14 E.).—On the places of P. Maxwell and neighbors, in the southeast quarter of section 24, are 35 acres of dark chocolate brown peat, in a long and narrow bed. The thickness is low, and the quality is only fair. Considerable clay has washed in and mingled along the sides with the peat.

On the farms owned by B. Keppler and neighbors, in the northeast quarter of section 35, are 40 acres of a fair quality of peat. This is also a long, narrow bed, with an average depth of about 3 feet and a maximum of 8 feet. The underlying formation is clay, and the color is a dark chocolate brown. The stripping is about $1\frac{1}{2}$ feet.

At the northwest end of Fish Lake, in the southwest quarter of section 21, is a peat bed of about 30 acres, which is largely beneath the water level, and is in a very loose condition. The quality is fair.

STEUBEN COUNTY.



LEGEND

■ Workable deposit of peat of a moss variety. ▲ Workable deposit of peat of a grass and sedge variety. ..... Lines enclosing areas in which peat deposits are found.

A small bed of about 7 or 8 acres occurs in the southeast quarter of section 16. The material is of a fair quality, the thickness light, and the color a dark chocolate brown.

In the northwest quarter of the same section, and the northeast of 17, around Johnson Lake, are 50 acres of peat, with a depth ranging between 4 and 12 feet. The quality is fair to good, the material being derived largely from sphagnum mosses. The stripping is light, the subsoil marl and clay, and the color a medium to a dark chocolate brown. Some peat moss litter is found near the surface of this deposit.

On the farms of George Hendry and neighbors, in the southeast, southwest and northwest quarters of section 8, and the northeast of 7, are 100 acres of a dark chocolate brown peat. The quality is from fair to good, and the stripping only about 1 foot. The thickness of the bed ranges between 3 and 25 feet, and enough material of good quality can be obtained to supply a small peat plant.

Steuben Township (36 N., R. 13 E.).—Advancing westward, no other deposit of economic importance is found until the southern shore of Pleasant Lake is reached. We find, here, one of the best peat deposits of the State, in a succession of large peat beds, which occupy an old glacial lake basin; the deposits extend south through each of the quarters of section 16; the southwest of 15, the north-central and south half of 21; the west half of 22; the northwest of 27; the northeast and west half of 28; the northwest of 33, and west to the north half of section 32 and the northeast and west half of 31. Single beds range in size from 10 to 120 acres, and taken altogether, cover about 1,400 acres. Beginning within 200 feet of the south shore of Pleasant Lake in the northeast quarter of section 16, and extending southwest for ¾ of a mile, are 200 acres of a good quality of peat, with a depth as determined by 14 well scattered soundings (see map) varying between 8 and 21 feet. The quality of the material is good, being derived from the sphagnum mosses. The stripping is very light, the underlying formation marl, and the color a medium to a dark chocolate brown. Not over one-quarter of this material is above the ground-water level. Immediately south of this bed the shallow muck and high ground commence, and extend south for about one-half of a mile. Here we find the northern boundary of a peat deposit which covers about 400 acres of surface. This 400-acre bed extends south for 2 miles and is from ⅛ to ¾ of a mile wide. The thickness of the material ranges from 2 to 25 feet, and probably 150 acres will average 8 feet. The quality is from fair to good, the stripping ½ to 1½ feet, and the color a dark chocolate brown. From 5 to 6 feet of the material is above the ground-water level. A section is as follows: (a) A rather sandy peat, containing the residual left from the surface fires, 1½ feet; (b) A rather fibrous peat, containing numerous blades of grass and sedges, 6 feet; (c) A more compact and less fibrous material, which makes up the lower portion of the bed.

Connecting with this bed is the northeast quarter of section 28 and the northwest of 27, and extending north to the village of Pleasant

Lake, is a 300-acre deposit that consists of a fair to good quality of material. The thickness ranges between 3 and 25 feet, and will average 5 feet (see map). The stripping is about 1 to 2 feet, and the material about 1-3 above the level of the ground-water.

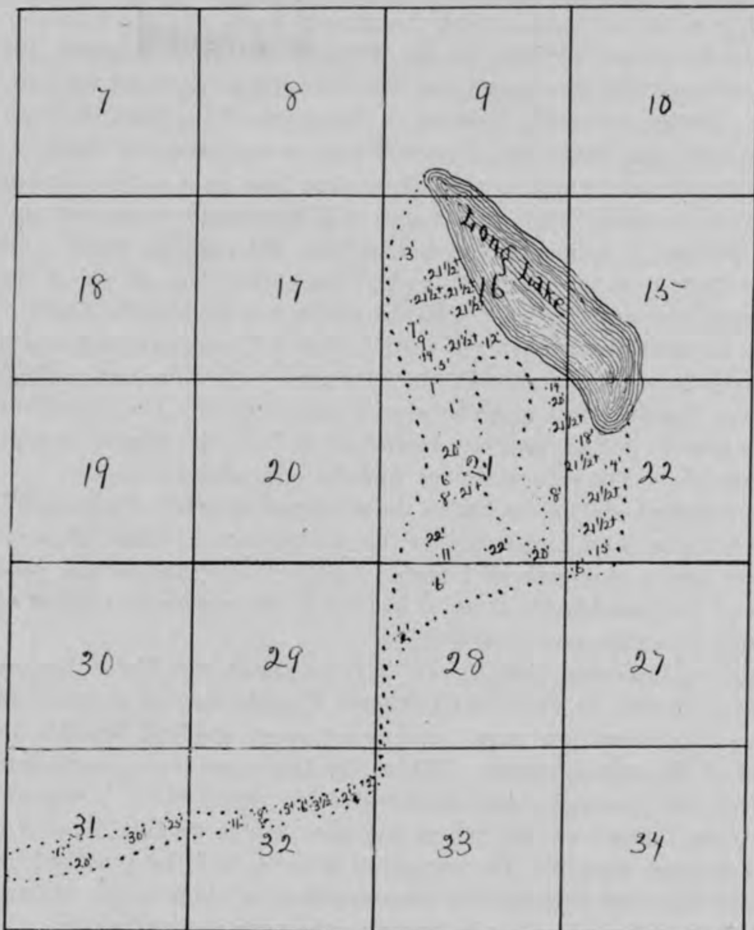


Fig. 1. Showing the thicknesses, where soundings were made, of peat beds in the central and southwestern parts of Steuben township, Steuben County.

The deposit of sections 31 and 32 is separated by a small scope of high ground from that of 33, 28 and 21. This deposit, which begins at Hudson and extends east for 2 miles, comprises over 100 acres of a fair to good quality of peat. The derivation has been from the sphagnum mosses, the grasses and sedges. The color is a dark chocolate brown and the stripping from ½ to 2 feet. The upper 6 feet of material are fairly well drained, and the substratum is clay. The thickness varies between 3 and 30 feet, 5 feet being the average (see map).

Taken as a whole, this chain of deposits contains material sufficient to justify the erection of a large peat plant; moreover the quality of the material is good, the amount large, and the transportation facilities excellent, as the Wabash Railroad touches the southern part of the deposit and the Lake Shore Railroad the eastern. Furthermore, the location is that part of the State farthest from any coal fields, the nearest being in southwestern Indiana; and the timber, which is the only native fuel used at the present time, is becoming very scarce, and will be largely exhausted, unless its use is decidedly lessened, during the next 25 years. All these facts tend to give peat, in the future, the place of one of the cheapest and best fuels for domestic use in this part of the State.

In the northwest quarter of section 34 is a 12-acre peat bed, which occupies a muck marsh. It was tested by 4 soundings, which showed the thickness to be between 5 and 11 feet. The quality of the material is fair, and the derivation is from the mosses, grasses and sedges. The subsoil is clay, and the stripping 1½ feet.

A peat bed of 25 acres lies in the southwest quarter of section 27. The material is of a poor quality, has an average thickness of about 2 feet, and a stripping of 1 foot. Another very shallow and poor deposit, of possibly 25 acres, is located in the southeast quarter of section 5 and the northeast of 8.

Salem Township (36 N., 12 E.).—Around the Little Turkey Lake in section 35, are about 100 acres of peat, varying in thickness from 1 to 8 feet (see map), and being about one-half beneath the level of the ground-water. Where the thickness is not more than 3 feet, the material contains considerable marl, which is the underlying formation; but where the thickness is greater, it is of a fair to good quality. The stripping is light, and the peat bed occupies what was formerly the greater extent of these lakes. At one time, without doubt, they belonged to the same body of water.

Several small patches of peat are found upon what was once the bottom of Lime Kiln Lake, in the northeast quarter of section 29, and the northwest quarter and east half of 28. The 5 acres just north of the northwest part of the lake are of excellent quality, being derived from the sphagnum mosses, and are almost entirely beneath the ground-water level, thus being undecomposed by the action of the air. The color is a medium chocolate brown, the stripping almost nothing and the thickness averaging 21½ feet.

Considerable green sphagnum, suitable for nurserymen, is found on the surface, and beneath this, a good quality of peat moss litter. The other deposits, which lie about Lime Kiln Lake, and east of it, are also in small patches of 4 or 5 acres, and will probably cover 25 acres. They contain a fair to good quality of material, have good thicknesses (see map), and are largely beneath the level of the ground-water. The stripping is light, and the underlying formation is clay.

A small bed of 4 to 5 acres is found in the south-central part of section 4 and the north-central of 9. The quality of this material is poor and the average thickness only 2 feet.

A tamarack marsh lying $3/4$ mile southwest of Turkey Lake, in the northwest quarter of section 19 of this county, and section 18 (36 N., 11 E.), of LaGrange County, is underlain by a poor to fair quality of peat. The extent is about 20 acres, and the thickness from 6 to $21\frac{1}{2}$ feet.

Immediately south of Turkey Lake, in the southeast quarter of section 18 and the southwest of 17, is a peat deposit containing 150 acres. The quality of the material is poor, being more or less mixed with marl. The thickness is from 1 to 7 feet, and the stripping heavy. The color is a dark chocolate brown, and the topographical position is what was previously part of the basin of Turkey Lake.

An impure form of peat, of a very poor quality, occurs in the northeast quarter of section 1. The area occupies about 80 acres in extent, and the thickness is from 2 to 5 feet.

TOWNSHIP 37 NORTH, RANGES 12, 13, 14 AND PART OF 15 EAST.

Jackson Township (37 N., 12 E.).—Occupying the southwest quarter of section 7 and the northwest of 18, are beds of peat, which taken together comprise an area of 150 acres. The quality of the material is poor, being sandy and much oxidized. The thickness is from 1 to 5 feet, and the stripping from 1 to 3 feet. In the crude condition only would the material be suitable for using.

A bed of sphagnum mosses, peat moss litter and peat, which is almost entirely beneath the ground-water level, and of a medium to a dark chocolate brown color, lies in the eastern half of section 34 and the southwest quarter of 35. The peat is of excellent quality, being derived from the sphagnum mosses and not having been exposed to the air. The thickness will average $21\frac{1}{2}$ feet (see map), and the stripping is almost nothing. However, the thickness would be less if the marsh were drained.

The upper 2 feet are largely made up of the green mosses and the peat moss litter, both of which are very good in quality. The location was once the extension of Mud Lake to the southeast. If transportation facilities were better, this would be a very good site for a small peat plant.

At very few places, in the muck marshes about Hog Back Lake, are the peat deposits of sufficient quality and depth to be of any economic importance as a fuel. About 20 acres of a sandy peat bed, with a thickness ranging from 1 to 3 feet, are found around the northeast part of this lake. A similar deposit of 30 acres is located on the shore of the lake, in the southeast quarter of the northwest quarter of section 36. A fair quality of peat is found in a 35-acre deposit at the southwest corner of the lake in the southwest quarter of the same section. Its thickness is from 8 to 20 feet, and the stripping very light. Much of the bed is of the quaking nature, showing that the peat is floating in the water, and in a very incompact condition. The color is a dark chocolate brown.

Pleasant Township (37 N., 13 E.).—Between Hog Back and Golden Lakes, in the southwest quarter of section 31, is a deposit of peat, which consists of about 100 acres. This is of a fair quality, being derived largely from the grasses and sedges, and lying mostly beneath the ground-water level. Where the bed has a thickness ranging from 15 to 25 feet, the material is floating in the water, and one is in danger of breaking through when walking upon it. In a few places the bed has been drained to a depth of 4 or 5 feet, by a large dredge ditch, connecting Hog Back and Golden Lakes. In such places the earth is full of holes and crevices from 1 to 4 feet across and 1 to 4 feet deep, which have been produced by the shrinking caused by draining.

Separated from Hog Back Lake by a ridge, and connecting with the peat bed, between Hog Back and Golden Lakes, described in the preceding paragraph, is a long, narrow deposit of about 90 acres, lying in the northwest and southwest quarters of section 31. The quality of the material is fair, being derived largely from the grasses and sedges, and being mostly beneath the ground-water level. The thickness of the bed varies between 2 and 15 feet, and the stripping is light. This deposit, as well as all the others about Hog Back Lake, occupies a position that marks the previous existence of a portion of a large lake, which comprised Hog Back, Golden and several other smaller ones of this vicinity.

Between Center and Loon Lakes, in the northeast quarter of section 21 and the North half of 22, are two splendid deposits of peat, peat moss litter and green moss, almost connecting and covering an area of 150 acres. The material is of a good quality, being mostly beneath the ground-water level, and not exposed to the action of the atmosphere. It is derived mainly from the sphagnum mosses, has a very light stripping, and rests upon a clay substratum. The color is a medium to a dark chocolate brown, and the thickness good, being about 10 feet. (See map.) Large areas of the deposit are covered with more than a foot of the green sphagnum mosses, which seem like a great carpet as one passes over them. Underlying the mosses are several feet of a good peat moss litter and next to this are several feet of a coarse fibrous peat, underlain by a less fibrous one. The topographical location is that of an old glacial lake basin, but is now a tamarack marsh. Many of the tamarack logs and roots are found in the peat bed. For peat, peat moss litter and green moss, this is an excellent location, being only one and one-half miles from the town of Angola. An interurban railway passes through the center of the marsh. The quality of the material is good, and the amount considerably better than workable.

Scott Township (37 N., R. 14 E.).—A peat bed, overlain by a large quantity of peat moss litter and green sphagnum mosses, occurs in the southeast quarter of section 15, the southwest of 14, and the northwest of 23. The deposit covers about 60 acres and is of good quality, being derived from the sphagnum mosses, and being largely beneath the level of the ground-water. The color is from a medium to a dark chocolate brown, being lightest at the top and darkest at the bottom. An old glacial lake basin once occupied the same location.

A similar quality of peat occurs in an old glacial lake basin in the northwest and southwest quarters of section 23 and the northwest of 26. It occupies about 80 acres, has a good thickness (see map), and a light stripping. The underlying formation is clay, which is somewhat mixed with the more shallow portions of the peat near the southern end of the deposit. The peat moss litter and green moss are lacking in this deposit.

Scott, York and Fremont Townships (37 N., R. 14 and 15 E., and 38 N., 14 E.).—Partly in the civil township of Scott (37 N., 14 E.), and partly in Fremont (38 N., 14 E.), is a 100-acre peat bed, occurring in the valley of Pigeon Creek, in the southeast quarter of section 3, the north half of 2 (37 N., 14 E.), and the southwest quarter of section 35 (38 N., 14 E.). The quality of this material is fair, and the thickness varies from 4 to 12 feet. The eastern half of this bed is more or less clayey.

Probably 15 acres of a fair quality of peat can be found in a considerable scope of muck, in the civil townships of Scott (37 N., 14 E.), York (37 N., 15 E.), and Fremont (38 N., 14 E.); and in the northwest quarter of section 1 and the northeast of 2 (37 N., 14 E.), and the southeast quarter of section 35 and the southwest of 36 (38 N., 14 E.). The material is somewhat clayey, having a thickness varying between 4 and 14 feet. The stripping is heavy and the color a very dark chocolate brown.

Part of Township 38 North, Ranges 12, 13, 14 and Part of 15 East.

Fremont Township (38 N., 14 E.).—A very singular and large deposit is found 2 miles east and northeast of Fremont in the north-

Plate IV.

Grass and Sedge Marsh occupying the site of the Prehistoric Cedar Lake, which lies two miles east of Fremont.

east and southeast quarters of section 22, the northeast of 27, the northwest of 26, the southwest, northwest and northeast of 23, and the southwest of 14. We find here what has very recently been a lake 2 miles long and from ¾ to 1½ miles wide, almost completely overgrown with grasses, sedges and sphagnum mosses. The surface, developed by this growth, although but a few inches thick in many places, will generally bear one's weight while walking over it. At this place one finds the forming of the peat in process, the new grasses, sedges and mosses crowding the others beneath the level of the water. They then undergo a partial decomposition, in which the fuel gases are largely retained and the non-combustible given off to a considerable extent. In this way the fuel value of this decaying vegetation is continually becoming better.

In this deposit, probably 400 acres are underlain by a fair to good quality of peat, which apparently has a good thickness (see map), but the vast amount of water would probably reduce it greatly. The peat about the shore and the islands is much more compact than that at a distance. The stripping is very light and the bottom seems to be clay. For a peat plant, this might be a fair location, since a branch of the Lake Shore & Michigan Southern Railway passes near the northwestern corner of the deposit, and the possibility is good of lowering the water level 7 or more feet.

One-fourth of a mile south of Cedar Lake, in the northeast and southeast quarters of section 27, are 35 acres of peat, with a thickness varying between 3 and 12 feet. The quality is hardly fair, the material being clayey. Another deposit containing an inferior quality lies in the northwest quarter of section 33.

Jamestown Township (38 N., 13 E.).—Situated between Marsh and Otter Lakes, in the southeast quarter of section 26, is a 65-acre deposit of a poor to fair quality of peat. Considerable clay is mixed with the material in the more shallow parts of the bed. The color is a dark chocolate brown, and the stripping varies from 1 to 3 feet. The depth is from 4 to 21½ feet, and the underlying formation is clay.

In the northeast quarter of section 26 and the northwest of 27, are 30 acres of a poor quality of peat, rather shallow in depth. A similar deposit for size and quality is found in the northeast quarter of section 21.

In an old lake basin in the southeast quarter of section 19 and the northeast quarter of 30, is a bed of peat, with an extent of 25 acres. The material is of a fair quality, and has a dark chocolate brown color. The thickness varies between 3 and 15 feet, and the stripping is about 1 to 1½ feet. Within a few hundred yards of this deposit are several small ones of 3 or 4 acres, which have a good thickness and a good quality of material, being derived from the sphagnum mosses. Also peat moss litter and green moss can be obtained from these small beds, that are found in deep glacial kettle basins.

A peat bed of 40 acres in the central part of section 31 has an average thickness of 4 feet and a fair to good quality of material. The color is a dark chocolate brown and the stripping is about 1 foot.

Millgrove Township (38 N., 12 E.).—Fourteen tests, well distributed over the marsh that follows the south branch of Crooked Creek from the northwest end of Belle Lake to the central part of section 26, indicated a poor quality of peat, spreading over about 100 acres; the thickness ranges from 2 to 12 feet, and averages 3½ feet. The stripping is 1½ feet and the color a very dark chocolate brown.

Another deposit consisting of 150 acres of peat is found along this same branch of Crooked Creek in the northwest quarter of section 26 and the southwest of 23, and follows the main branch northeast through section 23, southeast through 24, and into the northeast quarter of 25. This deposit is very much divided by the higher ground, and varies greatly in depth, the general average not being over 2½ feet. In a few places 10 or 12 acres can be found with a depth of 7 or 8 feet. The color is a very dark chocolate brown, and the quality is from poor to fair, the derivation being largely from the grasses and sedges. Clay and marl are the main subsoils. For fuel, the material should only be used in the crude form, not sufficient material of the proper quality being present for even a small peat plant.

About 35 acres of a rather shallow bed of peat occurs about Tamarack Lake, in the northeast quarter of section 27 and the southeast of 22. The quality of the material is fair, being derived mainly from the grasses and sedges. The thickness varies from 1 to 4 feet, and the underlying formation is marl.

Around Island Lake in the northeast quarter of section 31, are 60 acres of a fair quality of peat. The color is a dark chocolate brown, and the thickness of the bed will average 4 feet, the maximum being 12 feet.

A poor quality of material, occupying 15 acres, is found in the northeast quarter of section 30 and the southeast of 19. The color is a dark chocolate brown, and the average thickness is 3 feet. Another poor deposit, of 150 acres, lies in the southwest and northwest quarters of the same section. The color is a very dark chocolate brown, and the average thickness about 3 feet. The stripping is 1½ feet and the sub-strata are clay, marl and sand.

In this report of Steuben County, the writer has aimed to describe only the larger and more valuable deposits. Numerous others of 3 or 4 acres are found in every civil township of the county. Some of these contain the best qualities of peat, derived from sphagnum mosses. Many of these moss peat beds have, in addition to the peat, peat moss litter and the green moss, used by nurserymen. Where the wood fuel is scarce, in the vicinity of these smaller deposits, the consumers will find they can obtain a very suitable fuel, at a low expense, if they will spade out the material, stack it up to dry in the summer atmosphere, and then put it, in the crude condition, in their wood sheds. If the peat is of a good quality, the heat given off, while burning, will more than equal that given off from the same number of cubic feet of wood.

DEKALB COUNTY.

This county, which is found on the eastern boundary of the State, just south of Steuben County, ranks as one of the medium peat counties of Indiana in its amount of material, and among the first, in its quality. The deposits are largely of the moss variety.

Township 33 North, Ranges 12, 13, 14 and Part of 15 East.—Because of the draining of the glacial lakes by the St. Joseph River, and its tributaries, no place was left for the development of peat beds in the eastern part of this territory.

Jackson and Concord Townships (33 N., 13 and 14 E.).—A 10-acre peat deposit lies in the southwest quarter of section 3 and the southeast of 4 (33 N., 14 E.). It is rather shallow and is of fair quality.

On the place of S. Franks, in the southeast quarter of section 1 (33 N., 13 E.), and the southwest of section 6 (33 N., 14 E.), is a 10-acre bed of peat, which is shallow and of fair quality. Deposits of this extent are too small for a peat plant, being suitable for fuel only, where it is spaded out, stacked up to dry and used in the crude condition.

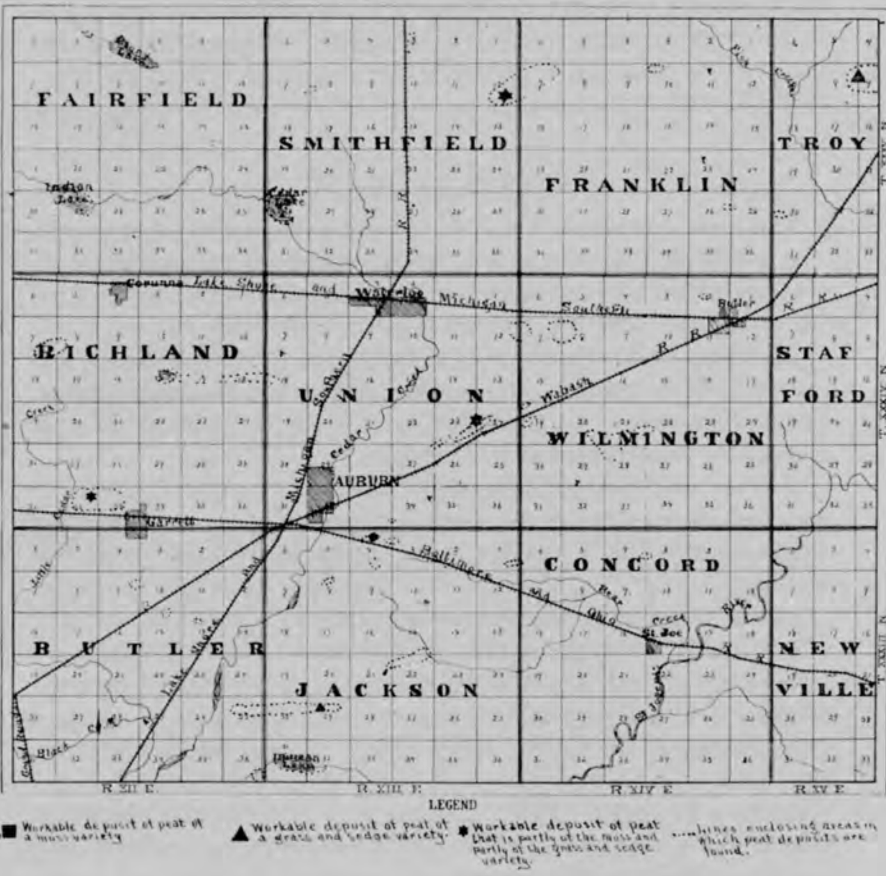
Jackson Township (33 N., 13 E.).—A peat bed having a length of 1 mile, and a width of 1-6 of a mile, is located in the northeast and northwest quarters of section 22, the southeast of 15 and the northeast of 21. Five soundings showed a good thickness (see map), and a stripping of about $1\frac{1}{2}$ feet. The color is a dark chocolate brown and the substratum is largely clay. More or less high ground is scattered through this deposit.

In an old glacial lake basin in the northeast quarter of section 4 and the northwest of 3, is a fair bed of peat of 20 or 25 acres. The color is a dark chocolate brown and the stripping about 1 foot.

In the northwest and northeast quarters of section 4 are 70 acres of peat on the farms of J. Weimer and W. Barnhart. The quality is fair, and the color a dark chocolate brown. The thickness is good (see map), the stripping about 1 foot and the sub-soil of clay.

A deposit, similar in quality to the one described in the preced-

DE KALB COUNTY.



ing paragraph, occurs in the south-central part of section 4. This bed extends over 40 acres, with a thickness varying between 6 and 20 feet. Since there are three deposits in this section, aggregating an extent of 135 or 140 acres, and the B. & O. Ry. passing east and west, almost bisecting it, the location would be good for a peat plant.

On the places of H. J. Buchanan and Elmer Weaver, in the northeast and northwest quarters of section 8, is a 35-acre peat deposit, of good quality, being derived from the sphagnum mosses. The thickness of this bed is from 5 to 25 feet (see map), and the stripping very light. Almost all of the material is beneath the ground-water level, and consequently has not been oxidized in the presence of the air. The surface is largely covered from ½ to 2 feet with green mosses, which would be very valuable to nurserymen. Immediately beneath these mosses are several feet of a good quality of peat moss litter, which has a light to medium chocolate brown color. Underlying this is the medium chocolate brown peat.

Jackson and Butler Townships (33 N., 12 and 13 E.).—Peat beds, varying greatly in thickness and extent, are found in pockets in the muck area, which extends east and west, with a length of about 2¾ miles and a width of 1-5 of a mile. They are located in the northeast and northwest quarters of section 29, the northeast and northwest of 30 (33 N., 13 E.), and the northeast and northwest of 25 (33 N., 12 E.). The area covered by these beds will probably be more than 125 acres. In the eastern portion of this area, just north of the center of section 29, is a 15-acre bed, which contains a good quality of peat, being derived largely from the sphagnum mosses. The stripping is about ½ of a foot and the underlying formation is clay. The thickness of this deposit is from 10 to 25 feet, with about one-sixth its material above the level of the ground-water. Advancing westward from this bed, in the muck area, we find numerous patches of 2 or 4 acres, where the peat is 5 feet or more in depth, and of good quality, being largely derived from the sphagnum mosses.

Around Duncan Lake, in the southeast quarter of section 31 and the southwest of 32, are some 20 acres of peat, which have been derived mainly from the sphagnum mosses, and is of good quality. The peat bed forms a belt about 100 yards wide around the lake, occurring between it and the higher ground. It is almost all beneath the water level, and thus has not been subjected to the oxidation of the air, but is in a very loose condition, and would shrink greatly if drained. The sub-soil is clay, and the stripping almost nothing.

Butler Township (33 N., 12 E.).—On the land owned by J. Paulin and M. A. Carnahan, in the southeast quarter of section 36, is a good bed of peat, ranging in thickness, as was determined by seven soundings, from 6 to 25 feet. It comprises about 55 acres, and has a stripping of 1½ feet. The underlying formation is clay. The color is a dark chocolate brown.

Twenty acres of rather clayey peat occur in the north-central part of section 14. The thickness of the bed is low and the stripping heavy. It is only suitable for use in the crude condition. A deposit similar in size, quality and thickness is located in the south-central part of section 10 and the north-central part of 15.

In the southwest quarter of section 10 are 15 acres of a fair to good quality of peat, with a dark chocolate brown color and a fair thickness. This material is derived from the sphagnum mosses.

A little more than 1 mile south of Garrett, in the northeast quarter of section 9, is a peat bed of 65 or 70 acres, where Baker & Co. are getting out peat moss litter on a commercial scale. Ten acres of this deposit have been carefully sounded by Mr. Moffer, superintendent of the plant, and are reputed to have an average thickness of 44 feet. Several soundings made by the writer in the remainder of the deposit, show that it ranges between 2 and 20 feet in thickness. The peat has a medium to dark chocolate brown color and is of excellent quality, being almost entirely beneath the ground-water level, and derived from the sphagnum mosses. The stripping is from ¼ to 1½ feet.

For six or seven years this company has been spading out the peat moss; it is then dried and baled for market. Numerous car loads of the material have been shipped to points in Ohio, Indiana, Michigan and Illinois, where it is used, with good satisfaction, as a litter for stables, fowl-houses, kennels, etc. Mr. Moffer says that tests prove that it will absorb from eight to twelve times its own weight of water, while ordinary straw cannot absorb more than three times its own weight. Further consideration of this peat moss and others are taken up in the introduction on page 103.

Township 34 North, Ranges 12, 13, 14 and Part of 15 East.

Richland Township (34 N., 12 and 13 E.).—Beginning at the west side of Garrett and extending west and northwest for 1½ miles, is a peat bed of 100 acres. Being more or less interrupted by the higher ground, it covers a large part of sections 32 and 33 (34 N., 12 E.). The thickness of the material ranges between 4 and 25 feet, and the stripping will average about one foot. The quality is from poor to good, being very impure in portions and much oxidized. The color is a medium to a dark chocolate brown, and the derivation largely from the sphagnum mosses. This would be a good location for a peat plant, since, in the village of Garrett, a large part of the product could be marketed; and a considerable amount of the material is of a good quality.

Probably twenty acres of peat can be found around the small lakes in the southeast quarter of section 7 (34 N., 12 E.). The material is of a fair quality and thickness. The topographical position is that of an old glacial lake basin.

A peat bed extends east and west through or near the centers of sections 15, 14, and 13, and 18 (34 N., 13 E.), and has a length of three miles and a width of from one-ninth to one-third of a mile. The quality of the material, as a whole, is good, the derivation being mainly from the sphagnum mosses. The color is a medium to a dark chocolate brown, and most of the deposit is either now or was recently beneath the ground-water level, so that the oxidation in the air has not effected it greatly. The thickness at various parts varies greatly. At the western end, around the lake in section 15, the thickness of the bed is from 8 to 25 feet; while in the western and central portions of section 14, it is only from 4 to 15 feet. In the eastern part of 14 and the western of 13, it becomes deep, in many places soundings not reaching a bottom at 25 feet. In the eastern part of section 13 and the western of 18, a 4½-foot ditch was dug for ¼ of a mile without reaching the bottom of the peat. Soundings in this same vicinity show from 4 to 20 feet of peat. The quality and amount of material make this extent of peat beds a desirable place for a peat plant.

Union Township (34 N., 13 E.).—An old glacial lake basin, which contains several acres of a fair to good peat, occurs in the southeast quarter of section 33 and the southwest of 34.

From about 2½ miles northeast of Auburn to a point near Mooresville is a chain of peat beds, which will comprise several hundred acres of fair to good peat, found in the northeast quarter of section 27, the southwest and southeast of 23, and the southwest and southeast of 24. Individual deposits are from 2 to 35 acres in extent, with the thickness ranging from 10 to 25 feet. The color is generally a dark chocolate brown, and the stripping varies between ¼ and 1½ feet. Since the Vandalia Railroad runs northeast and southwest, parallel with this chain of deposits, and only about ¼ of a mile distant, a good site for a peat plant might be found.

Wilmington Township (34 N., 14 E.).—A bed of muck, one mile long and one-third of a mile wide, containing numerous pockets of peat, appears in the southeast quarter of section 20, the southwest and southeast of 21 and the northwest of 28. The peat beds, from 2 to 20 acres in area, will likely aggregate 200 acres, and have a thickness varying between 4 and 25 feet. A ditch, with a depth of 7 feet, passing east and west for almost a mile through a large portion of the peat beds, has its bottom in the peat most of the time. The quality of the material is from fair to good, being partly from the sphagnum mosses and partly from the grasses and sedges. The stripping is from ½ to 2 feet.

On the farms of P. D. and Fred Gender, in an old glacial lake basin, in the southwest quarter of section 22 and the southeast of 21, are 40 acres of peat, underlain by a clay sub-soil. The thickness of the bed will average 5 feet, and the stripping about 1½ feet. The quality of the material is about fair.

In a 25-acre muck bed in the northeast quarter of section 8 and the northwest of 7, are about 40 acres of peat, more or less scattered in pockets of 10 acres or less. This peat is of a good quality, being derived largely from the sphagnum mosses, and is of a dark chocolate brown color. The stripping is 1½ feet, and the underlying formation mostly clay.

Ten or 15 acres of a fair quality of peat are found in the muck bed in the northwest quarter of section 7 and the northeast quarter of section 12 (34 N., 13 E.). Another small deposit of 10 acres occurs just west of the central part of section 2. It also is fair in quality. An area similar in size and quality of material is found in the southwest quarter of section 4.

Township 35 North, Ranges 12, 13, 14 and Part of 15 East.

Troy Township (35 N., 15 E.).—A peat deposit in the northeast and southeast quarters of section 8 and in parts of each of the quarters of section 9, has a length of one-half of a mile and a width of one-quarter of a mile. It has a good thickness (see map) and a good quality of material, derived mainly from the sphagnum mosses and having a dark chocolate brown color. Near the top it is very fibrous and bladed, while deeper, it becomes less fibrous and more compact. The very fibrous portion is a good quality of peat moss litter, and occurs here in large quantities. An old glacial lake once occupied the same place that this peat bed now covers. Very fair crops of onions are being raised on its decomposed surface. The quality and quantity will make it a good location for a peat plant, when the transportation facilities become better.

About twenty-five acres of peat occur in the west central part of section 30. The quality of this material is from poor to fair and the thickness rather shallow. A deposit of 15 acres, similar in quality and thickness, is found in the east-central part of section

26 and the west-central of 25 (35 N., 14 E.). Another shallow bed of a rather poor quality of material is located in the northwest quarter of section 10 (35 N., 14 E.), on the land owned by J. D. Haskins. None of these deposits could be economically utilized in any other way than spading the peat out and burning it in the crude form.

Franklin and Smithfield Townships (35 N., 13 and 14 E.).—In an old lake basin in the northeast, southwest and southeast quarters of section 12, Smithfield Township, and the southwest, northwest and northeast quarters of 7, Franklin Township, are about 250 acres of peat, in several large beds, separated by the higher ground and muck. The quality ranges between poor and fair, the derivation being, to a considerable extent, from the sphagnum mosses. The color is from a medium to a dark chocolate brown, and the stripping 1/4 to 1 1/2 feet. Some green moss for nurserymen and large amounts of peat moss litter can be procured in these beds. Probably one-third of the material is above the ground-water level. Fair crops of corn and onions are raised on the more decomposed portions. With better transportation facilities, this will be a good location for a peat plant.

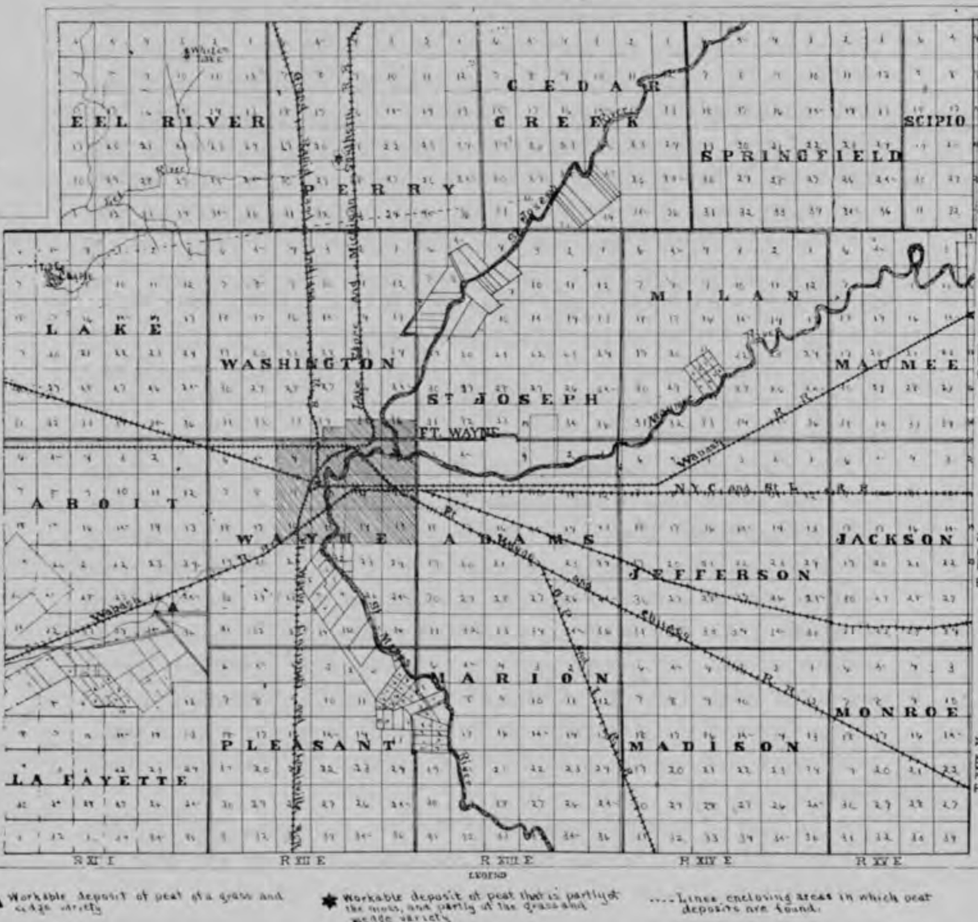
Forty acres of a rather shallow deposit of peat are found along the Lake Shore Ry. in the northeast and southeast quarters of section 3, Smithfield Township. The material is only fair in quality. Another small and shallow deposit of 15 acres occurs in the west-central part of section 8 and the east-central of 7. About 4 acres of a fair quality of peat can be found around Cedar Lake, in the northwest and southwest quarters of section 30. Another small deposit is located about Indian Lake in section 29, Smithfield Township. None of these deposits are sufficiently large for even a small peat plant, and are only suitable for supplying the fuel in the crude form.

A number of smaller deposits, of three or four acres, which have not been mentioned in this report, are found, more or less, over the entire county. Many of these are of good quality, and will afford a very economical fuel to those who wish to burn the peat in the crude condition.

ALLEN COUNTY.

Allen County is situated in the northeastern part of the State along the Ohio line.

ALLEN COUNTY.



Its peat beds, that are of any economic importance as fuel, are found in the civil townships of Wayne (30 N., 12 E.), Aboit (30 N., 11 E.), Lake (31 N., 11 E.), Eel River (32 N., 11 E.), Perry (32 N., 12 E.) and Cedar Creek (32 N., 13 E.).

In the northeast and northwest quarters of section 6 (32 N., 13 E.), are 70 acres of peat, scattered in small patches over the farms of A. Warner, H. Warner, S. Slaughter, and S. Surface. The thickness of the beds varies from 4 to 25 feet, the stripping is about one foot, and the quality is from fair to good. The material is largely derived from the mosses, is mostly below the level of the ground-water, and rests upon a clay sub-stratum.

Located in old glacial lake basins are two deposits in the southeast quarter of section 20, the southwest of 21, the northeast of 29 and the northwest of 28 (32 N., 12 E.), which contains about 50 acres. The average thickness is 12 feet (see map), the stripping is very light, and the quality is good. The northern bed is covered with huckleberry bushes and sphagnum mosses. These mosses have a thickness of from 1 to 2 feet, at the surface, and are of very good quality for nurserymen. Beneath the green mosses, the peat moss litter, which is of good quality, begins and extends for several feet deeper.

In the valleys of Little River and some of its main tributaries, commencing in section 28 (30 N., 12 E.) and extending westward and slightly southward to the Huntington County line, are shallow beds of peat, seldom attaining a thickness of 4 feet, and generally about 1 or 2 feet. These beds are frequently interrupted by the higher ground, and are only suitable for use in the crude form. Fair crops of corn are raised on the muck soil, originating from the decomposition of this peat; and especially good grops are grown, where the sand and muck or clay and muck become mingled. It is said that on this mixture, it is not infrequent for a corn crop to run 85 bushels to the acre, where the average production for the county is only forty-five.

In the northwest quarter of section 34, Charles Bash has a Filler Plant, where the muck is taken and prepared as a filler for the fertilizer. It is said to serve very well for this purpose.

Over 100 acres of a rather poor quality of peat is found in the east central part of section 19 (30 N., 12 E.). The thickness of the material varies between 2 and 5 feet, the stripping is 1½ feet, and it is mainly above the ground-water level. The surface is only a muck soil, on which potatoes and corn are being grown very successfully.

Fully 1,000 acres of a poor to fair peat are known to exist in Lake Township (31 N., 11 E.). Of course, the greater part is very shallow and will never be of economic importance, except in the crude condition, yet small patches of a few acres, greatly scattered, have a thickness ranging from 5 to 15 feet, and are fair to good in quality. The peat and muck beds are located as follows: 60 acres in the southwest quarter of section 5, 80 acres in the southeast quarter of 4, 160 acres in the southeast quarter of 8, 80 acres in the northeast quarter of 17, 150 acres in the northeast and northwest quarters of 16, 300 acres in the southeast and southwest quarters of 9, 250 acres in the northwest and southwest quarters of 10, and 100 acres in the southwest quarter of 3.

A deposit, which is mainly beneath the ground-water level, and is of sufficient size and thickness (see map) for a small peat plant, is found in the northeast quarter of section 2 (31 N., 11 E.), on the land of John Valentine. The bed is about 180 rods long and 100 rods wide. It has from ¼ to 1 foot of stripping, and has a clay substratum. The material is of good quality, and only the surface has been exposed to the air.

On the places of David Gallaway and neighbors, in the northwest and southwest quarters of section 23 and the northeast of 22 (32 N., 11 E.), is a peat bed, consisting of 120 acres, with an average thickness of 3 feet, and a maximum of 15 feet. The material is of a fair quality and a dark chocolate brown color. It has a stripping of 1 foot, rests upon a clay formation, and is one-third above the ground-water level. Sufficient material could be obtained for operating a small peat plant.

Around White Lake, in section 3 (32 N., 11 E.), is a 35 or 40-acre bed of peat, with a fair quality and a thickness ranging between 2 and 15 feet. The stripping is light, and the color a dark chocolate brown.

Along the Nickel Plate Railroad in sections 29 and 30 (31 N., 11 E.), is a long and narrow peat deposit of about 60 acres, with an average thickness of 3 feet. The stripping is one foot, the color a dark chocolate brown, and the quality from poor to fair. The material is mainly above the level of the ground-water, and is much broken by the high ground.

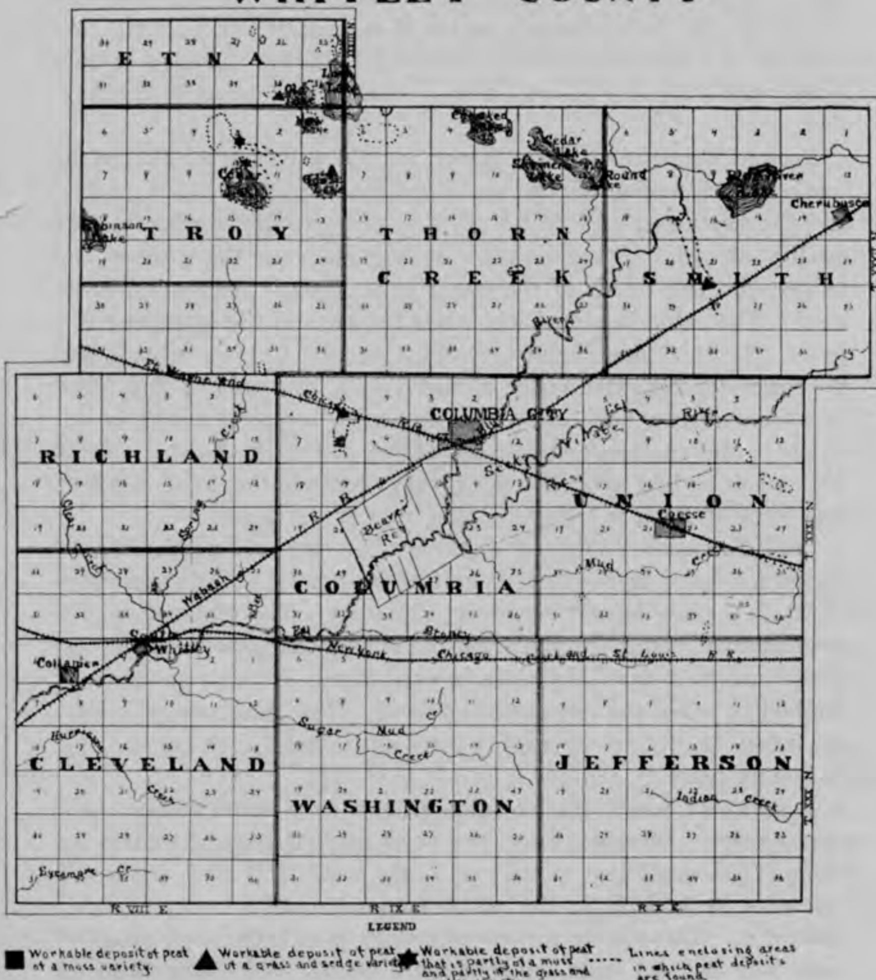
WHITLEY COUNTY.

Whitley County is situated in the northeastern part of the State, immediately west of Allen and south of Noble County. For amount and quality of its peat deposits, it ranks as one of the less important of the peat bearing counties. The only deposits that contain workable amounts of peat, occur near Collins, and in the vicinities of Goose, Cedar, Old, New and Loon Lakes.

TOWNSHIP 32 NORTH, RANGES 8, 9 AND 10 EAST; AND THE SOUTHERN PART OF TOWNSHIP 33 NORTH, RANGE 8 EAST.

Etna and Troy Townships (33 and 32 N., 8 E.).—Extending southward from Brown Lake, in the northwest quarter of section 26 (33 N., 8 E.), is a peat deposit, covering 20 acres. The material is of a good quality, being derived from the sphagnum mosses and being almost all beneath the ground-water level. The thickness of the bed will average 15 feet, the stripping is almost nothing, and the underlying formation is marl. The color is a medium chocolate brown.

WHITLEY COUNTY



In the northeast quarter of section 27 (33 N., 8 E.), is a deposit, similar in quality and physical characteristics, to that mentioned in the preceding paragraph. The areal extent is about 5 acres, and the average depth 6 feet. Another deposit, with about the same extent and quality of material, lies in the southwest quarter of section 25 (33 N., 8 E.). Its average thickness is 5 feet.

Extending northward from Loon Lake, and along its outlet, are 50 acres of peat in the southeast quarter of section 25 (33 N., 8 E.). The quality of the material is fair, and the thickness varies between 8 and 21½ feet (see map). It has a dark chocolate brown color, from ¼ to 1½ feet of stripping, and rests upon the clay. About ½ of it is above the ground-water level. On the west side of this lake, in the southeast quarter of section 36 (33 N., 8 E.), are 20 acres of a similar quality of peat. Its average thickness is only 3 feet, and stripping about 1 foot. Marl is the underlying formation.

Around two glacial lakes, known as Old and New Lakes, in the south half of section 35, the southwest quarter of 36 (33 N., 8 E.), and the northwest of 1 (32 N., 8 E.), are over 150 acres of a fair quality of peat. Its derivation is largely from the grasses and sedges, and two-thirds of the material is beneath the ground-water level. The color is a dark chocolate brown and the stripping is 1 foot. The thickness varies between 3 and 20 feet (see map), and the main deposit extends for almost 1 mile, due west of Old Lake, in a long, narrow belt. Since the timber is becoming scarce in this vicinity, and the nearest railroad station is 8 miles distant, a small peat plant would scarcely more than furnish the local demand. The town of Etna is within ¼ of a mile of the deposit.

Troy Township (32 N., 8 E.).—On the east and north sides of Tamarack Lake, in the eastern half of section 11, and the northeast of 10, is a peat deposit, covering 150 acres. The material is of a good quality, being derived from the sphagnum mosses and having a medium to a dark chocolate brown color. About two-thirds of the bed is below the ground-water level. The thickness will average 5 feet, the stripping varying between ¼ and 2 feet, and the subsoil being marl.

A series of small glacial lakes extend in a northwesterly and southeasterly direction, from the north-central part of section 11, through the southwest quarter of 2, the south half of 3, the southeast of 4, to a point in the northeast quarter of 4 and the northwest of 3. These lakes are enveloped by peat beds, some of which have been derived from the sphagnum mosses, and others from the grasses and sedges. These beds will aggregate 200 acres in area, and they have thicknesses ranging between 6 and 21½ feet (see map). The stripping is from ¼ to 2 feet, the sub-stratum is clay, and two-thirds of the material is below the ground-water level. The color varies between a medium and a dark chocolate brown. In the eastern portion of this chain of deposits, ditches have been cut. This has drained the peat, so that it has settled almost a foot, and has left the roots of the maple trees mostly above the surface.

The deposits, described in the two preceding paragraphs, could both be used to supply the same peat plant; and would provide a good location if the transportation facilities were better. Even as conditions are, a small plant would likely turn out no more of the finished product than would satisfy the local demand.

Surrounding Goose Lake, in the southwest quarter of section 12, are probably 75 acres of a fair quality of peat. This has been derived, largely, from the grasses and sedges. One-third of the material is above the ground-water level, the stripping ranges between ½ and 2 feet, and the thickness between 4 and 21½ feet (see map). The deposit rests upon a clay stratum, and has a dark chocolate brown color.

Twenty acres of a deep (see map) bed of peat are located in the northwest quarter of section 12. The quality is fair, and the derivation is mostly from the grasses and sedges. The stripping is ½ of a foot, and two-thirds of the material is beneath the ground-water level. The underlying bed is clay.

Richland Township (31 and 32 N., 8 E.).—Occupying what was once a glacial lake basin, in the southwest quarter of section 35 (32 N., 8 E.), and the northeast of 1 (31 N., 8 E.), is a peat deposit, covering about 40 acres. A section, at this deposit, shows the following: (a) Stripping, 1 foot; (b) dark chocolate brown material, which is rather fibrous, 7 feet; (c) a dark chocolate brown, less fibrous and more compact material, 8 feet. The average thickness is about 5 feet, and two-thirds of the deposit is beneath the ground-water level. The material is mainly derived from the grasses and sedges, and the underlying formation is marl. The soil of the deposit has the appearence of good onion ground.

A small and rather unimportant deposit is found around Robinson Lake, in the western half of section 18 and the northwest of 19. It would be suitable only for use in the crude condition.

Thorn Creek Township (32 N., 9 E.).—Partly formed from the sphagnum mosses Nos. 1 and 2, and partly from the grasses and sedges, is a bed of peat in the eastern half of section 6, and the western half of 5. It consists of 100 acres, has a medium to a dark chocolate brown color, and a fair to good quality. The thickness is from 2 to 12 feet, the average being about 3½ feet. Only one-third of the material is below the ground-water level, and the sub-soil is clay. The stripping, which is a good soil for onion raising, has an average thickness of 1½ feet.

A portion of a bed, which has its main extent in Noble County,* lies in the northeast quarter of section 6, and the northwest of 5. The surface covered is 40 acres, the average thickness 4½ feet, and the stripping ½ of a foot. About two-thirds of the bed is below the ground-water level, and the sub-strata are clay and marl. The quality of the material is from fair to good, being derived from the sphagnum mosses, the grasses and sedges. The color is a dark chocolate brown.

Small shallow and poor to fair deposits are found, in pockets of four or five acres, around Shriners, Cedar and Round Lakes. These range from 1 to 6 feet in thickness, and are three-quarters beneath the ground-water level. The derivation is from the grasses and sedges, and the stripping is ½ foot.

Along a creek, in the southeast quarter of section 22 and the southwest of 23, are 15 acres of a fair quality of peat, which is derived from the grasses and sedges, and has a dark chocolate brown color. The thickness ranges between 2 and 7 feet, the average stripping is 1 foot, and two-thirds of the material is above the level of the ground-water. The stubstratum is clay.

Smith Township (32 N., 10 E.).—Occupying what was once an old glacial lake basin, is a deposit, with a length of three miles and a width ranging between one-eighth and one-quarter of a mile, in the southeast and northwest quarters of section 28, the western half of 21, the eastern half of 20, the southwest of 16 and the southeast of 17. The quality varies greatly, depending on the amount of impurity. The deeper portions are of fair quality, but the shallow parts are poor. The derivation of the material is, mainly, from the grasses and sedges. The thickness varies between 2 and 20 feet, about one-half of the deposit is above the level of the ground-water, and the underlying formations are sand, clay and marl. The color is from a medium to a very dark chocolate brown. The stripping, which averages about one foot, furnishes a good soil for onions, which are cultivated extensively upon it. With the Vandalia Railroad crossing this bed, and a sufficient amount of material being present, the erection of a peat plant would be justified.

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*See page 141.

Union Township (31 N., 10 E.).—A deposit, 10 acres of which have been derived from the sphagnum mosses, and 50 acres from the grasses and sedges, occurs in the southeast quarter of section 11. The quality ranges from fair to good, and the color from a medium to a dark chocolate brown. The thickness of the tamarack portion is from 6 to 21½ feet, the stripping is ¼ of a foot, and only one-twentieth is above the ground-water level; while the thickness of the grass and sedge part will average about 2½ feet; the stripping is one foot, and about one-third is above the ground-water level.

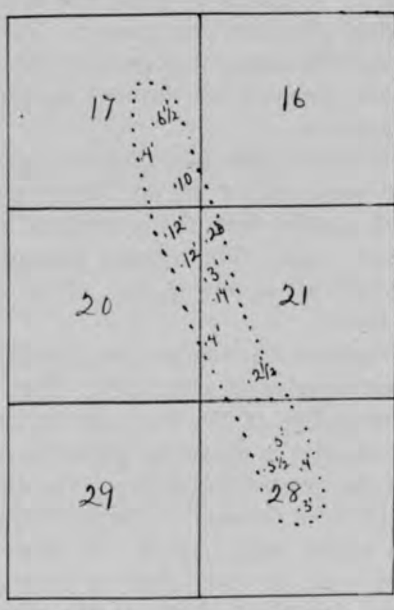


Fig. 2. Showing the thicknesses, where soundings were made, of peat beds in the western half of Smith township, Whitley county.

The upper 7 feet of the bed, in the tamarack marsh, is a good quality of peat moss litter, being very fibrous.

Occupying the site of an old lake basin in the northwest, and southeast quarters of section 13, is a bed of peat of 20 acres. It is poor in quality, being impure and derived from the grasses and sedges. The color is a very dark chocolate brown, the average thickness 2½ feet and the stripping ½ of a foot. About one-half of the material is above the level of the ground-water. The oxidized surface makes a good soil for onions.

Along the Pennsylvania Railway, in the northern half of section 25, are about 80 acres of a poor quality of peat. This has a very dark chocolate brown color, and the average thickness is 3 feet. The derivation is from the grasses and sedges, and over one-half of the material is above the ground-water level. The stripping, which is over 1 foot, makes a fair soil for onions.

A deposit of 6 acres, containing a poor to fair quality of peat, is located in the northeast quarter of section 35. The color of the material is a very dark chocolate brown, and the thickness is from 2 to 10 feet. Another poor and clayey bed of peat is located in the southeast quarter of section 34, and the northeast quarter of section 3 (30 N., 10 E.). It covers 25 acres, has an average thickness of 2½ feet, and a dark chocolate brown color. The stripping is 1½ feet, and two-thirds of the material is above the level of the groundwater. Both of these deposits are covered with a soil fairly well adapted to onion growing.

Occupying an old glacial lake basin, in the northeast quarter of section 31 and the northwest of 32, are 20 acres of a fair bed of peat. It is derived, largely, from the grasses and sedges, and has a dark chocolate brown color. The average thickness is 7 feet, the stripping 1½ feet, and about 50 per cent. of the material is above the ground-water level.

A peat bed bearing a similar topographical position to that above lies in the northeast quarter of section 30. This bed has a thickness of 5 feet, a stripping of 1½ feet, and an extent of 8 acres. About three-quarters of it is above the ground-water level, and its derivation is from the grasses and sedges. The quality* is poor.

A muck deposit of about 50 acres, in the southwest quarter of section 6, contains a rather poor quality of peat. The maximum thickness is 4 feet, and the derivation is from the grasses and sdges. More or less clay is mingled with the material. Fair corn crops are raised upon this muck.

Columbia Township (31 N., 9 E.).—Cut along the southern edge by the Pennsylvania Railway, is a 70-acre bed of peat, in the south-central part of section 5, and the north-central of 8. This deposit has a thickness ranging between 2 and 18 feet (see map), and is one-third above the ground-water level. The material ranges between fair and good in quality, being derived largely from the sphagnum mosses, and having a dark chocolate brown color. The stripping, which is 1 foot thick, makes a splendid onion soil. The underlying formations are clay and sand.

In the central and south-central parts of section 8 are tamarack and huckleberry marshes, covering 115 acres. These are entirely

*See page 84.

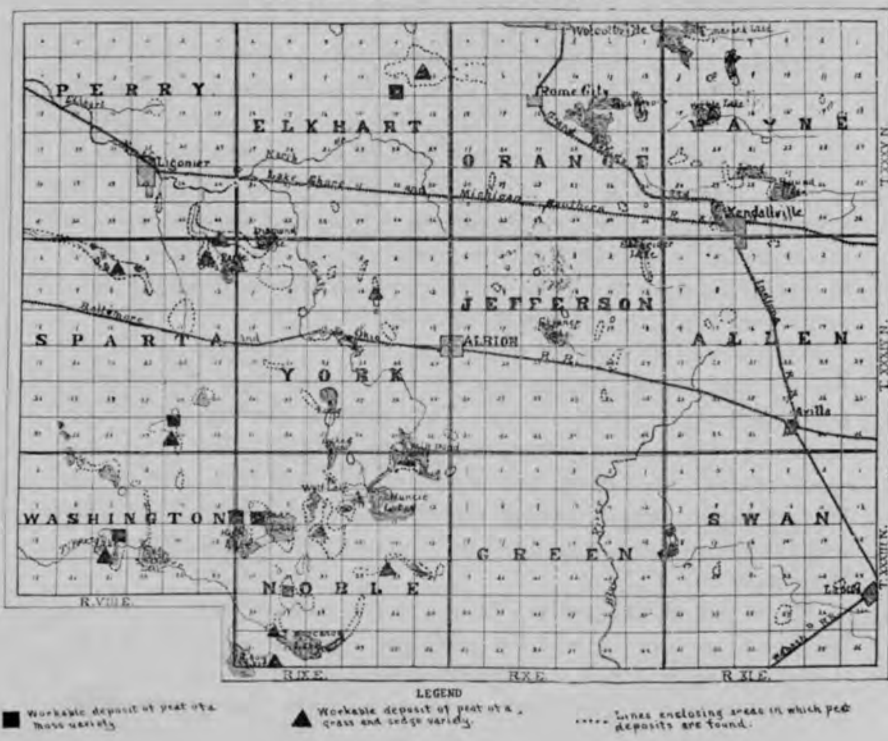
underlain by peat beds, which have a medium to a dark chocolate brown color. This material is of good quality, being derived from the sphagnum mosses, which are, at present, found growing over the more moist portions. Not over one-fifth of the deposit is above the ground-water level, and the stripping is very light. Including the upper part of the bed, which is a good quality of peat moss litter, the thickness ranges between 6 and 21½ feet (see map).

In addition to the deposits already described, there are a number of beds of three or four acres, found in almost all portions of the county. Because of their limited areas they will be suitable only for furnishing material in the crude form.

NOBLE COUNTY.

Noble County is situated in the northeastern part of Indiana, south of Lagrange, west of Dekalb, north of Allen and Whitley, and east of Kosciusko and Elkhart Counties. For quantity and quality of peat it ranks as one of the foremost counties of the State.

NOBLE COUNTY.



With the exception of the civil township of Green, all the townships seem to have workable deposits.

Township 35 North, Ranges 8, 9, 10, and 11 East.

The civil townships of Wayne, Orange, Elkhart and Perry correspond with these four congressional townships.

Wayne Township (36 N., 11 E.).—In the northwestern part of this township at the northeast side of Tamarack Lake, is a bed of poor to fair peat, covering about 100 acres. This bed has a thickness ranging between 1 and 9 feet, but likely averages about 3 feet. It rests upon a clay formation, has a very dark chocolate brown color, and about 1 foot of stripping.

A deposit of 25 acres is found near the center of section 8. The material has been derived from the sphagnum mosses and is a very good quality. The color is a medium chocolate brown, and the average thickness 9 feet, as was determined by four well-distributed soundings, which give the following depths: 6, 9, 8 and 21 feet. The stripping is ½ foot, and the bed is largely beneath the level of the ground-water. This would be a fair location for a small peat plant, since the quality of the material is so excellent.

Situated in the southeast quarter of section 5, the southwest of 4, the northeast and southeast of 8, and the northwest and southwest of 9, are about 200 acres of peat, ranging in quality between poor and good. The color ranges from a very dark chocolate to a medium chocolate brown, with a thickness of about 4 feet on the average (see map). The stripping is 1 foot, and the derivation of the material is largely from the grasses and sedges. This deposit is largely beneath the level of the ground-water, and would lose a large portion of its volume if drained.

Fifteen well-distributed soundings, over all the quarters of section 14 and the southwest quarter of 13, show beds of fair peat, which will aggregate 150 acres. They have an average thickness of about 6 feet, a color varying from a very dark chocolate brown to a medium chocolate brown, and a stripping of 1½ feet. About one-half of the material is above the ground-water level. The extent and thickness were determined by 15 soundings, well scattered over the entire area.

A peat bed of 60 acres was found by 6 soundings in the northeast quarter of section 21, and the northwest quarter of 22. The average thickness is 4 feet, the quality and color the same as that of the deposit described in the preceding paragraph, and the stripping, 1½ feet. Probably one-half of the material is above the ground-water level. The derivation has been from the grasses, the sedges and the mosses. This, as well as the deposit described in the preceding paragraph, would serve for a medium sized peat plant.

Probably 100 acres of peat varying between fair and good can be found around Wible Lake, in the northwest and southwest quarters of section 17. The color is a dark chocolate brown, the average depth 6 feet, the stripping 1 foot, and the derivation of the material mainly from the grasses and the sedges.

In the central and southwest quarter of section 19 there is an area of 70 acres underlain by peat, which, being clayey, will not average fair in quality. It has a dark chocolate brown color, an average thickness of 2½ feet, and rests upon a marl formation. The size, thickness and quality of this material makes it suitable only for using in the crude form.

In the southeast quarter of this same section and the southwest quarter of 20, are 30 acres of a dark chocolate brown peat, with an average thickness of 6 feet, and a quality ranging between fair and good. The material has been formed from the grasses and sedges, the stripping is 1½ feet, and about one-third of the deposit is above the ground-water level.

At the west and northwest part of Kendallville, in the southeast, northwest and northeast quarters of section 32, is a bed of peat, which will cover 120 acres. It will average 7 feet in thickness, ranges in color between a very dark chocolate brown and a medium chocolate brown, and in quality varies between fair and very good. About 35 acres, at the north side of the lake, is derived from the sphagnum mosses, and at present is covered by tamarack and a heavy growth of the mosses. Considerable peat moss can be obtained from this part of the deposit, as well as the green mosses for nurserymen. Most all of these 35 acres are beneath the ground-water level. The remainder of the bed is more shallow, more oxidized and of poorer quality for fuel. Its surface is said, however, to make splendid onion ground.

A poor to fair quality of peat, having a dark chocolate brown color and an average thickness of about 3 feet, is found extending westward from the west side of Long Lake, in the east central part of section 29, and the west central and northwest quarters of 28. The extent, of about 100 acres, and the average thickness, were determined by four soundings, which gave the thicknesses of 5, 6, 13 and 21 feet.

This bed, together with the one described in the preceding paragraph, would make a good location for a peat plant, there being a large amount of peat ranging between fair and good, excellent railway transportation across the beds, and a close market at Kendallville, for a large amount of the finished product.

A peat bed, derived from the sphagnum mosses, is situated in the northeast quarter of section 29 and the southeast of 20. It covers 25 acres, has an average thickness of 8 feet, is largely beneath the ground-water level, and consequently is in a very loose condition. The quality is good, and the stripping light. Some peat moss, suitable for stable litter, and green sphagnum, for nurserymen, can be obtained from this deposit.

The deposits all together about Round Lake will make about 35 acres, with a marl sub-soil, and a fair quality of material. Soundings gave thicknesses of 2, 9, 10 and 12 feet. Most all the deposit is beneath the ground-water level.

Orange Township (35 N., 10 E.).—A peat deposit of 50 acres, which is almost impracticable because of its shallowness and impure condition, is found in the central part of section 13. The thickness and quality were determined by soundings and following an open ditch.

In the northwest quarter of the same section and the southwest quarter of 12, a 20-acre deposit is located, which has a thickness of 2½ feet, and a poor to fair quality. Such a deposit can only be expected to furnish peat in the crude form.

Two miles east of Wolcottville, in the northeast quarter of section 2, is a fair bed of peat, which consists of about 150 acres. It has an average thickness of 6 feet, a color ranging from a very dark chocolate to a medium chocolate brown, and 1 foot of stripping. The material is largely derived from the grasses and the sedges. Six well distributed soundings were made, which gave the following thicknesses: 7, 9, 10, 15 and 21 feet.

A small deposit of 10 acres, with a thickness of 3 feet, a dark chocolate brown color, and a fair quality, is located in the north-central part of section 36. It will only be suitable for supplying peat in the crude form.

A deposit of similar quality and thickness is found in the northeast quarter of section 35, and the southeast of 26. It contains 25 acres, and has a dark chocolate brown color. Five soundings determined its thickness.

Several soundings in a bed of peat one-half mile north of Brimfield, in the northwest quarter of section 29, show an extent of 20 acres, and an average thickness of 4 feet. The stripping is 1½ feet, the quality of the material fair, and the color a dark chocolate brown. About one-quarter of the deposit is above the ground-water level.

About one-half mile southwest of Brimfield, in the north-central part of section 31, is a 5-acre deposit of a good quality of peat, with an average thickness of 5 feet. It is almost entirely beneath the ground-water level, and has a medium chocolate brown color.

Elkhart Township (35 N., 9 E.).—The deposits, in this township, are larger than those of Orange. Forty acres of a poor quality of peat is found in the northeast quarter of section 2. The color is a very dark chocolate brown, and the thickness 1½ feet.

A deposit similar in quality and color is found in the northeast quarter of section 4. The average thickness is 2 feet.

Underlying a tamarack marsh, in the south-central part of section 11, are 60 acres of an excellent quality of peat. The thickness of the bed, as was learned through a number of well-distributed soundings, is probably over 21 feet. The color of the material is a medium chocolate brown to a dark chocolate brown, and is almost entirely below the ground-water level. A very good quality of the peat moss occurs in the upper portion of this bed, in considerable quantity, and the upper 2 feet are, to a large extent, made up of the green mosses, which are very valuable to nurserymen. Because of the quality and amount of this material, the location for a peat plant would be very good.

In the northeast quarter of this same section, and northwest and northeast of 12, the southeast of 2 and the southwest of 1, are 500 acres of peat, which will average fair in quality. The map shows the various thicknesses of the bed. The color varies from a medium to a dark chocolate brown, and the stripping from ½ to 2 feet. Probably one-half of the deposit is beneath the ground-water level. The material has been derived largely from the grasses and the sedges, and partly from the mosses. The underlying formation varies in different portions, being sand, clay and marl. The material of this and the preceding deposit could be handled by one large peat plant, since they are within one mile of each other.

A deposit of 20 acres is found in the northeast quarter of section 33. It is of a good quality, has an average thickness of 8 feet and varies from dark to medium chocolate brown in color, has a light stripping, and is about one-quarter above the ground-water level.

A peat bed of 35 acres having an average thickness of 3 feet, and a fair quality, occurs in the northeast quarter of section 34 and the southeast quarter of 27. The color is a dark chocolate brown and the stripping 1 foot. One-half of the material is above the ground-water level, and its derivation has been largely from the grasses and the sedges. The underlying formations are marl and clay.

Perry Township (35 N., 8 E.) and Sparta Township (34 N., 8 E.).—Located partly in both of these townships is a deposit of 200 acres in the southeast quarter, central and north-central of section 10, southwest of 3, the southeast, southwest and northwest of 4 and the northeast of 5 (34 N., 8 E.); the southeast and southwest of 32, and the southeast and southwest of 31 (35 N., 8 E.). This bed is considerably cut up by the higher ground, has an average thickness of 2½ feet, and ranges between poor and fair in quality. The good quality, with the exception of the tamarack marsh in the southeast quarter of section 4 and southwest of 3, is found in section 10 (34 N., 8 E.). Here the thickness ranges between 7 and 10 feet. As one advances on westward the beds become more and more shallow, and are composed of a poor grade of material. The color of the deposits as a whole, varies between very dark and medium chocolate brown. The stripping averages about 1½ feet, and one-half of the material is above the ground-water level. The material is mainly derived from the grasses and the sedges, with the exception of the better portions, where it is derived largely from the mosses. The surface of this deposit is said to be good onion ground.

Located in both Perry and Sparta townships and also in York Township (34 N., 9 E.), is a bed in the northeast quarter of section 1 (34 N., 8 E.); northwest of 6 (34 N., 9 E.); and the southeast and southwest of 36 and the southeast and northeast of 35 (35 N., 8 E.). The area of this deposit is 250 acres, the thickness 5 feet on the average, and the stripping 1½ feet. The color is a dark chocolate brown, and the quality hardly fair, on the average. The material is derived from the grasses and the sedges, and rests upon a marl and clay formation. Some onions, which seemed to be growing well, were being raised on the decomposed surface.

Township 34 North, Ranges 8, 9, 10 and 11 East.

Sparta Township (34 N., 8 E.).—In the southwest and northwest quarters of section 1, is a peat deposit of 100 acres, which is largely covered with tamarack. The material is of fair to good quality, being derived partly from the sphagnum mosses and partly from the grasses and the sedges. The thickness of the bed, on the average, is about 7 feet. In the tamarack portion, some peat moss and green moss can be obtained. The color of the moss portion is a medium chocolate brown and the grass, a dark chocolate brown. About one-sixth of the material is above the ground-water level, and the stripping is from $1/4$ to $1\frac{1}{2}$ feet. The underlying formation is marl.

About 2 feet of a poor quality of peat, largely above ground-water level, is situated in the east-central part of section 26 and the west-central of 25. The deposit covers 40 acres, and has a very dark chocolate brown color. It is derived from the grasses and the sedges, and rests upon the marl. The surface is said to make a good onion soil.

In the southwest quarter of 26, the northwest, southwest and south-central of 35, and the northeast of 34, is a 270-acre bed of peat, having a medium to dark chocolate brown color, and a fair to good quality. The stripping is about 1 foot; one-sixth of the material is above ground-water level, and the derivation is largely from the sphagnum mosses, and somewhat from the grasses, the sedges and the weeds. The underlying formation is clay. The thickness can be seen from the map. Some peat moss for stable litter, and green moss for nurserymen can be procured from this deposit.

York Township (34 N., 9 E.).—A poor quality of material, covering an area of 350 acres, is located in the northeast quarter of section 7, southeast, northeast and northwest of 8, southeast of 6, and southwest of 5. The thickness of the bed is 3 feet, the color a very dark chocolate brown, and the derivation of the material mainly from the grasses and the sedges. Because of its shallowness, it is hardly suitable for fuel, unless used in the crude form; but for onion raising, it seems to serve very well.

A very good quality of material is found to cover about 40 acres in the northwest and southwest quarters of section 16. It is derived from the sphagnum mosses, and has a good thickness (see map). It is located beside the B. & O. Ry., and is almost entirely beneath the ground-water level, consequently it is in an undecomposed condition, yet very loose and fibrous. Sphagnum and grass now cover the surface. The color is from a light to a dark chocolate brown, and the stripping almost nothing.

In the southeast quarter of this same section a rather poor deposit of 65 acres is found. It will not average over 3 feet in thickness, has a very dark chocolate brown color, about 1 foot of stripping, and is derived from the grasses and the sedges. Probably one-tenth is above the ground-water level.

In the southeast quarter of section 4, and the northeast of 9, is a peat deposit of some 40 acres, which runs poor in quality; it has a thickness of $1\frac{1}{2}$ feet, and a dark brown color.

A fair deposit is found in a long narrow bed in the north central part of section 10, and the southeast and northeast quarters of 3, which consists of 40 acres. The color is a dark chocolate brown, and the average thickness 3 feet.

In this same section a good quality of material is found in the northeast and southeast quarters. The bed covers an area of 80 acres, is three-fifths miles long and 200 yards wide. It has a thickness, ranging between 5 and $21\frac{1}{2}$ feet (see map), is largely beneath ground-water level, and has scarcely any stripping. The color is a dark chocolate brown.

In the southeast quarter of section 10 and the northeast quarter of 15, is a 5-acre bed of fair peat, of a very dark chocolate brown color; it is 3 feet thick and has about 1 foot of stripping.

A very dark chocolate brown peat, with an average thickness of 4 feet, and an extent of 70 acres, is found in the northwest and southwest quarters of section 14. The quality is fair and the stripping about 1 foot.

In the west central part of section 21 is a huckleberry marsh, overlying a peat bed of 12 acres; it has an average thickness of 7 feet and a dark chocolate brown color. The quality of the material ranges from fair to good and the stripping is almost nothing, except for the green mosses, which are valuable for nurserymen; only one-fifteenth of the deposit is above the ground-water level. Some peat moss can be obtained from this deposit.

A bed of peat, very much interrupted by the higher ground, is located in the southeast quarter of section 19 and the southwest of 20. The extent of this bed is 35 acres and the average thickness $1\frac{1}{2}$ feet; the quality is from fair to good, and the color a dark chocolate brown. One-half of the material is above the ground-water level, and the stripping is two-thirds of a foot. The derivation is mainly from the grasses and the sedges. The shallowness makes this deposit of little economic importance, except for local use in the crude form.

A dark chocolate brown material of fair quality is found in the east central part of section 29 and the southwest quarter of 28. It covers about 25 acres, has an average thickness of 3 feet, a stripping of 1 foot, and is about one-half above the ground-water level.

Fifty acres of a fair quality of peat is situated in the southeast quarter of section 28, and the northeast of 33. The average thickness of the deposit is 10 feet, the color a dark chocolate brown, and the stripping 1 foot. One-fourth of the material is above the ground-water level, and the derivation is from the grasses and sedges.

A 20-acre bed of peat, with an average thickness of 6 feet, a stripping of 1½ feet, and a dark chocolate brown color, is in the southeast quarter of section 33 and the southwest of 34. The quality is fair, and about one-third of the material is above the ground-water level. The derivation has been largely from the grasses and the sedges.

Partly in York Township and partly in Noble (33 N., 9 E.), are 300 acres of peat in the southeast quarter of section 35, and the southwest of section 36; and the northeast, southeast and southwest quarters of section 2, and the northwest quarter of 1 (33 N., 9 E.). These beds occupy what was once the Mill Pond just south of Port Mitchell. The average thickness of the material is about 6½ feet (see map for thickness and extent), and the color is a medium to a dark chocolate brown. The stripping varies between ½ and 2 feet, and about one-third of the deposit is above the level of the ground-water. The derivation has been from the grasses, the sedges and the mosses. The beds occur in numerous pockets, which are separated by the higher ground. Considerable marl is found as an underlying formation. Large fields of peppermint are being successfully raised on the surface of this deposit, and several peppermint distilleries are located in the vicinity. The deposit, because of its size, amount and quality of peat, will be a good location for a peat plant, when the railroad transportation becomes better.

A deposit which occupies the northeast quarter of section 25 (34 N., 9 E.), and the northwest quarter of 30 (34 N., 10 E.), is found partly in York Township and partly in Jefferson. This deposit occupies 12 acres, has a dark chocolate brown color, and an average thickness of 5 feet. The quality is hardly fair, the stripping 1 foot, and about one-third of the material is above the ground-water level. The derivation has been from the grasses and the sedges.

Also in both of these townships is a bed in the east central part of section 36 (34 N., 9 E.), and the west central of 31 (34 N., 10 E.), which consists of 50 acres. The color is a dark chocolate brown, the average thickness about 7 feet, and the quality hardly fair. The stripping is 1 foot, and the derivation has been from the grasses and the sedges.

Jefferson Township (34 N., 10 E.).—In the central and west-central portions of section 8 in this township, are 35 acres of a dark chocolate brown peat of fair quality; it has an average thickness of 6 feet and a stripping of ½ to 1 foot. About one-half of the material is above the level of the ground-water.

Six acres of a fair quality of peat, that might be used in the crude condition, are situated in the southeast quarter of section 5. Another small deposit of 10 acres is located in the south-central part of 4. The bed has an average thickness of 3 feet, a medium chocolate brown color, and ranges in quality between fair and good. It has 1½ feet of stripping, and is one-half above the ground-water level.

A deposit of peat in the northwest quarter of section 15 has an average thickness of 5 feet, a dark chocolate brown color, and contains 30 acres. The material is from fair to good in quality and rests upon the marl; it has a stripping of ½ foot, and is about one-half above the level of the ground-water.

Extending south from Sackrider's Lake, through the central part of section 1, is a peat bed of 50 acres, which is poor in quality and has an average thickness of 3 feet; a very dark chocolate brown color, and a stripping of 1 foot. It will be suitable for local use, only, and in the crude condition.

In the northeast quarter of section 14 is a 10-acre bed of peat, with a dark chocolate brown color, a thickness of 3 feet, and of a poor quality.

In the southwest quarter of this same section are sixty-five acres of peat having an average thickness of 7 feet, a very dark chocolate brown color, a stripping of 1 foot, and a quality ranging from poor to fair.

In the southeast and northeast quarters of section 23, is a 70-acre deposit of peat, which is hardly fair in quality, has an average thickness of 2 feet, and a very dark chocolate brown color.

A good quality of peat is found in the northwest and southwest quarters of section 26. The bed covers 45 acres and has a good thickness (see map). The material varies in color from a medium to a dark chocolate brown, and is about one-third above the level of the ground-water.

Allen Township (34 N., 11 E.).—A large workable deposit of fair quality is found in the northwest and northeast quarters of section 17. The extent is 170 acres, and the thickness is fair (see map). The color is a dark chocolate brown, and the stripping 1½ feet. About two-thirds of the material is above the ground-water level.

Around the south side of Bixler Lake in the northwest quarter of section 3, is a peat bed of 50 acres, with an average thickness of 6 feet, a fair to good quality, a dark chocolate brown color, and a light stripping. Most of the deposit is beneath the level of the ground-water.

TOWNSHIP 33 NORTH. RANGES 8, 9, 10 AND 11 EAST.

Swan Township (33 N., 11 E.).—In the southwest quarter of section 24 are 35 acres of peat, with a good thickness (see map) and quality. This occurence is in a tamarack marsh, and the material is largely beneath the ground-water level. The color is a medium to dark chocolate brown, and the stripping is very light.

Another deposit, in a tamarack marsh, is located partly in the southwest quarter of this same section and the southeast quarter of section 23. It consists of 20 acres, is of a good quality, has an average thickness of 5½ feet, and a medium to dark chocolate brown color. The stripping is light, and about one-half of the bed is above the ground-water level.

A small tamarack marsh in the southwest quarter of section 26 is underlain by a good quality of peat, which covers about 15 acres. This bed has a good thickness (see map), a dark chocolate brown color, a very light stripping, and is about one-third above the ground-water level.

Interrupted by high ground and impure peat deposits, are 100 acres of a fair quality of material in each quarter of section 27. This deposit has a fair thickness (see map), a light stripping, and is about one-half above the level of the ground-water.

A material, similar in quality, is found in the northeast quarter of section 20. The bed consists of 40 acres, is underlain by clay, has a dark chocolate brown color and an average depth of 4 feet.

A poor quality of peat is found in a 50-acre deposit in the northeast quarter of section 19. It also rests on the clay, has a very dark chocolate brown color, and a thickness of 2 feet.

The best deposit of Swan Township is found about Rudy and Mud Lakes in the west half of section 18, and the southwest quarter of section 7. One hundred acres are occupied by this deposit. Its color is a dark chocolate brown, and the quality* of the material and the thickness (see map) are good. The stripping is about 1 foot, and one-half of the bed is above the ground-water level.

Noble and Green Townships (33 N., 9 and 10 E.).—The only de-

*See page 84.

posit worthy of mention in Green Township (33 N., 10 E.), is found in the west-central part of section 6, and the east-central part of section 1 (33 N., 9 E.) Noble Township. The extent is 40 acres, and the average thickness 7 feet. The color is a dark chocolate brown, and the quality fair. One-third of the bed is above the level of the ground-water, and the stripping is 1 foot. The material is derived largely from the grasses and the sedges.

Noble Township (33 N., 9 E.).—For extent and quality of peat deposits this civil township is nearly equal to all the others of this county combined, and is one of the very first in the State. Several good locations can be found for large peat plants, as soon as steam railroads or interurban railroads are built in the vicinity.

A peat bed largely formed from the sphagnum mosses Nos. 1 and 2, and still in the process of formation, lies in the northwest quarter of section 3. It is almost entirely beneath the ground-water level; it consists of 35 acres, and is of a very good quality. The thickness is 13 feet, the stripping nothing, and the color a light to medium chocolate brown. The upper 3 or 4 feet of this bed will make an excellent quality of stable litter. The material, not having been exposed to the oxygen of the air, is in a very fresh condition, but its apparent amount will greatly decrease upon drainage.

In the central part and northwest quarter of section 24, the northeast of 23, the south-central and southwest of 14, the northwest of 23 and the northeast and central of 22, is a peat deposit, with an extent of 250 acres, a good average thickness (see map), a dark chocolate brown color, and a fair quality. The stripping is 1 foot, and about one-half of the material is above the level of the ground-water. The derivation is largely from the grasses and the sedges. Because of the nearness of this deposit and the one mentioned in the preceding paragraph, a good location for a peat plant could be found in this vicinity, when transportation facilities become better.

Beds of peat, 4 to 10 acres in extent, aggregating 110 acres, are found, separated by narrow strips of higher ground, in the northwest and northeast quarters of section 10, the northwest of 11, and the southwest of 3. The average thickness is about 5½ feet, as was learned by a number of soundings, but the variation is large. Close to the lakes, the marl comes almost to the surface and not until one gets 150 yards away from the edges of these lakes is the peat of workable depth. The color of the material is a dark chocolate brown, and the derivation has been from the mosses, grasses and the sedges. At present the bed is covered with grass, except for portions, which are so decomposed at the surface, that peppermint is being very successfully grown. Two peppermint distilleries are found in the neighborhood. The stripping is from 1/4 to 1 1/2 feet, and about one-third of the deposit is above the ground-water level.

Around a small lake, three-quarters of a mile northeast of the village of Wolf Lake, in the southeast quarter of section 4, are 50 acres of a fair quality of peat, which has a dark chocolate brown color, an average thickness of 4 feet, and a stripping of 1 foot. The derivation of the material has been largely from the grasses and the sedges, and about one-half is above the level of the ground-water. The peat formation does not begin, with a workable thickness, until a distance of over 100 yards from the lake is reached; marl is the underlying formation of the lake and shore.

A tamarack marsh, underlain by a 25-acre bed of peat, of good quality, is situated in the northwest quarter of section 3. The material is derived from the sphagnum mosses, has a dark chocolate brown color, an average thickness of 16 feet, and a stripping of 1/2 foot. About one-quarter of the material is above the ground-water level. The upper part of the bed is composed largely of the foliage of the tamarack trees, and logs and roots are quite numerous throughout, making it very difficult to get the sounding auger down.

In the east central part of section 9, and the west central and the southwest quarter of 10, is a fair to good peat deposit of 75 acres, having a dark chocolate brown color, an average thickness of 5 feet and a stripping of 1 1/2 feet. The derivation of the material is largely from the grasses and the sedges, and about one-third is above the ground-water level.

About 50 acres of a fair quality of peat is found in the central and south central portions of section 9. The color is a dark chocolate brown, the average thickness 3 feet, and the stripping 1 1/2 feet. About one-half of the deposit is above the level of the ground-water.

Connecting with this deposit at the south, is a bed of 250 acres of a fair to good quality of peat, in the northeast, northwest and southeast quarters of section 16, and the west half of 15. The average thickness is good (see map), and the stripping from 1/2 to 2 feet. The material is derived from the mosses, the grasses and sedges, and is one-third above ground-water level. The color is a dark chocolate brown. As far as extent, depth and quality is concerned, this would be a good deposit for a large peat plant.

One hundred acres of a dark chocolate brown peat, with a fair to good quality, is located in the southeast quarter of section 17, and the northeast of 20 and the northwest of 21. The thickness is good (see map), the stripping is $1\frac{1}{2}$ feet, and about one-third of the material is above the ground-water level. Like most of the deposits of this civil township, the bed is more or less broken by high ground.

Extending west and southeast from Wolf Lake is a 45-acre bed of peat, covered more or less with tamarack. Four well distributed soundings showed an average thickness of 5 feet, a stripping of $\frac{1}{2}$ of a foot, a medium chocolate brown color, and a derivation mainly from the mosses. The material is from fair to good in quality, and about one-sixth is above the level of the ground-water. The underlying formation is marl and sand, and the peat frequently blends into a sandy material, and finally into pure sand.

A good quality of peat moss, covering $3\frac{1}{2}$ acres, is found on the place of S. Phillips in the northeast part of the southeast quarter of section 20. The material has a medium chocolate brown color, is very fibrous, and is covered with tamarack trees, huckleberry and blackberry bushes. About one-fifth of it is above the ground-water level. A section from the top down shows: (a) Very fibrous and slightly decayed sphagnum mosses Nos. 1 and 2, with a light choco-

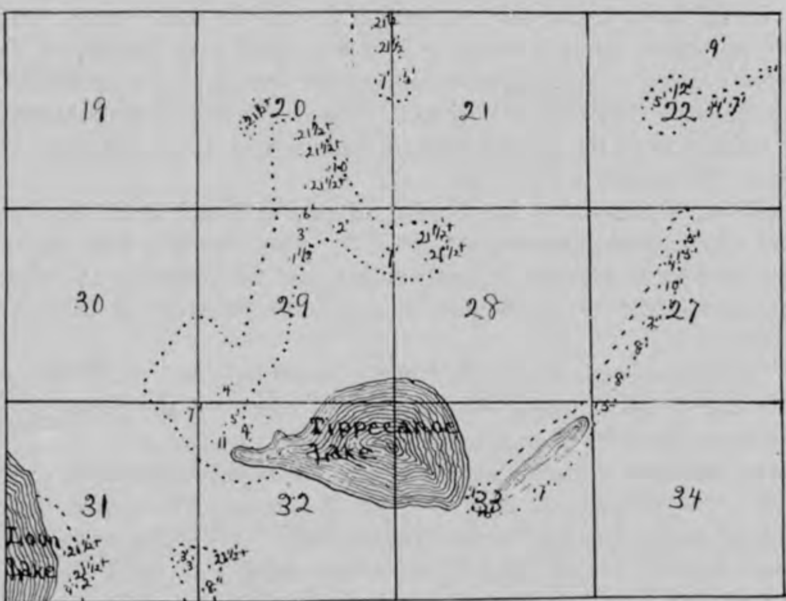


Fig. 3. Showing the thicknesses, where soundings were made, of peat beds in the southwestern part of Noble township, Noble County.

late brown to a light green color, 5 feet; (b) A medium chocolate brown moss, less fibrous and somewhat more decomposed, 5 feet; (c) A fine fibered peat, with a higher fuel value than the overlying portions, because of its more advanced decomposition beneath the ground-water level, 11½ feet.

Probably the best deposit of the county is found in the central and south-central part of section 20, the northeast of 29, and the northwest of 28. This bed consists of 250 acres, covered to a considerable extent by tamarack. The deposit has an excellent thickness (see map), a medium to dark chocolate brown color, and a light stripping. It rests upon a marl or sand bottom and is probably one-third above the ground-water level. The quality* of the peat is excellent. Also about 100 acres of a good quality of peat moss is present. Beneath the peat moss, which varies from 3 to 7 feet in depth, the coarse fiber gives way to a finer, of 5 feet in thickness; and so it continues with a greater depth, until an almost non-fibrous form is reached, which has a thickness of 11 feet, and is one of the best qualities of peat fuel. The best quality of peat and peat moss is enclosed by the dotted lines in the diagram.

Extending west and northwest from the west end of Tippecanoe Lake, is a peat bed of 80 acres, which is much interrupted by the higher land. A number of soundings show the material to have an average thickness of about 5 feet, ½ to 1 foot of stripping, a marl and clay sub-stratum, and a dark chocolate brown color. The quality ranges between fair and good, and one-third of the deposit is above the ground-water level. Some fair crops of onions are raised on the most decomposed portions.

South of Bear Lake in the southwest quarter of section 17, is a 50-acre bed of peat, with an average thickness of 6 feet, a fair to good quality, a medium to dark chocolate brown color, and a stripping of 1 foot. It occurs mostly in pockets separated largely by the higher ground. About one-third of the material is above the level of the ground-water, and the derivation is mainly from the grasses and the sedges. The underlying formation is, to a considerable extent, marl.

A 150-acre deposit of peat in the west half of section 27, the northeast quarter of 33, and the northwest of 34, possesses a good thickness (see map) and a fair quality. The color is a dark chocolate brown, the stripping 1 foot, and the derivation, largely from the grasses and the sedges. About one-quarter of the material is above the ground-water level.

*See page 84

A deposit, which extends south into Whitley County, is found in the southeast quarter of section 31 and the southwest of 32. The extent is 100 acres, the color a medium to a dark chocolate brown, and the quality fair to good. The bed has a good thickness (see map), a stripping of ½ foot, and is one-half above the level of the ground-water. It is covered by tamarack, and is derived from the sphagnum mosses. The sub-strata are marl and clay.

In the southwest quarter of section 31 are 70 acres of peat, ranging between fair and good in quality. The color is a dark chocolate brown, the thickness is good (see map), and the stripping light. About one-quarter of the material is above the ground-water level, and its underlying formation is marl. Onions, which are grown on the surface, are said to thrive well.

Washington Township (33 N., 8 E.).—This township also ranks well in the county, in its amount of peat, but cannot compare with Noble Township. Two hundred acres of a dark chocolate brown to almost a black peat is found in the north-central, central and south-central parts of section 10; the northeast and southeast quarters of 15, the northeast of 22, and the southwest of 14. The average thickness of the northern 60 acres is 6 feet, and of the remainder, 2½ feet. The quality ranges from fair in the deeper portions to poor in the more shallow. The stripping is 1½ feet, and about three-quarters of the material is above the level of the ground-water. Its derivation is largely from the grasses and the sedges. The decomposed surface is said to be good onion soil.

Twenty acres of a fair deposit of peat, with an average thickness of 3½ feet and a medium chocolate brown color, is located in the northeast quarter of section 9. The stripping is 1 foot, and one-half of the material is above the ground-water level.

In the central and south-central part of section 2 is a 35-acre bed of peat, with an average thickness of 5 feet and a dark chocolate brown color. The quality is fair, the stripping is 1 foot, and two-thirds of the material is above the ground-water level. The surface is said to be a good onion soil.

Partly in Washington and partly in Noble Townships are some large deposits, covering 350 acres, in the central, south-central, southeast and southwest quarters of section 7, and the north-central, east-central and southeast quarter of 18 (33 N., 9 E.), and the northeast of 13 and southeast of 12 (33 N., 8 E.). The thickness is about the average (see map), and the stripping 1 foot. The quality is good and the color is a medium chocolate brown. The material has been derived from the mosses, the grasses and sedges.

and is about one-half above the ground-water level. The underlying formation is largely marl. A number of acres of onions were raised immediately west of the north portion of Bear Lake. These were said to be doing well, and were planted on the surface of the muck, which was from 1½ to 2½ feet thick, with an underlying formation of marl.

Another deposit, which will probably cover 300 acres, but is much broken by high ground, is found in the northeast, northwest, southeast, and southwest quarters of section 16 (33 N., 8 E.). The

Fig. 3a. Showing the thicknesses, where soundings were made, of peat beds in the northwestern part of Noble and the eastern-central part of Washington townships, Noble county.

thickness is good (see map), and the quality ranges between fair and good. The color is from a medium to a dark chocolate brown, and the stripping from ½ to 1½ feet. The derivation of probably half of the material has been from the mosses, and the other half from the grasses and sedges. A large part of the underlying formation is marl. Parts of the surface are said to be good onion ground.

A 10-acre deposit, of fair quality, with an average thickness of 4 feet, is located in the southwest quarter of section 3. It has a stripping of 1 foot, is one-third above the ground-water level, and is covered with grass.

In the northeast quarter of section 4, is a 20-acre deposit, with a very dark chocolate brown color, an average thickness of 5 feet, and a fair quality. One-third of the material is above the ground-water level, and the stripping is 1 foot.

Seventy acres, very much broken by higher ground and lakes, are situated in the northwest, northeast and southeast quarters of section 5, and the northwest of 4. The quality of the material is poor, the average thickness 2 feet and the stripping 1 foot. About one-half of the deposit is above the level of the ground-water and its derivation is from the grasses and the sedges. A very singular phenomenon is found in this bed at the extreme east-central part of section 5. A mound, 50 feet long, 30 feet wide and 8 feet high, composed of peat, rises above the adjacent region, where the peat is only 2 feet thick. This bed is very wet, small pools of water being near its summit the year around, while the adjacent peat beds are not moist in the drier weather, and can be used for a pasture almost the entire year. The formation of this mound has been brought about by its more favorable location for the growing and partial decaying of vegetation in the presence of water; this permitted a greater accumulation than took place in the adjacent beds. Such hummocks are said to be common in Newfoundland. As the vegetation accumulates, the imporous texture will not permit a draining off of the water, and somewhat similar conditions are produced which are present when the vegetation gets beneath the water-level. The carbon gases are largely retained after the decomposition in the presence of the water, and the accumulation takes place.

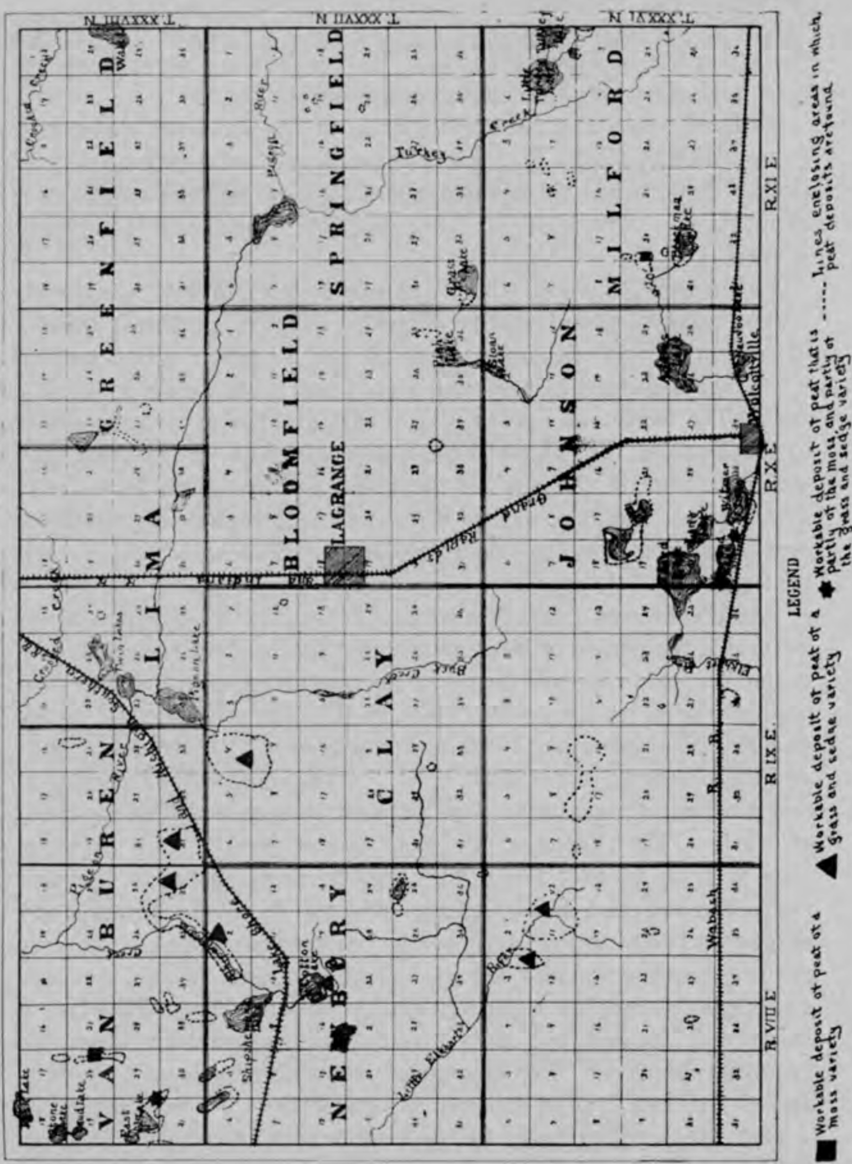
In addition to the peat beds of this county, described in this report, there are numerous smaller ones, which contain good deposits of peat. Many of these deposits are derived from the sphagnum mosses, and contain a good quality of peat moss litter, and green mosses, as well as peat. Although these smaller deposits cannot furnish a sufficient amount of peat for putting in a small peat plant, yet they can be utilized, in a very practicable way, by spading out the peat, drying it in the atmosphere, and then putting it under shelter in the crude condition. In this form, the moss peat is a better fuel than wood, and much cheaper and cleaner than coal.

LAGRANGE COUNTY.

Lying immediately west of Steuben County, and along the Michigan and Indiana border, is the county of Lagrange. As a peat county, it ranks between the medium and good, having a less amount than Steuben, and more than Dekalb. The material is three-quarters of the grass and sedge variety, which makes its quality, as a whole, less desirable than that of Steuben County.

As in Steuben and Dekalb Counties, the most characteristic topographical position of the peat deposits of this county is that of the old glacial lake basin.

LAGRANGE COUNTY.



PART OF TOWNSHIP 38 NORTH, RANGES 8, 9, 10 AND 11 EAST.

Lima and Greenfield Townships (38 N., 9, 10 and 11 E.).—Occupying about 40 acres in the southwest quarter of section 22, the northwest and southwest of 27 and the southeast of 28 (38 N., 10 E.), is a poor to fair peat bed. The depth will average 11 feet, and the stripping is about 1½ feet. The underlying formations are marl and clay, and the color is almost black.

Situated beneath a tamarack marsh, in the southeast quarter of section 27 (38 N., 10 E.), is a 10-acre deposit of a fair quality of peat. The average thickness is about 12 feet, and the stripping is about 2 feet. The color is a dark chocolate brown, and the sub-soil is marl.

Van Buren Township (38 N., 8 and 9 E.).—A bed, containing from a poor to a good quality of peat, lies in the northeast quarter of section 21 and the southeast of 16 (38 N., 9 E.). It covers 60 acres, has a good thickness (see map), and a stripping of ¾ of a foot. The depth and best quality of material lies toward the center of the deposit. The material has a dark chocolate brown color, and is mostly beneath the level of the ground-water. This leaves it in a very loose condition, so that drainage would so decrease the thickness of the bed, that the amount would be sufficient only for a small peat plant.

Van Buren and Clay Townships (37 and 38 N., 8 and 9 E.)—Several large bodies of peat, which are almost closely enough connected to form one, are found in the southwest quarter of section 25, and the northeast of 36 (38 N., 8 E.); the south-central of 30, and the northwest, southwest and southeast of 31 (38 N., 9 E.); and the northeast of 6 (37 N., 9 E.). These beds extend northwest and southeast for two miles, and have an average width of one-third of a mile. The thickness (see map) varies greatly, and the stripping is from ¼ to 2 feet. The quality ranges between fair and poor, the material being largely derived from the grasses and sedges, and there being considerable oxidation and sand in the more shallow portions. The color is a dark chocolate brown, and the underlying formation is largely sand, but some clay. This bed is fairly well drained, and fully 6 feet of the material are above the ground-water level. For amount of material, this deposit ranks as one of the very first of the county, and affords a fair location for a peat plant. The Lake Shore & Michigan Southern Railroad passes across the southern portion.

Van Buren and Newbury Townships (37 and 38 N., 8 E.)—Fol-

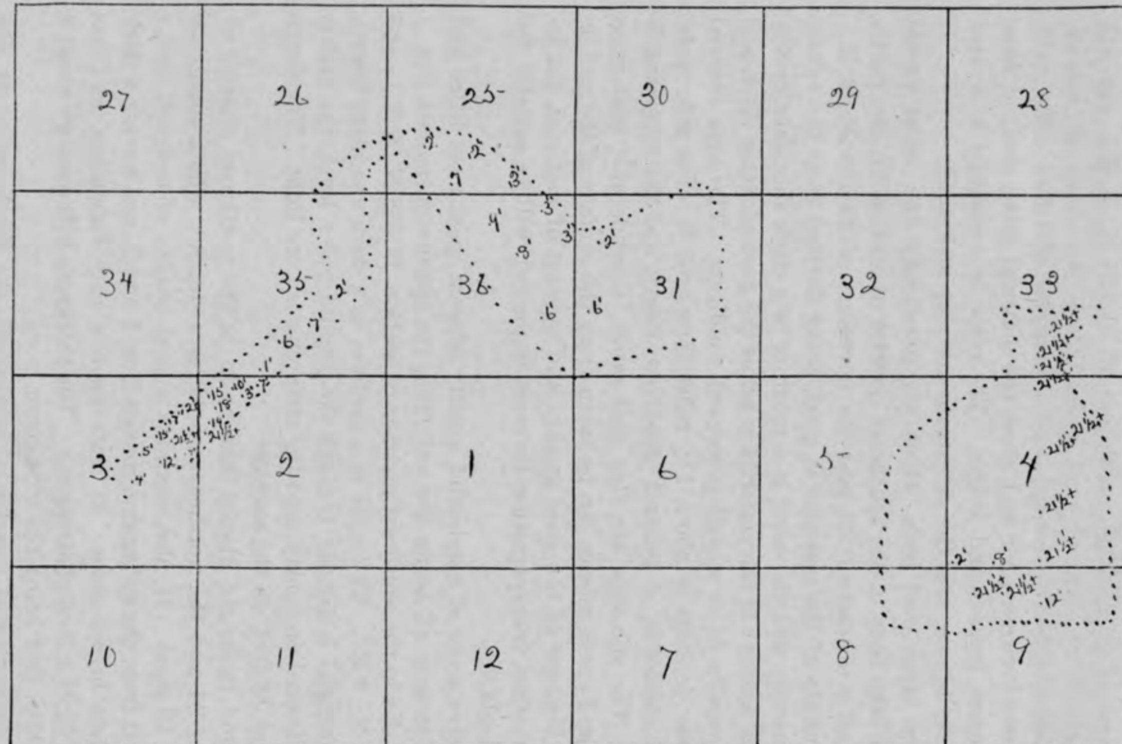


Fig. 4. Showing thicknesses, where soundings were made, of peat beds in the northwestern part of Clay, the northeastern part of Newbury and the south-central and southeastern parts of Van Buren townships, Lagrange County.

lowing a dredge ditch for two miles, in the southeast and northeast quarters of section 3, and the northwest of 2 (37 N., 8 E.); and the southwest, southeast and northeast of 35, the southeast of 26, the southwest of 25 and the northwest of 36 (38 N., 8 E.), one will cross about 80 acres of peat beds. These will have an average thickness of 7 feet (see map), and a stripping of 1 foot. The quality varies between poor and good, the material being derived from the mosses, grasses and sedges. The color is a medium to a dark chocolate brown, and the sub-strata are clay and sand.

Three large peat beds, which are practically one, occur in old glacial lake beds in the southeast quarter of section 17, the northeast and southeast of 20, and the northeast of 29 (38 N., 8 E.). The quality of the material is good, being derived from the sphagnum mosses, and the color is a medium to a dark chocolate brown. A large amount of the material is below the ground-water level, and consequently is in a well preserved condition. The area covered by these deposits is about 1¼ miles long and ⅛ of a mile wide. The thickness is, in general, good (see map), and the stripping is light. The sub-soils are clay and sand. Considerable peat moss litter and green mosses can be taken from the surface of the middle bed. Because of the good quality and amount of material, the location, when transportation becomes improved, will be suitable for a peat plant.

Twelve acres of a splendid quality of peat, peat moss litter and green mosses, all being derived from the sphagnum mosses Nos. 1 and 2, lie in the southeast quarter of section 33 (38 N., 8 E.); and 4 (37 N., 8 E.). The color is a medium to a dark chocolate brown. The material is largely beneath the ground-water level, the underlying formation is clay, and the stripping is very light. The depth is about 13 feet, on the average.

Found in an old glacial lake basin in the northwest quarter of section 34 and the northeast of 33, is a deposit, which comprises about 19 acres. It, also, contains a good quality of material, being derived from the sphagnum mosses Nos. 1 and 2, and having a dark chocolate brown color. It rests upon a clay formation, and has about ¾ of a foot of stripping. The thickness will average about 8 feet, 21½ feet being the maximum.

In the southeast quarter of section 30, the northeast of 31, the southwest of 29 and the northwest of 32, extending southeast from East Lake, is a peat bed, with a length of four-fifths of a mile, and an average width of one-tenth of a mile. The quality varies between fair and good, and the derivation has been from the mosses, grasses and sedges. The average thickness is about 6 feet (see map), and the stripping 1 foot. Most of the deposit is below the level of the ground-water, and it has a dark chocolate brown color. The amount and quality of the material might justify the erection of a small peat plant. About 25 acres of this bed, which are one-eighth of a mile from the lake, are covered with tamarack, considerable peat moss litter and green moss, all of which are of economic importance. Here, the thickness is 17 to 21½ feet; but as one draws nearer the lake the thickness rapidly decreases, and the material is more or less mixed with the marl, which underlies East Lake and the peat deposit near the lake.

This congressional township (38 N., 8 E.), ranks as first of the county for quality of material. Its peat, peat moss litter and green moss beds, which have not been mentioned in this report, because of their limited area, are numerous.

Township 37 North, Ranges 8, 9, 10 and 11 East.

Newbury Township (37 N., 8 E.).—An inferior quality of peat will cover about 50 acres of surface around Cass Lake, in the eastern half of section 6 and the western of 5 (37 N., 8 E.). The thickness of this bed will not average more than 2½ feet, the stripping is 1½ feet, and the color is a very dark chocolate brown. Marl is the main sub-soil.

One mile east of this deposit, in the eastern half of section 5, and extending southeast from Mud Lake, is a tamarack and huckleberry marsh, underlain by a deep (see map) bed of peat. The extent is about 25 acres, and the quality very good, the derivation being largely from the sphagnum mosses Nos. 1 and 2, and the material being beneath the ground-water level. The color ranges between a medium and a dark chocolate brown, and the stripping is almost nothing, if the green mosses and peat moss litter, which occupy the upper 4 feet of the bed, are taken into consideration. The deposit underlying this peat bed is marl.

Around the eastern side of Cotton Lake in the northwest quarter of section 15, are 100 acres of a good quality of peat, which is derived, to a great extent, from the sphagnum mosses. The thickness of the material is good (see map), and the stripping light. Probably one-third is above the level of the ground-water. The color is a medium chocolate brown, and the substratum is marl. With the Lake Shore & Michigan Southern Railroad, passing east and west, 1 mile north, the good quality of the material and the fair extent, this bed makes a fair location for a peat plant.

In the southeast quarter of this same section are 40 acres of a rather poor and shallow bed of peat. It has a dark chocolate brown color, and a rather heavy stripping.

A 15-acre peat deposit lies in the northeast quarter of section 26 and the northwest of 25. The material has an average thickness of 4 feet, a light stripping, and is largely above the ground-water level. The color is a dark chocolate brown, and the quality is from fair to good.

Around a small glacial lake in the northeast quarter of section 25, is a 30-acre bed of peat, which varies between fair and good in quality. The thickness will average 7 feet, and the stripping is very light, most of the material being beneath the level of the ground-water. This causes it to be very loose and unoxidized in the atmosphere. The color is a dark chocolate brown.

A bed of eight acres occurs in the southeast quarter of section 36 and northeast of 1. The quality of the material is fair, and the thickness from 3 to 21½ feet, with an average of about 4 feet. Another small deposit is found in the southwest quarter of section 28 (37 N., 9 E.). Its extent is 10 acres, and the average thickness is 1½ feet. This bed is thoroughly drained, and is becoming rapidly oxidized and mingled with the underlying clay formation.

Clay Township (37 N., 9 E.).—At the site of an old glacial lake in each of the quarters of section 4, the southeast of 5, the northeast of 8, and the northern half of 9, are 250 acres of peat, which will average good* in quality. The thickness is good (see map), the material is mostly beneath ground-water level, and the stripping is light. The material becomes mingled with the clay, and is frequently interrupted by the high ground. At the south end of the deposit, the peat beds have extended upon the hillsides, so that portions of them, having a thickness of 21½ feet, are 15 feet above the general level of the remainder of the deposit. In such parts, drainage would be very feasible. The bed, as a whole, has a dark chocolate brown color, and about an average stripping.

Bloomfield Township (37 N., 10 E.).—A fair to good quality of peat occurs in the southeast quarter of section 28, the southwest of 27, the northwest of 34 and the northeast of 33. The derivation is from the sphagnum mosses, the grasses and the sedges, and the color is a dark chocolate brown. The average thickness is about 7 feet, the stripping 1 foot and area covered, about 10 acres.

In a number of rather small beds in the south-central part of section 25 and the north-central of 36, are about 35 acres of a fair

*See page 84.

to good quality of peat. The stripping is about 1 foot. The thickness varies between 4 and 21½ feet, and the color is a medium to a dark chocolate brown.

Springfield Township (37 N., 11 E.).—Resting upon a bed of marl, is a peat deposit in the southwest quarter of section 31. The quality of the material is fair, being derived largely from the grasses and sedges, and having a dark chocolate brown color. The average thickness of the material is 2½ feet, the stripping about 1 foot, and the extent is 35 acres.

There are 1½ acres of a good quality of peat in the northwest quarter of section 23. The material has a dark chocolate brown color, and a good thickness.

Twenty-five acres of a medium to a dark chocolate brown material is located in an old glacial lake basin in the northwest quarter of section 14. This material occurs in 3 deposits, separated by the higher ground. The quality is good, being derived from the sphagnum mosses, grasses and sedges. The thickness is good (see map); the stripping will average 1 foot, and the sub-soil is largely marl.

TOWNSHIP 36 NORTH, RANGES 8, 9, 10 AND 11 EAST.

Milford Township (36 N., 11 E.).—Seven soundings were made, by the writer, in a little marsh, east of Stroh in the north-central part of section 13. These showed an area of three acres, an average thickness of 10 feet, and a good quality of material. The underlying bed is marl, and the stripping is light. The color is a dark chocolate brown. The deposit is almost entirely beneath the ground-water level, and seems to be floating in an underground extension of the small lake, which bounds it on the north and west.

On the farm of W. M. Goodsell, in the southwest quarter of section 3, and the northwest of 10, is a peat bed containing 15 acres of a dark chocolate brown material. The quality is good, the material being derived largely from the sphagnum mosses. The thickness is above the average (see map), the stripping is very light, and the sub-stratum is clay. The upper 3 or 4 feet of this bed are composed of peat moss litter and green mosses.

In the northwest quarter of section 10 and the northeast of 9, on the place owned by Andrew Forrest, is a fair to good quality of peat, in a deposit, covering 5 acres. It has a dark chocolate brown color, an average thickness of 12 feet and 1 foot of stripping. The sub-stratum is clay. From 3 to 5 feet of green moss and peat moss litter are found in a huckleberry marsh in the central part of section 9. The quality is good, being largely beneath the level of the ground-water and consequently in a very fresh condition. The deposit covers an area of 10 acres.

In the south-central portion of this same section, where an old lake once existed, a 20-acre bed of peat was determined by eight well distributed soundings. These showed a thickness ranging between 10 and 21½ feet, a stripping of 1½ feet, and a dark chocolate brown color. The quality is from fair to good, the material originating from the sphagnum mosses, grasses and sedges.

Combining all of the deposits of sections 9, 10 and 3 (36 N., 11 E.), enough material can be procured to furnish a small peat plant. No two of these deposits are farther apart than 2 miles, and the quality of all is largely good.

Very small deposits are found about Pretty, Long, McClish, Turkey, and Little Turkey Lakes, and the Lake of the Woods. The quality of the material found in them ranges from poor to good, being derived from the sphagnum mosses, the grasses and sedges. All will furnish fuel in the crude form, but none are large enough for even a small peat plant.

A tamarack marsh, containing a bed of peat of 30 acres, lies in the extreme northwest corner of section 20. The material is of a good quality, being formed from the sphagnum mosses Nos. 1 and 2, and largely beneath the ground-water level. The color is a medium chocolate brown, and the stripping light. The thickness will average about 11 feet, as was learned through several well distributed tests.

Covering an area of 160 acres and occupying an old glacial lake basin, is a peat bed, surrounding Mud Lake, in the east-central part of section 20 and the west-central of 19. It is largely beneath the ground-water level and is derived, to a great extent, from sphagnum mosses, thus being of good quality. The stripping is about 1 foot, and the thickness is good (see map). For size of bed, and amount of material this bed would be a fair location for a peat plant. Probably 100 more acres, which occur within one-half a mile of this deposit, could be utilized by the same plant.

One of these other deposits is found just southeast of the center of section 19. It contains 20 acres, and has a thickness, as was learned through several soundings, ranging between 4 and 21½ feet, the average probably being about 6 feet. The quality is good, being derived mainly from the sphagnum mosses. The color is a medium to a dark chocolate brown, and the stripping very light. Some peat moss litter and green moss can be obtained from this deposit.

A similar deposit for quality, color and derivation, occurs in the southwest quarter of this same section. The extent is 10 acres, and the average thickness about 4 feet. A considerable amount of this deposit is a peat moss litter and a green moss, both of which are valuable; the former for a stable litter, and the second for packing roots and trees in nurseries.

Another of these smaller deposits, which could be obtained by a peat plant near Mud Lake, lies in the southwest quarter of section 20. It consists of 15 acres, has a thickness ranging between 3 and 13 feet, and a stripping of 1 foot. The color is a dark chocolate brown, and the quality rather inferior, there being more or less clay associated with it.

About Blackman Lake, in the northeast quarter of section 30 and the northwest of 29, are several beds of a material, which will average about 5½ feet in thickness. They occur in long and narrow marshes, and will, altogether, cover about 60 acres. The material is fair to good in quality, being derived from the sphagnum mosses, grasses and sedges. The stripping is light and the deposit is mostly beneath the level of the ground-water. The color is a medium to a dark chocolate brown.

Johnson Township (36 N., 10 E.).—Along the nothern shore of Nauvoo Lake, in the south-central part of section 35, is located a 50-acre bed of peat, which rests upon a marl subsoil and has a medium to a dark chocolate brown color. The material is of good quality, being largely beneath the ground-water level, and originating, to a considerable extent, from the sphagnum mosses, grasses and sedges. The stripping is 1½ feet.

On the north side of Witmer Lake, in the northwest quarter of section 33 and the northeast of 32, are several peat beds, which will cover an area of 100 acres. These beds are too shallow, for any other use than in the crude condition, the average thickness being only 1½ feet. The color is a dark chocolate brown.

Ten well distributed soundings, in the southern half of section 32, and the southeast of 31, show the deposits bordering the south side of Witmer and Atwood Lakes to be more extensive, of better quality and deeper than those on the north side of the former lake. The area covered is about 200 acres, and the quality of the material is from fair to good, it originating from the sphagnum mosses, grasses and sedges. The thickness varies between 3 and 21½ feet, and will average 5½ feet. The stripping is about 1 foot, and the underlying stratum is marl. That portion of the deposit is found between Atwood and Witmer Lakes. Here, the material runs the thickest and is beneath the ground-water level, thus being in a fresh condition. Sufficient material can be obtained at this place to warrant the installation of a peat plant.

A peat bed lies in the northwest quarter of section 21, of about 20 acres, which has formed a surface over what was once the extension of a small lake. This leaves the material in a very loose and floating condition. Its quality is fair to good, and the color is a medium chocolate brown. The average thickness is 21½ feet, and the underlying formations are sand and marl.

Connecting up with this deposit is one extending east from Olin Lake, in the northeast quarter of section 20 and the northwest of 21. The area covered by this bed is 60 acres, and the thickness ranges between 3 and 21½ feet, with 5½ feet as an average. The quality of the material is from fair to good, and the color is a medium chocolate brown. The underlying bed is marl. Information regarding this deposit was gained through four well distributed soundings.

Lying largely beneath the ground-water level and in a very loose condition, are some peat beds, more or less connected, in the southeast quarter of section 18, the northeast of 19 and the southwest of 20. These beds almost surround Oliver Lake, and cover about 200 acres. Seven soundings made over the area, gives thicknesses of 2, 2½, 4, 5, 6, 8 and 10 feet. Probably 3½ feet would be an average. The quality is from fair to good, being derived from the sphagnum mosses, grasses and sedges. The color of the material is a medium chocolate brown, and the stripping is light. Marl forms the sub-stratum.

Along Elkhart River in the northwest quarter of section 19 (36 N., 10 E.), is a fair bed of peat, with a thickness varying between 3 and 12 feet, and a length of ½ of a mile and a width of ⅛ of a mile. The color of the material is a dark chocolate brown, the stripping 1½ feet and the sub-soil largely marl.

Clear Spring and Johnson Townships (36 N., 9 and 10 E.).—Along the north side of Third and Dallas Lakes, in the central and southeast quarter of section 24 (36 N., 9 E.), and the south-central and southwest quarter of section 19 (36 N., 10 E.), are fully 1,000 acres of a poor quality of peat, which will not average more than 1 foot in thickness. It is clayey and much oxidized, and is only suitable for use in the crude condition. The color is a very dark chocolate brown, and the underlying formations are marl, clay and sand.

Occupying the location of an old glacial lake basin, on the places of J. Hill and neighbors, in the southwest quarter of section 2, and the southeast of 3, is a peat deposit covering about 10 acres. The quality is good, the material being formed, to a large extent, from the sphagnum mosses, and being beneath the ground-water level. The color is a medium chocolate brown, and the sub-soil is marl. The thickness is from 12 to 21½ feet, and the stripping is light.

Clear Spring Township (36 N., 9 E.).—A fair to good quality of peat occurs in the southeast quarter of section 13 and the northeast of 24. The bed covers 70 acres, has an average thickness of 6 feet, and a stripping of 1 foot. The color is a dark to a medium chocolate brown.

With an extent of 8 acres, and an average thickness of 3 feet, is a peat bed on the farm of John Price, in the south-central part of section 22. The quality of the material is fair, and the stripping is light. The underlying formation is a clay.

In the northwest quarter of section 26 is a 30-acre deposit, which varies between 2 and 8 feet in thickness. The quality of the material is fair, and the color is a dark chocolate brown. The substratum is clay.

Five well-distributed tests determined the extent of a peat bed in the northern half of section 34, to be 70 acres. The thickness is 2½ feet, and the stripping 1½ feet. The color is a dark chocolate brown, and the quality is hardly fair, it being clayey in portions and almost all above the ground-water level. This leaves it in an oxidized condition.

A large body of muck, commencing in the northeast corner of section 18 and extending eastward through the southwest quarter of section 8, the northwest and northeast of 17, to the northwest of 16 and the southwest of 9, contains a number of pockets of peat, which will likely aggregate 70 acres. This material is shallow, not averaging over 2 feet in thickness, and having 1½ feet of stripping. The quality is poor, being more or less clayey and oxidized, by the action of the air. These beds can never be economically utilized, as a fuel, otherwise than in the crude condition.

Eden Township (36 N., 8 E.).—Covering an area of over a square mile, and having a thickness ranging between 1 and 14 feet (see map) are some beds of peat in the eastern half of section 3, the western of 2, the northeast quarter of 10, the northwest, northeast and southeast of 11, the southeast of 2, the southwest of 1, and the western half of 12. These deposits rest largely upon a sandy subsoil, and have a very dark chocolate brown color. The quality of the deeper portions* is good, while that of the more shallow is poor.

*See page 84.

This is due to the fact that the material of the thicker beds has not become so much mingled with the underlying formation, nor has it undergone so great an oxidization. The derivation has been largely from the grasses and sedges. The amount of material is sufficient to satisfy a peat plant, but the quality will hardly average fair.

Eight acres of a poor to fair quality of material lies in the northeast quarter of section 1, and the southeast of 36 (37 N., 8 E.). The average thickness is 5 feet, and the color a dark chocolate brown.

One-fourth mile south of the center of section 23 is a peat deposit, which covers 12 acres. The quality is from poor to fair, being derived, mainly, from the grasses and sedges, and containing sand in places. The average thickness is 3½ feet, and the color is a dark chocolate brown.

In the large muck and sandy loam areas, which extend northwest and southeast, through sections 26, 21, 17, 8 and 5 (36 N., 8 E.); and 31, and 30 (37 N., 8 E.); are a number of small beds of peat. These are generally shallow and range from poor to fair in quality, none being such as would merit the establishment of even a small peat plant.

The writer does not overestimate when he makes the statement that there are, at least, 300 more peat deposits in Lagrange County ranging between 1 and 3 acres in extent, that cannot receive consideration in this report. Many of these are from fair to good in quality, and will furnish a good fuel to those who care to spade it out, dry it, and burn it in the crude condition.

ELKHART COUNTY.

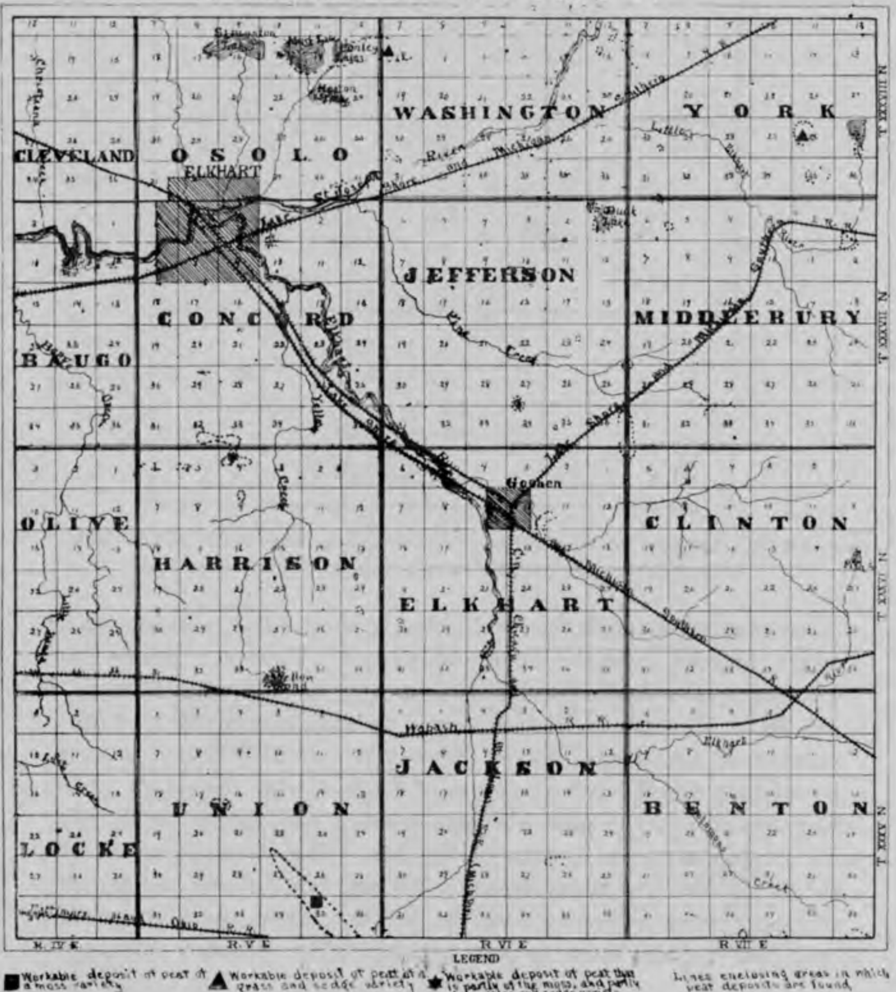
This county borders on the Michigan line, in the north-central part of the State of Indiana. It lies north of Kosciusko, west of Lagrange and east of St. Joseph County. For amount and quality of peat, it is about an average county for Indiana.

Township 35 North, Ranges 5, 6, 7 and Part of 4 East.

Benton Township (35 N., 7 E.).—This township contains no peat deposits of sufficient size and quality to even supply a small peat plant. There are a few shallow beds of 4 or 5 acres in the southern parts of sections 36, 35, 34 and 33, having a rather impure quality of material.

Jackson Township (35 N., 6 E.).—A tamarack swamp, underlain by a good quality of peat, lies in the northwest quarter of section 26. The bed covers 50 acres, and is of a good thickness (see map), being fully four-fifths below the level of the ground-water. The stripping is very light, the color a medium chocolate brown, and the underlying formations sand and clay. This material has almost entirely originated from the sphagnum mosses and even, at present, a large amount of these mosses, in the green condition, are growing

ELKHART COUNTY.



on the surface. Underlying these green mosses are 3 or 4 feet of a good quality of peat moss litter.

Union Township (35 N., 5 E.).—Probably the best and most extensive bed of this county lies in an old glacial lake basin, in the southwest quarter of section 22, the northwest, northeast and southeast of 27, the southwest of 26, in each of the quarters of 35, and the southwest of 36. The material is of a fair to good quality,* being

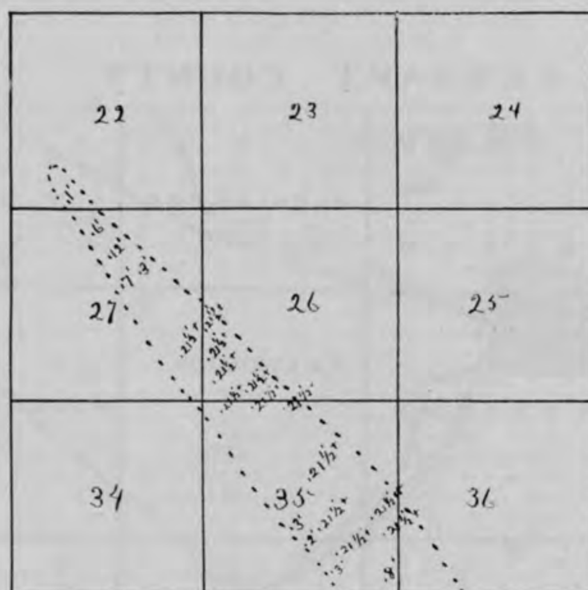


Fig. 5. Showing the thicknesses, where soundings were made, of peat beds in the southeastern part of Union township, Elkhart County.

three-quarters beneath the level of the ground-water, and having its origin, largely, from the sphagnum mosses. The color ranges from a medium to a dark chocolate brown, and the stripping from 1 to $2\frac{1}{2}$ feet. The thickness (see map), as was determined through a number of soundings, ranges between 3 and $21\frac{1}{2}$ feet. It is reputed that a well having a depth of 60 feet, near the center of the bed, was still in the peat when the sinking was discontinued. The underlying stratum is principally clay. The onion crops on the surface of this bed range between 200 and 600 bushels to the acre; the large yield occurring near the borders, where the high ground and peat become more or less mingled. For quality, amount of

*See page 84.

material, and railway facilities, this is an excellent bed. The price of land, however, is considerably higher than the average for peat deposits.

Occupying an old glacial lake basin, and having an average thickness of about 3 feet, and an extent of 60 acres, is a peat bed in the southeast quarter of section 17, and the southwest of 16. The quality will not average fair, because of a considerable amount of oxidation, and more or less impurities. The color is a dark chocolate brown, and the underlying formations are sand and clay. Almost the entire deposit is above the ground-water level, and the stripping is 1 foot. The onions grown upon the surface do well.

Township 36 North, Ranges 5, 6, 7 and Part of 4 East.

Olive Township (36 N., 4 E.).—A poor to fair bed of peat occurs 1½ miles due west of Wakarusa. It has an extent of 30 or 40 acres, and a dark chocolate brown color. The thickness is low and the amount of oxidation high.

Harrison Township (36 N., 5 E.).—Lying almost entirely beneath the water-level, and in a very incompact condition, is a peat bed in the southwest quarter of section 34. The material is at present forming from the mosses, ferns, grasses and sedges. The thickness of the bed ranges between 6 and 15 feet, and the stripping is about ½ of a foot. The color is a medium to a dark chocolate brown, and the quality is from fair to good. The surface covered by this deposit, occupies perhaps 30 acres.

Largely covered by huckleberry bushes, and having a medium to a dark chocolate brown color, is a peat deposit in the north-central part of section 25, and the south-central portion of 24. Its extent is 15 acres, the thickness is from 6 to 13 feet, and the stripping about ½ of a foot. About four-fifths of the material is beneath the ground-water level, and the quality ranges between fair and good.

Four soundings in a marsh in the north-central part of section 24, showed a peat bed to cover about [illegible] acres, and to have an average thickness of 7 or 8 feet. The derivation being from the grasses, sedges and ferns, and the material lies largely beneath the ground-water level; the quality ranges between fair and good. The color is a dark chocolate brown, and the stripping 1½ feet.

Located in the north-central part of section 9 is a bed of peat, which has an extent of 20 acres, and a thickness ranging between 5 and 18 feet. The material, originating from the grasses and sedges, and being about five-sixths beneath the level of the ground-water, is of a good quality. The color is a dark chocolate brown, and the stripping is 1 foot.

More or less broken by the higher ground, are 50 acres of peat in the northern half of section 6, and the northwest quarter of 5. These beds are shallow, the quality poor, and the deposit of little economic importance as a fuel. The color is a very dark chocolate brown, the derivation from the grasses and sedges, and the subsoil is sand. About one-half of the material is above the ground-water level.

Harrison and Concord Townships (36 and 37 N., 5 E.).—In the northern half of section 4, Harrison Township, and the southern halves of sections 33 and 32, Concord Township, are about 200 acres of a material, which have a good thickness (see map), and are of good quality.* About 80 per cent. of the material is beneath the level of the ground-water, and the color is a dark chocolate brown. The stripping is from 1 to 2½ feet, and the underlying bed is a fine sand. Fully 100 acres of the surface of this deposit are planted annually to potatoes. Because of the quality, extent and thickness, this deposit will furnish a good location for a peat plant, if railway transportation comes a little nearer.

Elkhart Township (36 N., 6 E.).—Near the center of section 30 are 10 acres of a good quality of peat. The thickness of the bed varies between 3 and 13 feet, and the color is a medium to a dark chocolate brown.

A shallow and poor quality of material, being derived from the grasses, sedges and weeds, lies in the southeast quarter of section 28 and the northeast of 33. The extent of this deposit is 20 acres, and its topographical position is a terrace of the Elkhart River. The subsoil is a sandy clay.

At the eastern side of the City of Goshen, in the southeast quarter of section 10 and the soutwest quarter of 11, where several large celery farms are found, are 50 acres of a fair to good quality* of peat. It has had its origin, to a considerable extent, from the sphagnum mosses, and has a good average thickness (see map). Over half of the material is below the ground-water level, and the stripping is about 1½ feet. The underlying bed is sand, and the color is a dark chocolate brown. Lying near the City of Goshen this deposit would make a fine location for a small peat plant.

Clinton Township (36 N., 7 E.).—This township contains only

*See page 84.

very small peat beds, none of which are of sufficient size for even a small peat plant. A 5-acre deposit, of good quality, occurs in the south-central part of section 5. The bed originated from the sphagnum mosses, ranges between 3 and 15 feet in thickness, and has scarcely any stripping. The color is a medium chocolate brown, and three-quarters of the material is beneath the ground-water level. Sand is the main substratum. Some peat moss litter can be obtained from the surface of this deposit.

Township 37 North, Ranges 5, 6, 7 and Part of 4 East.

Middlebury Township (37 N., 7 E.).—Varying greatly in thickness, and broken considerably by the higher ground, is a bed of peat in the southern half of section 1, and the northern half of 12. It is of fair quality, having its derivation from the grasses, sedges and weeds, and is more than one-half beneath the ground-water level. The extent is about 15 acres, and the thickness varies between 2 and 8 feet. The color is a dark chocolate brown.

In the east-central part of section 6 and the west-central part of 5, are 20 acres of a dark chocolate brown peat. Since this material is more than ½ above the ground-water level and the derivation is from the grasses and sedges, the quality ranges between poor and fair. The thickness will average about 4 feet, and the stripping 2 feet. The underlying formation is sand.

Middlebury and York Townships (37 and 38 N., 7 E.).—Fifteen acres of a poor to fair quality of peat lies in the southeast quarter of section 31, York Township, and the northeast quarter of 6, Middlebury Township. The color is a dark chocolate brown, and the average thickness about 3 feet. The stripping is 1½ feet, and the derivation is from the grasses and sedges. Almost all of the material is above the ground-water level, and the underlying bed is sand.

Middlebury and Jefferson Townships (37 N., 7 and 6 E.).—In the southwest quarter of section 19 and the northwest of 30, Middlebury Township, and the southeast quarter of 24 and the northeast of 25, Jefferson Township, are 15 acres of a medium chocolate brown peat. With its good quality, a thickness ranging between 6 and 13 feet, a small amount of stripping, and a location where fuel is very much needed, the deposit becomes a desirable one for getting the material out in the crude form. Most of this deposit is beneath the ground-water level, and the subsoil is sand.

Occurring at the junction of Middlebury, Jefferson, Elkhart and Clinton Townships, in the southwest and northwest quarters of section 31 (37 N., 7 E.), the northeast and southwest of 36 (37 N., 6 E.), the northeast of 1 (36 N., 6 E.), and the northwest of 6 (36 N., 7 E.), are 150 acres of peat, distributed in a number of various sized pockets. The quality, as a whole, is very poor, and the thickness will not average over 1½ feet. The color is a very dark chocolate brown, and practically all of the material is above the groundwater level, being in a highly oxidized condition.

Jefferson Township (37 N., 6 E.).—Around a small glacial lake, surrounded by tamarack trees, in the southwest quarter of section 27 and the northwest of 34, are 35 acres of a medium chocolate brown peat. The thickness of the bed ranges between 6 and 15 feet, and as the material is almost entirely beneath the groundwater level, and thus unoxidized from atmospheric contact, the quality is good. The derivation has been from the sphagnum mosses, some of which are still growing on the surface. This deposit has scarcely any stripping, and contains in its upper portions a good quality of peat moss litter.

Another deposit of similar origin and quality lies in the southwest quarter of section 10, in an old glacial lake basin, surrounded by morainic hills, ranging between 30 and 70 feet in height. The surface covered by this bed is about 45 acres, and the thickness varies between 3 and 15 feet. The color of the material is a medium chocolate brown, the stripping almost nothing, and the subsoil a fine sand. Large quantities of green sphagnum mosses carpet the surface of this deposit; and immediately underneath are several feet of a good quality of peat moss litter. Because of a scarcity of fuel in this vicinity, the output of a very small peat plant would no more than supply the local demand.

Rather shallow and unimportant beds of peat are found in section 1, about Dock Lake and the immediate vicinity. Taken together, these beds will probably cover 30 acres.

Two small bodies of peat, together covering about 20 acres, occur in an old glacial lake basin in the southeast quarter of section 10 and the northeast of 15. The average thickness of these beds is not over 2 feet, and they are almost entirely above the ground-water level, and are of a poor quality. These deposits have a very dark chocolate brown color and are derived from the grasses, sedges and weeds. Sand forms the underlying stratum.

Concord Township (37 N., 5 E.).—In the north-central part of section 21, are 10 acres of a poor quality of peat, originating from the grasses and sedges. It has a very dark chocolate brown color, a very low thickness, and is about one-half above the ground-water level.

Baugo Township (37 N., 4 E.).—No peat deposits of a greater extent than two or three acres occur in this township, and these deposits are shallow and of poor quality for fuel.

PART OF TOWNSHIPS 38 NORTH, RANGES 5, 6, 7 AND PART OF 4 EAST.

Cleveland Township (38 N., 4 E.).—A few very shallow beds of five or six acres lie in sections 25, 26, 35 and 36. None of these are of sufficient size for even a very small peat plant.

Osolo Township (38 N., 5 E.).—Lying almost entirely above the ground-water level, and therefore in a high state of oxidation, are 60 acres of peat in the southeast quarter of section 35 and the southwest of 36. The thickness of this bed ranges between 1 and 6 feet, and the stripping is 1½ feet. The color is a very dark chocolate brown, and the origin of the material is from the grasses, sedges and weeds. Sand forms the underlying formation. Because of the poor quality and shallowness, this deposit will not justify the erection of a small peat plant.

A 20-acre bed of peat, similar to this in quality, color and thickness, lies in the east-central part of section 36. The topographical position of the bed is that of a small lake ("bayou" or "ox-bow lake")[1], left in the meandering of the St. Joseph River.

Fig. 6. Showing the thicknesses, where soundings were made, of the peat beds in the vicinity of Conley and Mud Lakes, Elkhart County.

Osolo and Washington Townships (38 N., 5 and 6 E.).—With exception of the large deposit in Union Township, no other in the county is equal to the one found in the northeastern portion of Osolo Township and the northwestern part of Washington, in all quarters of sections 15 and 14, and the southwest, northwest and northeast of 13 (38 N., 5 E.); and the northern half of 18 (38 N., 6 E.). In the northeast quarter of section 13 (38 N., 5 E.), and the northern half of 18 (38 N., 6 E.), occurs the best portion of the de-

[1] See page 79.

posit. Here the average thickness (see map) is the greatest, the oxidation being low and the quality[2] excellent, while around Cooley Lake and between this lake and Mud Lake, the average thickness is not over 2 feet, the oxidation is high and the quality is poor. At the west end of Mud Lake there are 40 acres of a fair to good quality of material, having a good thickness (see map), and being little oxidized. In these deposits the main source of derivation has been the sphagnum mosses, grasses, sedges and weeds. The underlying formation about the lake is principally marl; but one-half mile from the lake it is sand. The topographical position is that of a large glacial lake basin, which comprises Simonton, Mud and Cooley Lakes, and the surface covered with the peat and muck. The separation of these lakes at present is due to the ground-water level being lower than previously. This deposit, being within three miles of the L. S. & M. S. Railroad, and six miles of the City of Elkhart, and having a good quality, affords an excellent location for a peat plant. It covers a large extent in a vicinity where timber, now the only native fuel in use, is almost exhausted. The City of Elkhart, alone, would likely use the entire supply.

The principal plants now growing upon the surface of these peat beds are as follows: (a) Over the beds of 5 feet or more in thickness, one finds the grasses, sedges and ferns predominating; (b) nettles and ferns are common over the portions ranging between 2 and 5 feet in thickness; (*c*) forget-me-nots and wire grass over beds of 2 feet and less.

Washington Township (38 N., 6 E.).—A bed ranging in thickness between 2 and 7 feet, lies in the north-central part of section 31 and the southwest quarter of 30. The surface covered by the deposit is 40 acres, and the quality will average about fair. The origin of the material has been largely from the grasses and sedges, and the color is a dark chocolate brown. The subsoil is sand.

Thirty acres of a poor to fair quality of peat, with a dark chocolate brown color, lies in the northeast and southeast quarters of section 32, and the northwest and southwest of 33. This bed is surrounded by 200 acres of black muck. It has a dark chocolate brown color, an average thickness of $4\frac{1}{2}$ feet, and is about one-half above the ground-water level. The stripping is $1\frac{1}{2}$ feet, and the sub-strata are marl and sand.

Several small deposits, which taken together, will cover about 20 acres, are found in the central part and southeast quarter of section 22. Since they have an average thickness of only 3 feet and are

[2] See page 84.

fully one-half above the ground-water level, thus being much oxidized by air contact, the quality will not average fair. Their origin has been mainly from the grasses and sedges, and their present sites mark the locations of small glacial lake basins. The stripping is about 1 foot, and the color is a dark chocolate brown.

Several other small deposits occur in the north-central part of 13 and the southeast of 12. These deposits cover about 40 acres, have an average thickness varying between 2 and 9 feet, and a dark chocolate brown color. Sixty per cent. of the material is beneath the ground-water level, the stripping will average about 1 foot. The underlying bed is sand. The grasses and sedges seem to have been the main sources of origin. The quality of this material is about fair. A rather singular and interesting phenomena was noted in the topographical position of this bed. It occurs as the highest terrace of the St. Joseph River, being bounded on the east by the valley side of this river, and on the west by the sandy flood plain. The altitude of this peat bed is 5 feet greater than that of the sandy flood plain, and at the point of contact, is a rather abrupt grade.

This topographical position may be accounted for as follows: A river in meandering frequently leaves, on one side of its valley, a "bayou"* or "ox-bow lake." In this case, this bayou would have been developed before the river had lowered its channel to the extent it has at present, and would have been flowing at about the height that this peat terrace occupies at present. When this ox-bow lake was developed, the water-loving vegetation would begin to creep out upon its surface, very similar to which it does over the glacial lakes at present. This vegetation would soon die and settle below, or else be pushed beneath the water-level, by other growing upon its surface, and there would undergo only a partial decomposition. This partial decomposition would give rise to an accumulation which, after the process had been carried on for a considerable length of time, would result in the peat beds that we find forming the higher terraces of the St. Joseph River, in this vicinity.

Washington and York Townships (38 N., 6 and 7 E.).—A peat bed lies in the northeast quarter of section 13 of Washington Township, and the west half of 18, York Township. Since it has an extent of 100 acres, a thickness (see map) ranging between 3 and 15 feet, and a fair to good quality, it is the best fuel deposit in this vicinity, and it is especially valuable because of the scarcity of tim-

*For an explanation of how these bayous are developed see Chamberlain and Salisbury's Geology, Vol. 1, pp. 185–184.

ber, the only native fuel now being used. The color is a dark chocolate brown, and the stripping from ¼ to 2 feet. About 60 per cent. of the material is beneath the ground-water level, and the underlying bed is sand. The derivation is chiefly from the grasses and sedges.

York Township (38 N., 7 E.).—Underlying a huckleberry marsh, in the southeast quarter of section 30, are 25 acres of a good quality of peat, overlain by several feet of peat moss litter and the green sphagnum. The thickness (see map) of this bed has a good average, and the material is almost entirely beneath the level of the ground-water. The stripping is practically nothing, if the economic importance of the peat moss litter and green sphagnum is taken into consideration. These green mosses, over the damper portions of this deposit, form a covering 1 foot in thickness; and the peat moss litter, immediately under the mosses, is of very good quality. For a very small peat plant, the location would be suitable.

A deposit, containing a great many islands and being somewhat interrupted by the higher ground, lies in the west-central part of section 26. It has an extent of one-half mile from north to south and one-third of a mile from east to west. Probably the higher ground will occupy one-third of this extent. The average thickness of this bed being high, and the material largely beneath the ground-water level, the quality is good. The derivation has been from the sphagnum mosses, grasses, sedges and ferns, all of which are found growing, at present, on the surface of the deposit, where the process of formation is still going on. The color is a medium to a dark chocolate brown, the stripping very light, and the subsoil a fine sand. In places peat moss litter can be gotten from this deposit.

A bed similar in quality, color and derivation, lies in the east-central part of section 35. This bed will cover 55 acres, and has a good thickness (see map). About 80 per cent. of the material is beneath the ground-water level, the stripping is very light, and the underlying formation is fine sand. Some peat moss litter can be obtained from the upper portion of this bed. One large peat plant could probably handle the material of this deposit and that of the deposit described in the preceding paragraph, since the locations are within less than a mile of one another.

Several small beds of peat, found mostly where the tamarack trees are growing, in the large marl bed in the southeast quarter of section 25 and the northeast of 36, will, taken together, cover about 40 acres of surface. The material of these beds has a medium chocolate brown color and is of good quality, being largely beneath the ground-water level and having a fair thickness. The origin of the material has been principally from the sphagnum mosses, and the subsoil is marl.

KOSCIUSKO COUNTY.

Kosciusko County is found in the second tier of counties from the north boundary of the State, immediately west of Whitley and Noble Counties, and east of Fulton and Marshall Counties. The morainic topography, which gave rise to the glacial lakes in which the peat is formed, is very pronounced in parts of this county. The Saginaw and Erie lobe, presents itself as an interlobate morain in the eastern and southern portions. For amount and quality of peat, this ranks as one of the leading counties of the State.

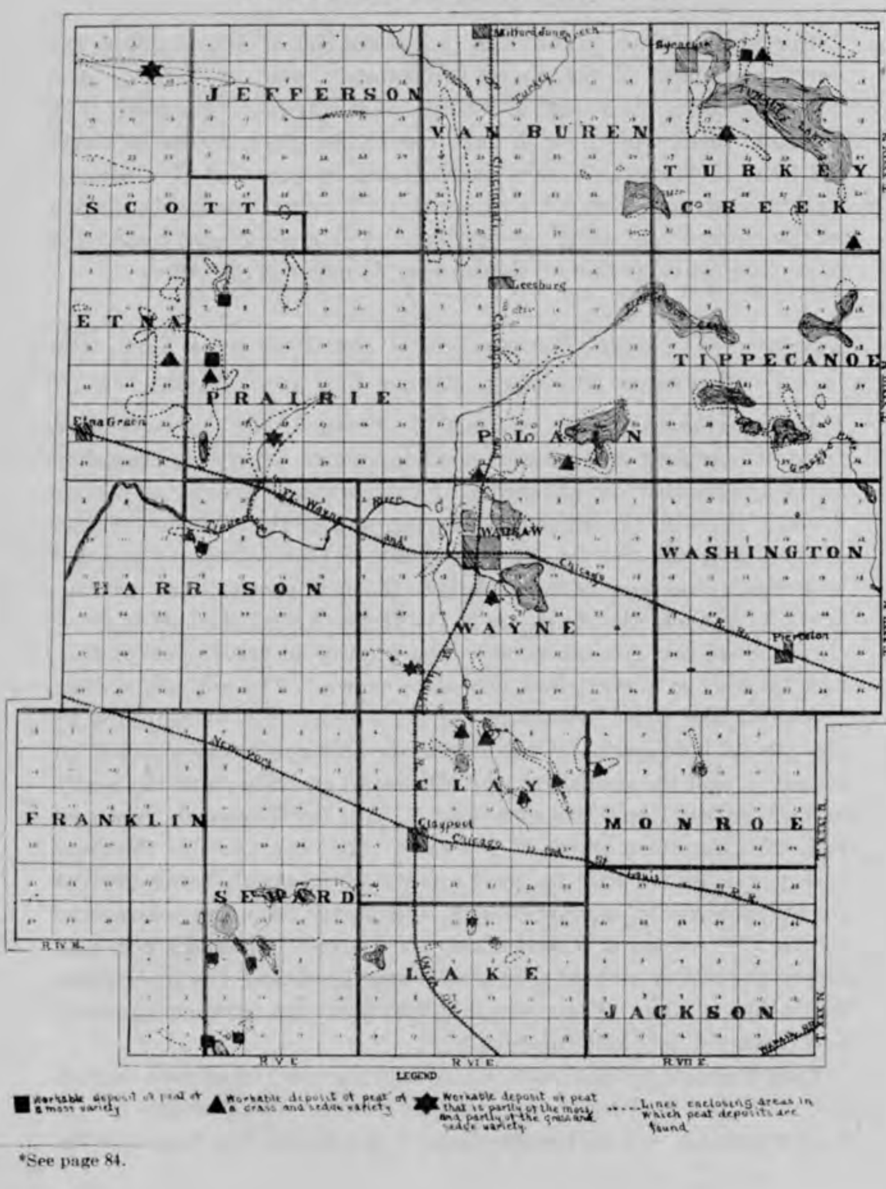
Township 31 North, Ranges 5, 6, 7 and Part of 4 East; and Township 30 North, Ranges 5, 6 and 7 East.

Monroe Township (31 N., 7 E.).—Formed, for the most part, from the grasses and sedges, is a deposit of 70 acres, extending north and south from the center of the northeast quarter of section 4, south through the southeast quarter, and to the east-central part of section 9, and the west-central of 10. The thickness of this bed is variable, ranging between 1 and 15 feet, probably an average being 3 feet; and the stripping is 1½ feet. About one-half is above the level of the ground-water. The quality is from poor to fair, and the clay is a very dark chocolate brown. The sub-soil is clay.

Monroe and Clay Townships (31 N., 6 and 7 E.).—Occupying an old glacial lake basin, in the northeast and northwest quarters of section 7, and the southwest of 6, Monroe Township; and the southeast of section 1, and the northeast of 12, Clay Township, is a peat bed, with a surface extent of 150 acres. It has a variable thickness (see map), and a fair to good quality of material, being derived partly from the sphagnum mosses, and partly from the grasses and sedges. The color is a dark chocolate brown. About 50 per cent. of the deposit is above the ground-water level, and the underlying formation is clay. The stripping, which ranges between ¼ and 2 feet, makes a fair soil for corn.

Clay Township (31 N., 6 E.).—A long narrow bed of peat extending northwest and southeast and being more or less broken by the higher ground, is found, occupying an old glacial lake basin, in the northwest quarter of section 13, the southwest and northwest of 12, the northeast and northwest of 11, and the southwest of 2. It is of a good quality*, and is derived largely from the grasses and sedges, but somewhat from the sphagnum mosses. The color is a dark

KOSCIUSKO COUNTY.



*See page 84.

chocolate brown, and the thickness has a good average (see map). Probably 200 acres are of economic importance. These are about one-half above the level of the ground-water, and have a stripping of from 1/4 to 2 feet. The underlying formations are marl and clay. The quantity and quality of this deposit are sufficient for a peat plant; but the nearest railway facilities are from three to four miles distant.

In an old glacial lake basin, in the northwest quarter of section 14, the southwest of 11 and the southeast of 10, is a peat bed covering 200 acres. Its surface is more or less marshy, and is covered with the grasses and sedges, and a less amount of tamarack. The peat of the tamarack portion is largely formed from the sphagnum mosses, while that of the grass and the sedge part have been derived from these plants. The quality varies between fair and good, and the color is a dark chocolate brown. The thickness (see map) is better than that of an average deposit, and the stripping is about one-half foot. Probably 50 per cent. of the material is above the ground-water level, and the underlying bed is clay. The surface of this deposit makes a fair soil for corn and onions.

In the east-central and the northeast and northwest quarters of section 9, the southeast, northeast and southwest of 4, and the southeast of 5, is a 250-acre peat bed, with a fair thickness and almost 1 foot of stripping. The quality is from poor to fair, being derived from the grasses and sedges, and more or less impure. About one-half of the deposit is above the level of the ground-water, and the sub-formations are clay and marl. The color is a dark chocolate brown.

Clay and Wayne Townships (32 N., 5 and 6 E.).—A peat deposit lies in the southwest quarter of section 36 (32 N., 5 E.), the southwest of 31 (32 N., 6 E.), and the northeast of 5 (31 N., 6 E.). It covers 25 acres, has an average thickness of 4 feet, and 1 foot of stripping. The color is a dark chocolate brown, and about one-half of the material is above the ground-water level.

A long, narrow bed of peat, having an extent of 75 acres, and an average thickness of 3 feet, lies in the northeast quarter of section 4, Clay Township; and the southwest of 32, Wayne Township. The quality ranges between poor and fair, the derivation being from the grasses and sedges; and the color is a dark chocolate brown. The deposit is hardly suitable, because of its quality and shallowness, for a peat plant.

Lake Township (30 and 31 N., 6 E.).—Situated in an old glacial lake basin, in the northwest and southwest quarters of section 3, and the northwest of 2, is a bed of peat one-half a mile long and between one-eighth and one-half of a mile wide. It is covered with grasses, sedges and weeds, and is largely formed from these. The quality is fair, and the color is a dark chocolate brown. The thickness has a good average (see map) and the stripping is about 1 foot. Probably 50 per cent. of the material is above the level of the ground-water, and the sub-soil is clay.

A fair to good quality of peat occurs in the north-central part of section 3, and the south-central of 34. The deposit occupies about 20 acres, has a thickness ranging between 2 and 15 feet, and a stripping of three-quarters of a foot. The color is a dark chocolate brown, and about one-third of the material is above the level of the ground-water.

Located in the southwest and northwest quarters of section 34, and the southeast and northeast of 33, is a deposit, extending almost due north and south, with a length of three-quarters of a mile and a width of one-sixth of a mile. The thickness of the bed is from 3 to 15 feet (see map), and the origin has been, largely, from the sphagnum mosses, and to a small extent from the grasses and sedges, thus giving a fair to good quality. The color is a medium to a dark chocolate brown. About one-half of the material is above the ground-water level, and its underlying bed is clay. The one foot of stripping, which is an oxidized form of peat, makes a good soil.

In a large glacial kettle basin, in the northwest quarter of section 5 and the northeast of 4, is a peat deposit of fair quality. Its extent is about 45 acres, and the thickness is between 7 and 15 feet (see map). The color is a dark chocolate brown. About 30 per cent. of the material is above the ground-water level, and the stripping is 1 foot. The sub-formation is clay. This deposit, as well as the one mentioned in the preceding paragraph, would be sufficient to supply, at least, a small peat plant.

Lake and Seward Townships (30 and 31 N., 5 and 6 E.).—Extending southwest from Silver Lake, in the southwest quarter of section 6, Lake Township, and the southeast of 1, Seward Township, are 100 acres of a poor to fair quality of peat, derived, mainly, from the grasses and sedges. The bed has a dark chocolate brown color, 1 foot of stripping and is about one-half above the ground-water level. The thickness will average about 4 feet (see map), and the underlying formations are marl and clay.

Seward Township (30 and 31 N., 5 E.).—Fifty acres of a dark chocolate brown peat surrounds Mud Lake, in the southeast and southwest quarters of section 26 (31 N., 5 E.). The deposit will not average more than 3 feet in thickness, and the quality ranges between poor and fair. Fully 90 per cent. of the material is above the ground-water level, and the stripping is 1 foot. Marl comprises the underlying bed. A similar deposit in quality, thickness and color, is found on the south side of Yellow Creek Lake, in the southeast quarter of section 27 and the northeast of 34 (31 N., 5 E.). It has an extent of 30 acres, is 90 per cent. above the ground-water level, and rests upon the marl.

Covering an area three-quarters of a mile in length, with a width ranging between one-twelfth and one-half of a mile, and extending in a northwest and southeast direction, is a peat bed in the southeast, northeast and northwest quarters of section 3 (30 N., 5 E.). Some high ground and several small lakes occur in this bed, and probably comprises one-third of its area. The thickness of the bed has a high average (see map), while 80 per cent. is beneath the ground-water level, and the stripping is generally light. The color is a dark chocolate brown and the quality is fair. This bed, at the western edge, connects up with a deposit, which is found along the eastern side of Loon Lake and extends southeast from this lake.

The Loon Lake bed lies in the southwest and northwest quarters of section 3 and the northeast of 4 (30 N., 5 E.). It also has an excellent thickness (see map), a very light stripping, and is only one-sixth above the ground-water level. The quality is, for the most part, good, the derivation being largely from the sphagnum mosses. In this deposit are many tamarack logs, which, in places, are so numerous that it was with difficulty that the writer succeeded in getting his 15-foot sounding auger down. The surface, in many places, is carpeted with a heavy growth, six to nine inches, of the green mosses, which are valuable for nurserymen. Immediately beneath these mosses are several feet of a very good quality of peat moss litter. Beneath this is found the medium chocolate brown peat, and deeper, that of a dark chocolate brown color. The medium chocolate brown is much more fibrous and loose than the deeper material, and consequently has a lower fuel value. Since in area this bed is about the same as the one described in the preceding paragraph, and these two beds are so near one another, the location for a peat plant will be a good one, when the transportation facilities become improved.

About forty acres of a fair quality of peat lies on the western side of Beaver Dam Lake, in section 33 (31 N., 5 E.). Considerable high ground and some shallow places are scattered over this deposit.

thus leaving the average thickness only about 4 feet, while the maximum is 21½ feet. The quality of the material is fair, the color a dark chocolate brown, and the stripping about ¾ of a foot.

Franklin Township (30 and 31 N., 4 and 5 E.).—In the east-central part of section 32 (31 N., 5 E.), are 30 acres of a fair quality of peat. It has a dark chocolate brown color, and occurs in a shallow bed.

A tamarck and maple marsh, which overlies 80 acres of peat, lies in the northwest and southwest quarters of section 4 (30 N., 5 E.). The quality of the material ranges between fair and good, the derivation being partly from the sphagnum mosses and partly from the grasses, sedges and weeds. The color is from a medium chocolate brown to a dark chocolate brown. Seven soundings show the depth to range between 3 and 15 feet, and the stripping is ¾ of a foot.

Derived largely from the grasses and sedges, and poor to fair in quality, is a 120-acre peat bed in the northwest quarter of section 15 and the southwest of 10 (30 N., 5 E.). This material has a dark chocolate brown color, is largely above the ground-water level, and has 2 feet of stripping. It rests upon a clay and marl bottom, and makes a good soil for onion raising. The deposit has a fair thickness, and occupies the site of an old glacial lake basin.

One of the largest and best peat beds of the State lies in the vicinity of Rock Lake, in the southwestern part of Kosciusko County, and the northwestern part of Fulton County. In Kosciusko County it is found in Seward and Franklin Townships, in all quarters of section 16, the northeast, southeast and northwest of 17, and the southeast of 8 (30 N., 5 E.). Probably three-quarters of the deposit, either is or has been, covered, more or less, with tamarack trees and sphagnum mosses. The material is largely beneath the ground-water level, and consequently has not lost its fuel value by undergoing decomposition in the presence of the atmosphere. This condition, together with the sphagnum moss derivation, gives a good quality of fuel. The color is a medium to a dark chocolate brown, and the underlying formations are clay and marl. The stripping is very light and the thickness is good (see map). Large quantities of peat moss litter and green sphagnum mosses can be obtained in the upper part of the bed. A section, from this deposit, is as follows: (a) Green sphagnum moss, 1½ feet; (b) peat moss litter, 3 feet; (c) a very fibrous peat, 6 feet; (d) a medium fibered peat, 4 feet; (e) a rather compact material, containing a very fine fiber, 8½ feet.

TOWNSHIP 32 NORTH, RANGES 5, 6, 7 AND PART OF 4 EAST.

Harrison Township (32 N., 4 and 5 E.).—Just south of Tippecanoe River, in the northeast, northwest and southwest quarters of section 12, and the northeast of 11 (32 N., 4 E.), are 200 acres of marsh land, 75 acres being covered with tamarack trees, and 125 with the grasses and sedges. The 75 acres are underlain by a good quality of peat, which has been derived largely from the sphagnum mosses, while the 125 acres are underlain by a fair quality of material. The average thickness of the tamarack portion is about 13 feet, and of the grasses, about 5 feet. The colors vary between medium and dark chocolate brown, and the underlying bed is largely sand. Not more than one-tenth of the tamarack bed is above the ground-water level, while about one-third of the grass portion is above. The stripping for the tamarack part is about one-third of a foot, and that of the grass about one foot. These deposits are sufficiently large to supply a peat plant.

Extending both east and west, from the deposits described in the preceding paragraph, are numerous small isolated beds of poor to fair qualities of peat. These deposits are generally near the Tippecanoe River, and have a dark chocolate brown color.

Harrison and Prairie Townships (32 and 33 N., 4 and 5 E.).—In the northwest quarter of section 4, Harrison Township, and the southwest of 33, Prairie Township, is a deposit, extending north and south, with a length of 100 rods and a width of 25 rods. Its thickness (see map) averages good, and the stripping is light. The quality ranges between fair and good, the derivation being from the grasses, sedges and sphagnum mosses. The color is a dark chocolate brown, and the underlying bed is mainly clay.

Wayne Township (32 N., 5 and 6 E.).—A small peat bed of about 10 acres occurs in the south-central part of section 31 (32 N., 6 E.). The material has a dark chocolate brown color, a quality ranging between poor and fair, and an average thickness of 3½ feet. The stripping is about one foot, and probably one-half of the deposit is above the level of the ground-water.*

Having a good thickness (see map), and an extent of 60 acres, is a peat bed in the northwest quarter of section 32 (32 N., 6 E.). The color of the peat is a dark chocolate brown, and its quality is rather poor, being clayey. The stripping is 1½ feet, and about one-half of the bed is above the ground-water level. The underlying bed is mainly clay.

Another clayey bed of peat is situated in an old glacial lake basin, in the southwest and southeast quarters of section 29 (32 N., 6 E.). The area covered by this deposit is about 120 acres, and the thickness (see map) is fair. The color is a dark chocolate brown, and the stripping is about 1½ feet. Almost one-half of the material is above the ground-water level, and the sub-soil is largely clay.

A deposit of 200 acres occupies the site of an old glacial lake basin, in the northeast quarter of section 36, the southeast and southwest of 25, and the northeast of 26 (32 N., 5 E.). This bed is about two-thirds beneath the level of the ground-water, has a light stripping, and a good average thickness (see map). The color is a dark chocolate brown, and the quality varies between fair and good. The stripping is one-half of a foot, and the underlying formation is, for the most part, clay. Just south of Mud Lake, which is in this area, the upper 2 feet are composed of a good quality of peat moss litter. Beneath these 2 feet, a good quality of fuel commences, becoming less fibrous and more compact as it is found at greater depths in the deposit. A sufficient amount of material for operating a peat plant can be supplied from this deposit.

A rather poor and clayey variety of peat lies in the northwest quarter of section 18, and the northeast of section 13 (32 N., 5 E.). This body occupies 150 acres, has a fair thickness (see map), and a stripping of one foot. Most of the material is below the ground-water level, and the derivation is mainly from the grasses and sedges. The underlying formation, where the writer made soundings, was clay.

. A fair quality of peat is located in the south-central part of section 17 and the north-central of 20 (32 N., 6 E.). The deposit extends over about 70 acres, has a fair thickness (see map), and a stripping of one foot. The derivation has largely been from the grasses and sedges, and the bottom is composed of marl and clay. The color is a dark chocolate brown.

Along the west side of Winona Lake, in the southwest quarter of section 16 and the northwest of 21, is a bed of peat covering 100 acres. The quality is from poor to fair, the derivation being from the grasses and sedges, and the thickness (see map) is low, thus leaving most of the material above the level of the ground-water and consequently in a more or less oxidized condition. The color is a dark chocolate brown, and the underlying bed is marl.

In an old glacial kettle basin, in the southwest quarter of section 21, is a 20-acre bed of peat. The quality is fair, the average thickness about 6 feet, and the stripping one foot. The color is a dark chocolate brown and over half of the deposit is beneath the ground-water level. The sub-soils are clay and marl.

A poor quality of material is found north of Warsaw, in the central and south-central parts of section 6 (32 N., 6 E.). The bed covers 50 acres, has an average thickness of 4 feet, and a stripping of one foot. Four-fifths of it is beneath the ground-water level, and the color is a dark chocolate brown. The material upon which it rests is clay.

Immediately north of Warsaw, on the west side of Center Lake, are 60 acres of peat, ranging between poor and fair for quality. It has a dark chocolate brown color, and one-quarter foot of stripping. The thickness of the deposit is 2 feet, and one-quarter of it is above the ground-water level. The grasses and sedges seem to have been the main sources for the derivation, and the underlying materials are marl and clay.

A shallow bed of peat occurs in the southeast quarter of section 23 and the southwest of 24. It has an extent of 25 acres, a thickness ranging between 1 and 4 feet, and a stripping of one foot. It is almost entirely above the ground-water level, and rests upon a sandy sub-soil. The color is a dark chocolate brown.

Extending eastward from the east end of Pike Lake, in the south-central part of section 4 and the northwest quarter of 9, are 150 acres of a fair quality of peat. It will average 4 feet (see map) in thickness, has a stripping of one foot, and is almost all beneath the level of the ground-water. The color is a dark chocolate brown, and the derivation is, for the most part, from the grasses and sedges. The sub-soil is marl.

Along Deeds Creek, in sections 4 and 5, are a number of small isolated peat beds, which will likely aggregate 150 acres. For the most part, they are poor in quality, and are very shallow. The color is a dark chocolate brown, and the derivation of the material from the grasses and sedges. The sub-soils are clay, marl and sand.

Washington Township (32 N., 7 E.).—A 12-acre deposit of peat lies in the northeast quarter of section 3. It has an average thickness of 4½ feet, and is fair in quality. The color is a dark chocolate brown, and the origin has been from the grasses and sedges. The stripping is about one foot, and one-half of the material is above the ground-water level. The underlying bed is marl.

In an old glacial lake basin, now covered by a tamarack marsh, occurs 15 acres of a good quality of peat in the southeast quarter of section 30 and the southwest of 29. The derivation has been from the sphagnum mosses, and the color is a medium chocolate brown. The average thickness of the bed is 21½ feet, and the stripping is practically nothing. Only one-eighth of the material is above the level of the ground-water. Some peat-moss litter can be obtained from the upper few feet of this deposit.

Township 33 North, Ranges 5, 6, 7 and Part of 4 East.

Tippecanoe Township (33 N., 7 E.).—A small and shallow bed of peat occurs in the northeast quarter of section 35. The extent is 15 acres, the average thickness 3 feet, and the stripping 1½ feet. The quality is poor, more or less sand being mingled with the peat. The derivation of this material has been mainly from the grasses and sedges, and two-thirds of it is above the ground-water level, thus being exposed to the oxidizing effects of the atmosphere.

In the southeast quarter of section 2, the southwest of 1, the northeast of 11 and the northwest of 12, are 50 acres of a dark chocolate brown material, with a quality varying between poor and fair. The bed is shallow, not averaging more than 2 feet in thickness, and the derivation is largely from the grasses and sedges. The stripping is 1 foot and the underlying formation is marl.

Along the south side of Tippecanoe Lake, in the northeast and northwest quarters of section 18, are a number of small beds of peat, aggregating about 150 acres. Their thicknesses will average 3 feet, the quality ranges between poor and fair, and the predominating color is a dark chocolate brown. The derivation of the material is mainly from the grasses and sedges, and the stripping is 1 foot. About the one-eighth part of these beds are above the level of the ground-water, and the sub-soils are marl and clay.

Probably 200 acres of peat can be found about the Barbee Lakes, in the southeast and southwest quarters of section 20, the northeast of 29, the northeast, northwest and southeast of 28, all quarters of 27, and the south-central part of 22. The thickness (see map) and quality of these beds vary greatly, some being derived from the grasses and sedges, some from the sphagnum mosses, and some containing considerable marl and clay. Those which occur in the south-central part of section 22, are of sphagnum moss origin and are of excellent quality, while the remainder are largely from the grasses and sedges, and vary between poor and good in quality. The color is from a medium to a dark chocolate brown, and the amount of stripping will average about 1 foot. The maximum part of the material is above the level of the ground-water, and the principal underlying formation is marl. Some peat-moss litter can be obtained in the south-central part of section 22, in a tamarack marsh.

A peat deposit in the south-central portion of section 23 has about ¾ of its bulk beneath the ground-water level, and rests on the marl. This bed spreads over about 40 acres, has an average thickness of 6 feet, and an average stripping of 1¼ feet. The material has been, largely, formed from the grasses and sedges, and the quality is fair. The color is a dark chocolate brown.

Another old lake basin, which is now occupied by a 20-acre peat deposit, lies in the southwest of the northeast quarter of section 26. It also has an average thickness of 6 feet, is fair in quality, and is largely derived from the grasses and sedges. About one-eighth of the material is above the ground-water level, and the stripping is 1 foot. The sub-soil is marl.

Taking the deposits mentioned in the two preceding paragraphs, together with those situated about the Barbee Lakes, a sufficient amount of material could easily be found to furnish a peat plant. At present, however, the transportation facilities are not suitable for a plant of this kind, unless it would be very small, and used to supply the local demand.

Plain Township (33 N., 6 E.).—A shallow and impure peat deposit is found in several small beds in the northwest, northeast and southwest quarters of section 9. It has a very dark chocolate brown color, and has originated from the grasses, sedges and weeds. The corn, growing on its surface, seems to do well.

Lying almost entirely beneath the level of the ground-water, and originating, largely, from the sphagnum mosses, is a bed of peat in the southwest quarter of section 16. The surface covered by this bed is 45 acres; and the average thickness for the 25 acres which are nearest to the center, is 21½ feet, and for the remainder about 3 feet. The color ranges between medium and dark chocolate brown, and the stripping, if peat moss litter and green mosses are considered, is nothing for the deeper portion of the bed. The green sphagnum mosses of the central portion form a sort of carpet over the surface, and have an average thickness of over 1 foot. Immediately beneath these mosses is found a good quality of peat moss litter, which has a depth of several feet; and beneath this, the peat fuel, of good quality, begins. A peat plant, built at the west end of this deposit, would be very near the Big Four Railroad.

Dr. C. R. Barnes, Professor of Physiological Botany at the University of Chicago, examined samples of the mosses growing on the surface of this peat bed, and found them to be as follows: Probably 90 per cent. of these mosses are *Sphagnum cymbifolium*, 7 per cent. *Sphagnum acuminatum*, while the most important of the remaining forms are *Climacium americanum*, *Cylindrothecium* (probably *C. seductrix*), *Serile* (probably *S. eucalypta*), and *Dicranum scoparium*.

Extending west and a few degrees north from the extreme southern end of Little Eagle Lake, in all quarters of section 35, and the eastern half of 34, is a bed of peat, covering 200 acres. The quality of the material will average fair, and the color is a dark chocolate brown. The origin has been largely from the grasses and sedges. About four-fifths of the material is beneath the level of the ground-water, and the stripping is from ½ to 1 foot. The thickness (see map) ranges between 3 and 13½ feet, and the sub-soils are clay and sand.

Around the west and north sides of this same lake are several large bodies of peat. The main ones lie in the northeast, northwest and southwest quarters of section 26, the southeast of 27, the northeast of 34 and the northwest of 35. The material is of a medium to a dark chocolate brown color, and varies from fair to good in quality. The entire area covered by these beds is, at least, 200 acres, and the amount of stripping is about 1 foot. The derivation has been, to a considerable extent, from the grasses and sedges, and the underlying beds are marl and clay.

About four-fifths of the material is beneath the ground-water level, thus leaving the main part in a fresh and loose condition. A great shrinkage of volume will undoubtedly ensue upon drainage.

Occurring on either side of the Tippecanoe River, and following its course for about 2 miles, is a chain of peat beds, in the northern half of section 28, the southwest, southeast and northeast quarters of 21, the southwest, northwest and northeast of 22, and the southern half of 15. These beds range between fair and poor in quality and have a very dark chocolate brown color. About two-thirds of the material is below the level of the ground-water, and the stripping is 1 foot. The origin of the peat has been, mostly, from the grasses and sedges, and this* development was in progress when a glacial lake, something like Tippecanoe Lake is at present, existed, where these beds now occur. The thickness (see map) of these beds will average about 3 feet, and they rest, for the most part, upon a clay sub-soil.

*See page 82.

Occupying the site of an old lake basin, in the northern half of section 28, is a bed of peat, covering about 20 acres. The color of this material is a medium to a dark chocolate brown, and the quality is good. The derivation has been, chiefly, from the grasses and sedges. The thickness will average 7 feet, the stripping $1\frac{1}{2}$ feet, and seven-eighths of the material is beneath the ground-water level. The underlying formation is clay.

Resting upon a clay sub-soil and originating from the grasses and sedges, is the bed of peat, which occurs in the southeast quarter of section 28. The area covered is about 45 acres; and three soundings gave thicknesses of 11, 12 and 15 feet. The color is a very dark chocolate brown, and the quality is from poor to fair. About one-half of the bed is above the ground-water level, and the stripping is 1 foot.

In the southern half of section 32, and the southwest quarter of 33, are several beds of peat, which together have an extent, east and west, of 1 mile, and an average width, north and south, of one-sixth of a mile. Numerous islands occur in this deposit, causing a great variation in thickness (see map). The quality* of the material is from poor to fair, and the origin has been, chiefly, from the grasses and sedges. The color is a very dark chocolate brown. Probably three-fourths of the bed is above the ground-water level, and the stripping is 1 foot. The topographical position is that of an old glacial lake basin.

Prairie Township (33 N., 5 E.).—Occupying several hundred acres, in the southeast quarter of section 4, the southwest of 3, the northern half of 9 and the northwest quarter of 10, is a very dark chocolate brown peat deposit. It lies almost entirely above the ground-water level, and the amount of impurities is considerable. The derivation has been from the grasses, sedges and weeds. The average thickness is not over 2 feet, and the stripping 1 foot. The underlying formation is clay. The highly oxidized surface makes a fair soil for onions and corn, which have been grown on it successfully.

Beginning in the southeast quarter of section 5, and extending northeast through the northeast quarter of the same section, then through the eastern half of 32, the northwest quarter of 33, the southeast of 29, the southwest, southeast and northeast of 28, the northwest of 27, and to the southwest of 22, are several large beds of peat, which will average one-fifth of a mile in width. The material is two-thirds beneath the level of the ground-water and is de-

*See page 99 for the fuel value of the better portion of this deposit.

rived, in part, from sphagnum mosses and in part from grasses and sedges. It is, therefore, from fair to good in quality. The average thickness (see map) is high, and the stripping from ½ to 1 foot. The color is a dark chocolate brown, and the bottoms rest, principally, upon the clay. A very good quality of swamp grass grows on the surfaces of these deposits. Since the railroad facilities are good, the material good and in sufficient amounts for operating a peat plant, the location will eventually become a desirable one.

Radiating from a small glacial lake, in the southeast quarter of section 6, the southwest of 5, the northeast of 7, and the northwest of 8, is a peat bed of about 100 acres, which has a thickness of from 4 to 15 feet (see map). The quality is very good, the material being seven-eighths beneath the ground-water level, and consequently in a very fresh condition. The origin has been chiefly from the sphagnum mosses, the stripping is very light, and the color a medium chocolate brown.

A deposit of similar material is found in the northwest and southeast quarters of section 6. It covers about 30 acres, has a thickness ranging between 6 and 15 feet and a stripping of one-third of a foot. Its derivation is also from the sphagnum mosses, and the color is a medium chocolate brown. The quality is good, the material being almost all beneath the level of the ground-water, and in a very pure condition.

Prairie and Etna Townships (33 N., 4 and 5 E.).—One of the largest and best deposits, for extent and quality, in the State, lies in the southern half of section 12, the northeast quarter of 14, the southeast of 23, the northeast of 26, the northeast, northwest and southeast of 25, and all quarters of 13 and 24, Etna Township; and the northeast and northwest quarters of 31, and all quarters of 30, 19 and 18, Prairie Township. It occupies what was once the site of an old glacial lake basin. The part of the deposit occurring in section 18, Prairie Township, has originated, largely, from the sphagnum mosses. These mosses are, at present, growing upon the surface of this part of the deposit, in abundance, often attaining a thickness of 1½ feet. The remainder of this deposit, with exception of 10 or 15 acres, here and there, has been derived, principally, from grasses and sedges.

The sphagnum moss portion of the deposit contains an excellent quality of peat, with an average thickness of 13 feet. In addition to the heavy covering of green moss, it contains several feet of a very good peat-moss litter. Considerable tamarack is found growing upon the surface of this peat, and tamarack logs and stumps are found all through the bed. The grass and sedge portion of the bed, is from a fair to a good quality, but does not attain the thick-

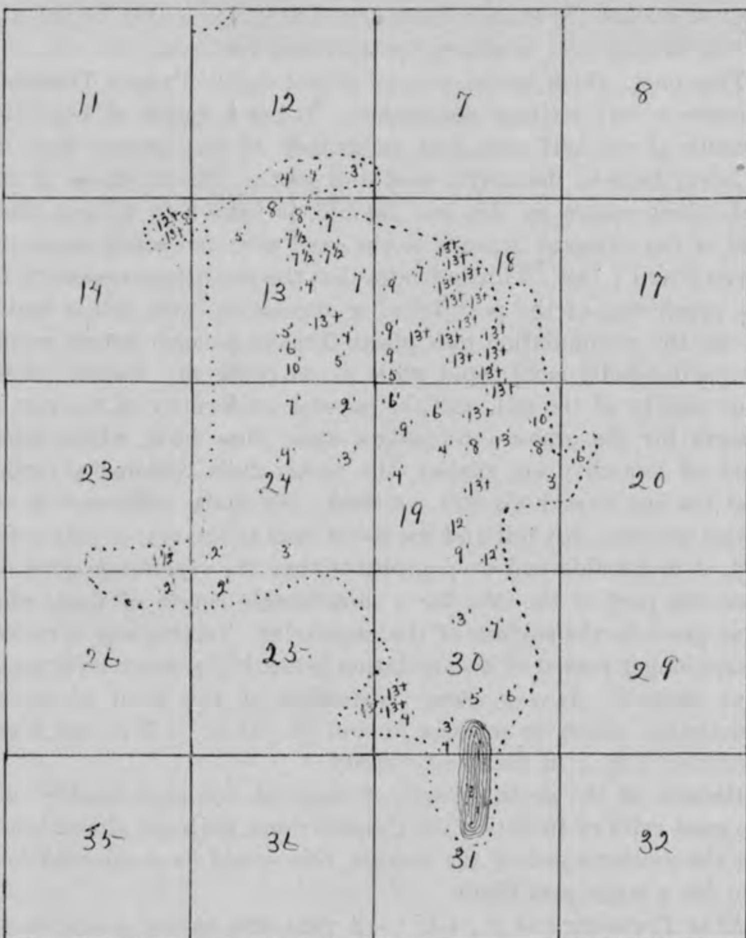


Fig. 7. Showing thicknesses, where soundings were made, of peat beds in the western part of Prairie and the eastern part of Etna townships, Kosciusko County.

ness of the moss part; nor is it so much beneath the level of the ground-water, thus having been oxidized to a greater extent by atmospheric contact. The color of the moss portion is a medium chocolate brown, and that of the grass and sedge a dark chocolate brown. The stripping of the moss area is nothing, if the green moss and peat-moss litter are utilized; while for the grass and sedge surface, it is about 1 foot. The underlying formation is sand. By fertilizing, fair corn crops are raised on the more shallow parts of the grass and sedge deposit. However, one part, which includes most of section 19, Prairie Township, and is designated on the map by the broken line, is said to be worthless for crops.

This part, which includes most of section 19, Prairie Township, presents a very striking phenomena. It has a length of 1¼ miles, a width of one-half mile, and an altitude 10 feet greater than the adjacent beds to the north, west and south. The thickness of this bed, which makes up this low flat hill, is from 6 to 13 feet, while that of the adjacent deposits to the east, west and south ranges between 2 and 7 feet. This indicates that the conditions necessary for the preserving of the peat forming vegetation, were either better, or else the accumulation took place, through a much longer period, or was decidedly more rapid while it was going on. Because of the poor quality of the soil, and the general uniformity of the rate of growth for the grasses and sedges upon these beds, where conditions of humidity are similar, the writer feels reasonably certain that the last hypothesis will not hold. Since the difference in elevation between this hill and the lower beds to the east is only a few feet, it is possible and even probable that the vegetation grew out over this part of the lake for a considerable length of time, while none grew on the surface of the remainder. In this way a considerable longer period of accumulation beneath the water level would have ensued. A very good illustration of this kind of an accumulation occurs in sections 31 and 32 (33 N., 3 E.), and 6 and 5 (32 N., 3 E.), in Marshall County.

Because of the great amount of material, the good quality, and the good railway facilities, the Pennsylvania Railroad almost touching the southern end of the deposit, this would be a splendid location for a large peat plant.

Etna Township (33 N., 4 E.).—A peat bed, having a length of 1 mile and a width ranging between one-eighth and one-third of a mile, lies in the southeast quarter of section 1 and the northern half of 12. This deposit is of a fair to good quality, being derived mainly from the sphagnum mosses and to a less extent from the grasses and sedges, and having 75 per cent. of its volume beneath the ground-water level, thus being little exposed to the atmospheric oxidation. The color is a dark chocolate brown. The stripping will average about 1 foot and the thickness (see map) 5 feet.

Occupying what was once an old lake basin, and having an extent of 35 acres, is a peat deposit in the southern half of section 10. This material, being derived from the grasses, sedges and weeds, having an average thickness of only 4 feet, and being only 1/4 below the level of the ground-water, is hardly fair in quality. Its color is a dark chocolate brown, and the stripping is 1½ feet. The surface of this deposit has proven to be a good soil for onion growing.

Township 34 North, Ranges 5, 6 and 7 East, and Part of 4 East.

Scott Township (34 N., 4 E.).—In sections 22, 23, 24, 25, 26 and 27 are a number of small peat beds, which, taken together, will cover about 100 acres. The material found in these beds is of a poor quality, being generally more or less sandy, largely above the ground-water level, and of very little thickness, probably not averaging more than 2½ feet. The color is a very dark chocolate brown, the stripping rather heavy, and the derivation from the grasses, sedges and weeds. Some of these beds are said to make good corn and onion ground.

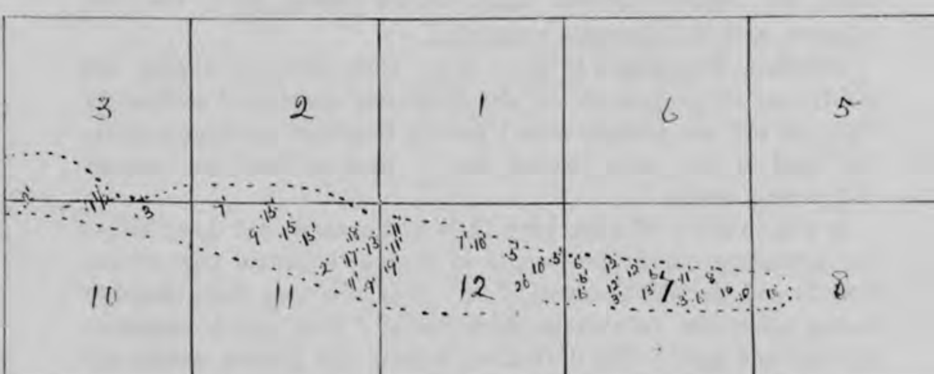


Fig. 8 Showing thicknesses, where soundings were made, of peat beds in the northern part of Scott and the northwestern part of Jefferson townships, Kosciusko County.

Scott and Jefferson Townships (34 N., 4 and 5 E.).—Extending east and west, through the southern half of section 3, the northeast quarter of 10, the southwest of 2 and all quarters of 12, Scott Township, and 7 to the western half of 8, Jefferson Township, is a peat bed, with a width varying from one-fourth to one-half of a mile. The peat of this deposit found in the western half of section 7, Jefferson Township, all of section 12, and the eastern half of 11, Scott Township, is largely of moss origin, of a good quality, and of a good thickness (see map), while the remainder is more shallow, and of a poor to fair quality. The former portion is largely, or has been recently, below the ground-water level, while the latter is mainly above. The stripping is from ¼ to 2 feet, and the subsoils are blue clay and sand. The color ranges between a medium and dark chocolate brown. With this large amount of material and good railway facilities within 1½ miles to the north, the location would be suitable for the erection of a peat plant. However, the fertility of the surface for onion and cabbage growing, makes the price of the farms far above the average for peat land.

The surface or stripping of the better portion of this deposit is a muck, having undergone too much oxidation to be considered a peat. This stripping makes a splendid soil, especially where the sub-soil is clay, for onion and cabbage growing. Where the McLachlan Bros. of Nappanee have added phosphate to this soil, the onion yield has been as great as 800 bushels to the acre. The soil overlying the more shallow portions of this deposit is a black, sandy loam. This has resulted by a further decomposition of the muck, the organic material almost wholly passing off in the form of gases, and the inorganic remaining.

Jefferson Township (34 N., 5 E.).—Fifty acres of a poor and sandy quality of peat lie in the northwest quarter of section 29. The bed will not average over 1 foot in thickness, is entirely above the level of the ground-water, and is derived from the grasses, sedges and weeds.

A poor quality of peat, very little better than that described in the preceding paragraph, occurs in the north-central part of section 33 and the south-central of 28. It is of a very dark chocolate brown color, has an average thickness of 2 feet, and is underlain by clay and sand. The derivation is from the grasses, sedges and weeds.

In a large deposit of muck and black sandy loam, which comprises most of sections 14 and 15, are a number of 15 or 20-acre beds of a very dark chocolate brown peat. It will hardly average fair in quality, and seldom attains a thickness of over 6 feet. Probably 75 per cent. of it is above the level of the ground-water, and the derivation has been from the grasses, sedges and weeds. The main sub-soil is sand, clay occurring over limited areas. The surface is considered to be a very fair soil for onion growing.

The southern end of a rather large body of peat, occurring in Elkhart County, is found in the northeast quarter of section 2, and the northwest of 1. This will average 3 feet in depth, has a stripping of 1½ feet, and is three-fourths above the level of the ground-water. The color is a dark chocolate brown.

Van Buren Township (34 N., 6 E.).—Occupying an old glacial lake basin is a 10-acre bed of peat, of good quality, immediately north of Milford, in the southeast quarter of section 8 and the southwest of 9. It has a medium chocolate brown color and a thickness ranging between 6 and 18 feet. Only one-twentieth of the material is above the ground-water level, and the stripping is almost nothing. The material has been formed from the sphagnum mosses.

Van Buren and Plain Townships (34 N., 6 and 7 E.).—A succession of peat beds extend north and south, from the center of section 7, through 18, 19, 20, 30, 29, 31 and 32, Van Buren Township, to the northern part of 6, Plain Township. The width (see map) of this chain ranges from nothing to one-half a mile, and the thickness (see map) of the beds is generally small. Only in the deeper portions could the material be considered fair in quality. The stripping will average 1½ feet, and the color is a very dark chocolate brown. The derivation has been mainly from the grasses, sedges and weeds, and the sub-soil is sand. The quality and shallowness of these deposits make them rather impracticable for a peat plant, unless it would be a very small one to supply the local demand. This material could be spaded out, dried and burned in the crude form.

On the farms of William Paul and neighbors, in the southwest quarter of section 23, and the northwest of 26, are 35 acres of a fair quality of material. The thickness of the bed ranges between 4 and 15 feet, and the stripping is 1½ feet. Fully four-fifths of the deposit is below the ground-water level, and its color is a dark chocolate brown. The derivation has been from the grasses and sedges.

A peat deposit having an average thickness of 5 feet and a quality varying between poor and fair, lies in the southwest quarter of section 24. Its extent is 30 acres, and the stripping 1½ feet. About one-half of the material is below the level of the ground-water, and its origin has been, principally, from the grasses and sedges. The color is a dark chocolate brown.

Extending along the southwestern shore of Dewart Lake, in the southeast quarter of section 25 and the northeast of 36, is a bed of 20 acres in extent. It has a thickness of 2 feet, a stripping of 1½ feet, and is about three-fourths above the ground-water level. The material is highly oxidized, from the contact with the atmosphere, and is consequently of poor quality.

A deposit, having a similar quality of material and a thickness ranging between 2 and 6 feet, occurs in the east-central part of section 36. It also has a very dark chocolate brown color, and is about three-fourths above the ground-water level. The surface covered by this bed is about 45 acres.

Another bed, containing a poor quality of material and having a thickness of 1 or 2 feet, lies in the northeast quarter of section 7 and the southwest of 8. Here, the surface covered is about 40 acres, the color is a very dark chocolate brown, and the material is entirely above the level of the ground-water. The derivation has been from the grasses and sedges, and the underlying formation is sand.

Turkey Creek Township (34 N., 7 E.).—About 17 acres of a fair quality of peat extends eastward from the northeast corner of Dewart Lake, in the east-central portion of section 30. The material has been formed from the grasses and sedges, and is about five-sixths beneath the ground-water level, thus being in a rather fresh condition, and having a fair quality. The thickness of the bed varies between 5 and 14 feet, and the stripping is about 1 foot. The color is a dark chocolate brown.

In the southwest quarter of section 29, is a 45-acre deposit, having its origin, largely, from the grasses and sedges, and a thickness (see map) ranging between 4 and 21½ feet. The color of the material is a dark chocolate brown, and the quality is from fair to good. The stripping is 1 foot, and 75 per cent. of the bed is beneath the ground-water level. Sufficient material can be obtained from this bed to supply a small peat plant.

A series of peat deposits, having their beginning in the southwest quarter of section 8, extend southward through the northwest, southwest and southeast quarters of 17, the southwest of 16, and into the northern half of 21. These beds cover about 300 acres, and have an average thickness (see map) of 3 or 4 feet. The color is from a medium to a dark chocolate brown, and the origin has been chiefly from the grasses and sedges, but to some extent from the sphagnum mosses. Especially has it been from the latter in the portions covered by the tamarack trees; and it is in these places that the thickness is at its maximum, and the quality the best. The quality ranges between poor and good, the poorer material being found where the deposit is shallow and largely, if not entirely, above the level of the ground-water. The stripping will average 1¼ feet.

Containing clay in places, and hardly averaging fair in quality, is a peat bed in the southeast quarter of section 27, and the northeast of 34. The thickness of this deposit will average 6 feet, and the surface covered is 60 acres. The color of the material is a dark chocolate brown, and its derivation has been from the grasses and sedges. About one-half is above the ground-water level, and the stripping ranges between ½ and 2 feet. Onions which have been grown on the surface of this deposit are said to do well.

A good quality of peat, derived largely from the grasses and sedges, occurs in the southwest quarter of section 36. Its extent consists of 150 acres, and the thickness (see map) of the bed is considerably above the average. Fully two-thirds of the material is beneath the level of the ground-water, thus leaving the larger portion in a very fresh condition. The derivation has been from the grasses and sedges, and the color is a medium to a dark chocolate brown. The stripping has an average thickness of about 1 foot and the topographical position is what was once the extension of the small glacial lake, which the deposit surrounds.

Occupying what was once the extension of Wawasee Lake to the southward, is a 60-acre bed of peat, in the east-central part of section 26, and the northwest, the southwest and southeast quarters of section 25. This material has a dark chocolate brown color, and ranges in quality between poor and fair, a large portion being more or less marly. The average thickness is 3½ feet, and the stripping is 1½ feet. About four-fifths of the material is below the ground-water level, and the underlying formation is marl. This material has originated, mainly, from the grasses and sedges.

A peat bed having an average thickness (see map) of 3½ feet, and an extent of 150 acres, borders the northeast corner of Wawasee Lake, in the southern half of section 11. The material has a dark chocolate brown color, and is derived from the grasses and sedges. The quality is fair, and the sub-soils are sand and marl. About 75 per cent. of this deposit is beneath the level of the groundwater, and the stripping ranges between ½ and 1 foot.

The largest and most important deposit about Wawasee Lake is located in the northwest and southwest quarters of section 3, all quarters of 4, the northern half of 9, and the northwest quarter of 10. The surface covered is 300 acres, and the amount of stripping will average 1 foot. The derivation of the material is about one-fourth from sphagnum mosses and three-fourths from grasses and sedges. Most of the moss peat is beneath the ground-water level, thus being fresh and of a poor quality, while the grass and sedge variety is largely above the water-level, and is only of a fair quality. The color ranges from a medium chocolate brown, for the moss variety, to a dark chocolate brown, for the grass and sedge kind. The thickness of the moss portion will average more than 18 feet, while that of the grass and sedge is only about four feet. Clay seems to be the principal underlying formation.

A 300-acre mixture of peat and muck beds lie in the southwest quarter of section 1, the southeast, southwest and northwest of 2, and the northeast of 3. The peat will not average fair in quality, and the average thickness of the beds in only $2\frac{1}{2}$ feet. The color is a very dark chocolate brown and the average stripping is $1\frac{1}{4}$ feet. Probably three-fourths of the deposits are above the ground-water level, and the origin of the material is from the grasses and sedges.

In the northeast quarter of section 1 are 15 acres of a poor quality of peat. The thickness only averages 2 feet, and considerable clay is associated with the material. Almost the entire deposit is above the ground-water level, and the color is a very dark chocolate brown. The stripping is about 1 foot, and the sub-soil is clay.

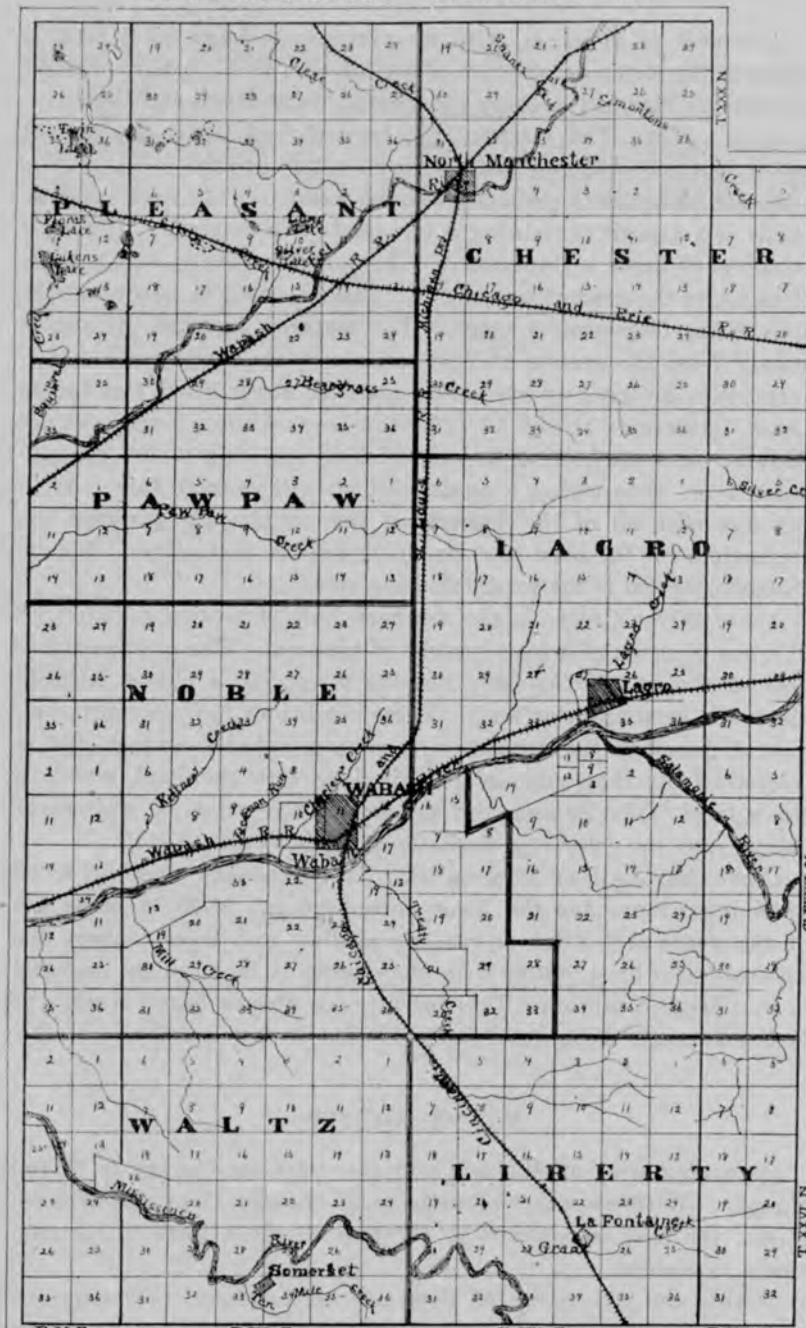
In all the congressional and civil townships of this county may be found small deposits of peat that are not described in this report. Some of these, which contain from 3 to 12 acres, could very well be utilized by spading the material out in the crude condition, piling it up to dry in the summer atmosphere and then hauling it to the wood house before it has had a chance to absorb the fall rains. Even in this condition the peat will produce a warmer fire than wood and will hold a fire longer.

WABASH COUNTY.

This county lies south of Kosciusko and north of Grant County. For amount and quality of peat, it is of little importance. The only deposits worth taking into consideration are those occurring in Pleasant Township.

Pleasant Township (29 and 30 N., 5 and 6 E.).—Where an old glacial lake basin once existed, in the northeast quarter of section 32 (30 N., 6 E.), are 50 acres of a fair quality of peat. Since the thickness is 12 feet on the average, and the material is largely beneath the ground-water level, the deposit is in a fresh condition. The grasses and sedges have been the main sources of origin, and the color is a dark chocolate brown. Marl comprises the underlying bed and the stripping is 1 foot.

WABASH COUNTY.



LEGEND

------ Lines enclosing areas in which peat deposits are found.

A deposit of 40 acres, with an average thickness of 4 feet, is found in the northeast quarter of section 31 (30 N., 6 E.). Eighty per cent. of this bed is above the ground-water level, and the stripping is 1 foot. The material has been derived from the grasses and sedges, and the color is a dark chocolate brown.

Surrounding the Twin Lakes and extending northwest from these 1 mile is a deposit containing a fair quality of material. It has an extent of 65 acres, a thickness of 3 feet on the average, and is four-fifths above the ground-water level. The stripping is 1 foot and the underlying formation is marl. The material has had its source mainly from the grasses and sedges.

Deposits covering an area of 30 acres lie about Flora and Luken Lakes, in sections 11 and 14 (29 N., 6 E.). Although the beds are shallow, over one-half of the material occurs beneath the ground-water level, thus giving a quality which will average fair. As in the case with all of the deposits of this county, the material has originated, for the most part, from the grasses and sedges. A dark chocolate brown is the predominating color.

Along Silver Creek, in the southern half of section 8 (29 N., 6 E.), are 50 acres of a poor quality of material. The average thickness of the bed is 2¼ feet, and the stripping is almost entirely above the ground-water level. These conditions have permitted almost a complete decomposition from atmospheric contact, and a comparatively large amount of mingling with the sand, which is the subsoil. The grasses and sedges are the principal sources of origin, and the color is a dark chocolate brown.

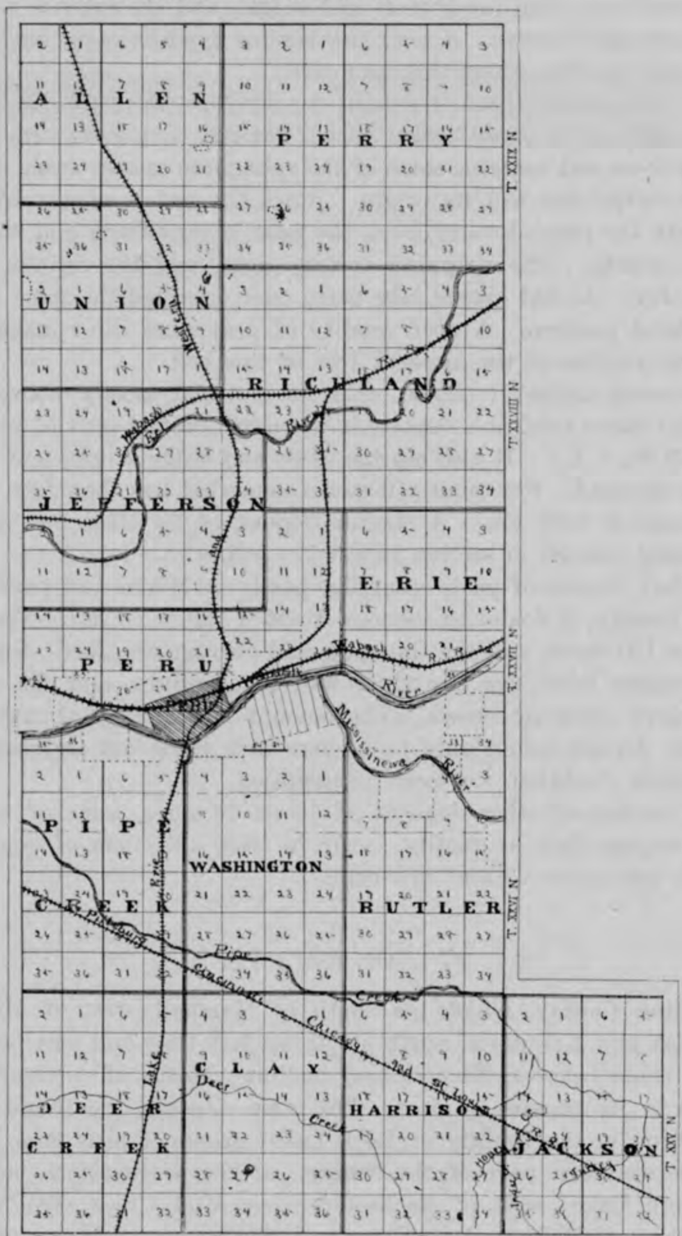
Other beds of 15 or 20 acres occur in this county, and will be of some importance for the home consumption. Most of these are of the grass and sedge origin, are shallow and largely above the ground-water level, but in some the quality is fair and the material is in a fresh condition. This condition is always found where the bed is beneath the ground-water level.

MIAMI COUNTY.

Occurring west of Wabash and east of Cass County is Miami County. With exception of some small deposits along the Wabash River, the peat is confined to the two northern tiers of congressional townships.

Within the city limits of Peru are several small peat deposits. of 15 or 20 acres, that will average fair in quality. These are about one-half beneath the ground-water level and range between 2 and

MIAMI COUNTY.



★ Workable deposit of peat that is partly of the moss, and partly of the grass and sedge variety.

.... Lines enclosing areas in which peat deposits are found.

10 feet in thickness, with $3\frac{1}{2}$ or 4 feet as an average. The derivation has been from the grasses and sedges, and the color is a very dark chocolate brown. A very few similar deposits occur both east and west of Peru, along this same river.

In the southern half of section 26 (29 N., 4 E.), are 125 acres of a medium chocolate brown peat. The bed is covered with tamarack trees and contains some of the sphagnum mosses from which the material has had its origin. Since the bed is almost wholly beneath the ground-water level, the peat is very fresh and is of a good quality. The stripping is very light, and the sub-soil is a blue clay. An old glacial lake basin once occupied the same topographical position. A good quality of peat moss litter makes up a large portion of the upper 2 feet of this bed.

Covering about 70 acres, with its material mostly above the ground-water level, is a deposit in the north-central part of section 21 (29 N., 4 E.). It also has the grass and sedge origin, and rests upon the sand. For quality it ranks somewhat less than fair. The thickness is very low. A similar deposit of 20 acres lies in the southeast quarter of section 16 (29 N., 4 E.).

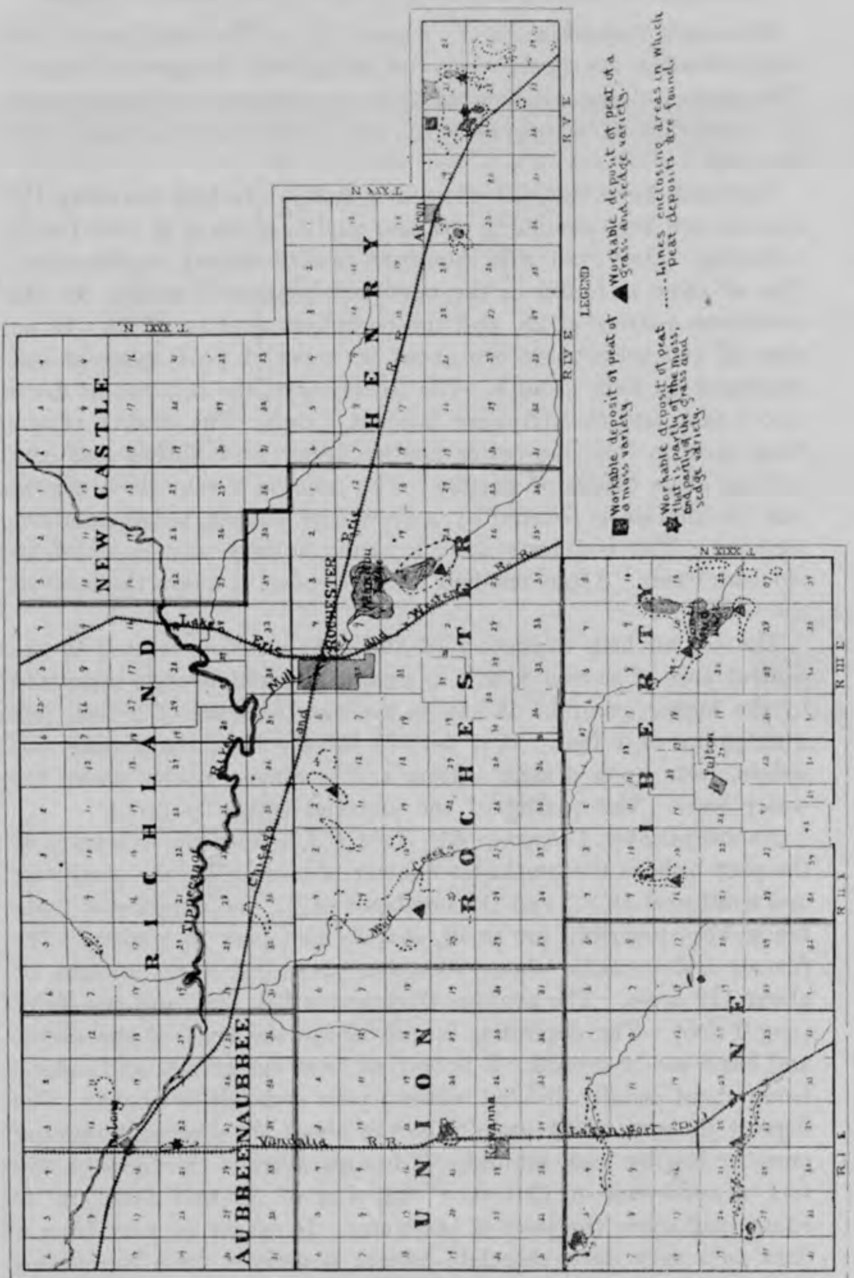
A fair deposit of peat, occurring partly in Miami and partly in Cass County, is found in sections 2 and 3 (29 N., 3 E.). The extent is 100 acres, and the thickness will average $2\frac{1}{2}$ feet. Grasses and sedges have been the chief sources of origin, and the color is a dark chocolate brown. The amount and quality of material in this deposit would only pay where it is taken out and used in the crude condition, for local consumption.

A number of other deposits of 15 or 20 acres, some of which will average fair in quality, occur in these two tiers of congressional townships, 29 and 30 North.

FULTON COUNTY.

Fulton County, which lies south of Marshall, west of Miami, Wabash and Kosciusko, north of Miami and Cass and east of Pulaski, ranks between the poor and medium counties of northern Indiana in its amount of peat. The main deposits are found east of Akron in the vicinity of Rock Lake; around South Mud Lake in the southern part of the county; at the southeastern end of Manitou Lake; west of Rochester along Mud Creek; $2\frac{1}{2}$ miles northwest of Fulton, along Grass and Mill Creeks in Wayne township, and one mile north of Kewanna. Besides the beds mentioned there are probably no others of more than 50 acres.

FULTON COUNTY.



TOWNSHIP 31 NORTH, RANGES 1, 2, AND 3, AND PART OF 4 EAST.

Newcastle Township (31 N., 3 and 4 E.).—The peat beds of this civil township are small, very few being over 25 acres in extent. The peat is almost all derived from the grasses and sedges, with the exception of a few beds in very small tamarack and moss marshes.

Richland Township (31 N., 2 and 3 E.).—In this township the deposits are very similar in size and quality to those in New Castle township. Only two will therefore receive special consideration. One of these is found in the northeast quarter of section 32, the southwest quarter of 28, and the northwest quarter of 33. In an area of 140 acres there are about 90 acres of peat, more or less separated by high ground. The thickness of the bed ranges from 1 to 5 feet, and the stripping is about 1 foot. The quality ranges from poor to fair, the better portion being very fibrous and containing large blades of grasses. The color is a very dark brown, and the surface is covered by a growth of grasses, sedges and cottonwood. The bed rests upon a sandy subsoil, and occupies an old lake basin. About one-half of the deposit is above the level of the water.

The second bed, consisting of about 40 acres, is located in the central part of section 8, and in numerous small pockets separated by the higher ground. It has an average thickness of 2 feet, and a stripping of 1 foot. It is derived largely from the grasses and sedges, rests upon a sand bottom and is almost wholly above the water level. The quality of the material is hardly fair.

Aubbeenaubbee Township (31 N., 1 E.).—With the exception of the peat beds in the southwest quarter of section 11, the northwest and southwest of 22, and the northeast of 21, the deposits of Aubbeenaubbee township are small, shallow and poor in quality. The former bed contains about 70 acres, spreading over an area of about 110 acres. The average thickness is 2½ feet, and the stripping 1 foot. The deposit is largely above the level of the water, and has a sandy subsoil. It is derived from the grasses and sedges, being about equally divided between poor and fair in quality. The deposit in sections 21 and 22 covers about 70 acres, interrupted more or less by high ground. It has an average thickness of 4½ feet, a maximum of 13 feet, a stripping of one-half foot, and is about half above the level of the water. It ranges in color from a dark to a very dark chocolate brown, is derived from the mosses and grasses, and rests upon a sandy subsoil. The quality varies between fair and good.

TOWNSHIP 30 NORTH, RANGES 1, 2, 3, 4, AND PART OF 5 EAST.

Henry Township (30 N., 4 and 5 E.).—The eastern portion of this civil township contains the largest and best peat beds of Fulton County. These beds lie around Rock, Mud and Summit Lakes. They are located in old lake basins, and being almost wholly derived from the sphagnum mosses, are of excellent quality. The portion of the deposit which extends southeast from Rock Lake through the southwest quarter of section 21, the northeast and

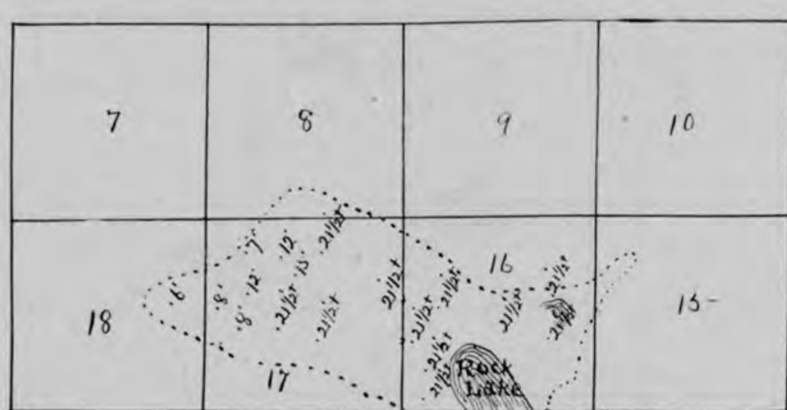


Fig. 9. Showing thicknesses, where soundings were made, of peat beds in the vicinity of Rock Lake.

southeast of 28, the northwest and southwest of 27, and the north-central portion of 34, has an extent of 250 acres; the average thickness being 6 feet with a maximum of more than 15 feet. The color ranges between a light and dark chocolate brown. The stripping is from one-fourth to one foot, and about one-third of the bed is above the ground-water level. About 60 acres of this deposit is covered with tamarack, the remainder with cottonwood, grasses, sedges and weeds. In the tamarack portions, considerable peat moss can be found.

Extending west and southwest from Rock Lake are 300 acres of peat, which are situated in the northeast and northwest quarters of section 20. These will likely average 12 feet in thickness, with a very light stripping, and are almost entirely derived from the sphagnum mosses. Not more than one-seventh of the bed is above the level of the water, and the quality ranks among the best in the State of Indiana. Also present in this marsh are large quantities of peat moss that would be very suitable for stable litter.

The green mosses are present in considerable abundance, and would be very valuable for nurserymen. In making the soundings in this marsh, much difficulty was experienced in getting the 15-foot sounding auger down, on account of the tamarack logs and roots, and in a number of places the writer was unable to reach the bottom at a depth of 15 feet. The material is in a rather loose condition and will occupy much less space when the water is drained off.

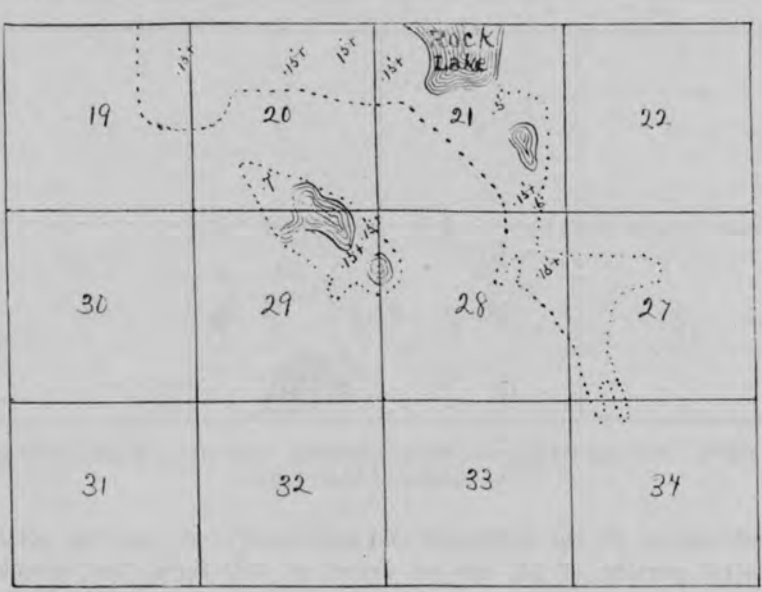


Fig. 10. Showing thicknesses, where soundings were made, of peat beds in the southeastern part of Henry township, Fulton County.

Around Summit Lake in the northwest and southwest quarters of section 28, the southeast, the northeast and northwest of 29, and the southwest and southeast of 20 are about 100 acres of peat, with an average thickness of 7 or 8 feet and a maximum of over 15 feet. Fully seven-eighths of this material is below groundwater level, and consequently is in a very incompact condition. Considerable shrinkage must be considered in determining the exact amount.

A small tamarack marsh containing a deposit of peat of about 10 acres is found in the northwest quarter of section 34. The quality of the material is good, the average thickness several feet and the stripping light.

In the northeast quarter of this same section is a rather poor deposit of peat of about 30 acres, which will not average over $1\frac{1}{2}$ feet in thickness, with a stripping of 1 foot. It has been derived from the grass, and is almost entirely above the ground-water level. Two other similar deposits with extents of about 20 acres each are found in the northwest quarter of this same section.

In the southwest quarter of section 24, the southeast of 23, the northwest of 25, and the northeast of 26 is a bed of peat consisting of about 50 acres, but frequently interrupted by high ground. It has an average thickness of 2 feet and a stripping of $1\frac{1}{2}$ feet; its color is a very dark brown and it is largely derived from the grasses and sedges. The quality will hardly average good, and the bed in many places rests upon marl. The upper portion of this bed is well decomposed in a large number of places, and raises very good crops of the blue grass. This furnishes an excellent pasture for cattle.

Rochester Township (30 N., 2 and 3 E.).—As we advance westward no other workable deposit is found until we reach the southeast edge of Manitau Lake in the southwest quarter of section 14, the southeast and southwest of 15, the northwest and southwest of 23, and the northeast, northwest and southeast of 22. This is a bed of 250 acres, with a thickness of about 8 feet on the average, though many places have a thickness of more than 13 feet. Probably not more than one-fifteenth of this deposit is above the level of the ground-water, and consequently it is in a very loose conditon so that much settling will take place after draining. The color varies from a very dark chocolate to a medium chocolate brown; the material is derived partly from the grasses and sedges, and partly from sphagnum moss.

Two miles west of Rochester in the southeast and southwest quarters of section 1 are about 60 acres of a very dark chocolate brown peat, derived from the grasses and sedges and of a fair quality. The bed has an average thickness of 3 feet and rests on a sandy sub-soil, and has about 1 foot of stripping. The bed is more than one-half above the level of the ground-water.

A bed, with an extent of 100 acres and an average thickness of 5 feet, is located in the northeast and southeast quarters of section 2, and in the north-central portion of 11. About one-half of the deposit is above the level of the water, the stripping is 1 foot and the sub-soil is sand. The derivation is from the grasses and sedges, and the quality is fair.

A 60-acre bed of peat is found in the southwest quarter of section 2, the northwest of 11, the northeast of 10, and the southeast of 3. The average thickness is about 2½ feet, with a maximum of more than 13 feet, and a stripping of 1 foot. The material is of a very dark brown color, rests upon a sandy sub-soil, and is derived from the grasses and sedges. It ranges between poor and fair in quality. The decomposed surface makes a fair soil for pasture.

About one mile west in the southwest quarter of section 4, the southeast of 5, the northeast of 8, and the northwest of 9 is a 100-acre extent of peat, with an average thickness of 2 feet, about 1 foot of stripping, and a very dark chocolate brown color. About three-fourths of the bed is above the level of the water; the bottom rests upon sand, and the quality is hardly fair. It is derived from the grasses and sedges.

A 300-acre peat deposit, which is sandy, very much cut up by the higher ground, and is below the average in quality, is found along Mud Creek in the northern half of section 17, each quarter of 16, the western half of 21, and the eastern half of 20. The average thickness is about 3 feet and the maximum more than 13 feet. The color is a very dark chocolate brown, the stripping 1 foot and the sub-soil is sand; the derivation of the material is from the grasses and sedges. The decomposed surface has formed a fair soil for pasturing. A workable amount of peat for a large plant could probably be found in this deposit.

One-fourth mile east of Mud Creek in the northeast quarter of section 15 are some 50 acres of peat, rather low in thickness, having a very dark chocolate brown color, and being mostly of a poor quality. Like the preceding deposit, it is derived largely from the grasses and sedges, and rests upon a sandy subsoil. It is also said to be a fair pasture and corn land, and is situated in a basin of an old lake.

Union Township (30 N., 1 E.).—In the civil township of Union the only deposit that would be workable is found 1 mile north of Kewanna in the northwest quarter of section 22, and the northeast quarter of 21. It has an average thickness of 7 feet and a maximum of more than 15 feet, while the stripping is about ½ foot. One-third of the material is above the level of the water. The color is from a dark to a medium chocolate brown, the derivation being from the sphagnum mosses.

TOWNSHIP 29 NORTH, RANGES 1, 2, AND PART OF 3 EAST.

Wayne Township (29 N., 1 E.).—The main peat beds of the civil township of Wayne are found along Grass and Mill Creeks. The former deposit commences in section 5 and extends east for several miles, then southeast to a point 3/4 of a mile northeast of Mt. Vernon. This deposit occurs only as pockets in the higher ground, and is generally very shallow, not averaging over 1½ feet in thickness. The maximum thickness is probably 6 feet. The quality is generally poor, considerable sand being mixed with the material, and the upper foot being very much decomposed. It is almost entirely above the level of the water, and the stripping is rather heavy. The derivation has been largely from the grasses and the sedges, and the surface is decomposed into a fair soil for pasture. The Mill Creek bed is similar to the other in almost all respects and is found more or less throughout the extent of this stream in the township.

Liberty Township (29 N., 2 and 3 E.).—About 2½ miles northwest of Fulton are 200 acres of peat separated into rather small patches by the higher ground. The beds will probably average 4 feet in thickness, and in many places attain more than 13 feet. The stripping is 1 foot and fully one-half of the bed is above the level of ground-water. The quality will average almost fair, the peat having a fibrous texture and the blades of grass being very pronounced. The best portion of the deposit is in the southern third of the bed, where the thickness will probably average 9 feet. The color is a very dark chocolate brown, and the subsoil is sand. The derivation of the material is mostly grass. The surface is covered with a fair pasture grass.

About 4 miles northeast of the town of Fulton in the southwest quarter of section 8 and the northwest quarter of 17 is a bed of peat containing about 30 acres and of a fair quality; its thickness is 5 feet and its color a very dark brown. It has about 1 foot of stripping and is about one-half above the ground-water level. This deposit would not be of sufficient size except for a plant of possibly 30 tons output.

The extent of the deposit about North and South Mud Lakes will aggregate 500 acres, 100 of which are found in the southwest quarter of section 10, the northwest and southwest of 15, and the northeast and southeast of 16; 200 in the northwest, southwest, northeast and southeast of 17, and the southwest of 16; and 200 more in the southwest and southeast of 21, and the southwest of 22. The thickness, which will average 6 feet, is in many places more than 13 feet. The stripping is one-half foot, and about one-twelfth of the bed is above the ground-water level. Since such a large portion of the deposit is beneath the water level it is very loose and will contract greatly upon the drainage of the bed. The material is largely derived from the grasses and sedges, and is of a fair quality. These beds rest in many places upon the marl and sand and are located in what was previously a greater extent of the Mud Lakes. The location is good for a large peat plant, there being an abundance of the material, a limited amount of wood in this locality, and a railroad near the south end of the beds.

One-half mile east of South Mud Lake in the southeast quarter of section 15 and the northeast of 22, are 50 acres of a rather poor quality of peat, which has a very dark chocolate brown color. The bed has an average thickness of 2½ feet, and is largely above the ground-water level. It has a stripping of 1 foot, and rests upon a sandy sub-soil. It has been derived from the grasses and sedges, and, at present, makes a fair pasture soil.

One-half mile south, in the northeast quarter of section 27, is a peat bed of 40 acres, having an average thickness of about 3 feet, a stripping of 1 foot, and lying about one-half above the level of the ground-water. It rests upon the sand and the quality is about equally divided between a poor and fair. The color is a very dark chocolate brown, the derivation having been from the grasses and sedges.

In the southeast quarter of the same section is a good bed of peat, which has been derived from the sphagnum mosses. It is now covered with tamarack, consists of some 30 acres, has an average thickness of 4 feet and a light stripping.

Numerous small deposits are found in this county that have not been mentioned on these pages, but which will serve very well for individual use, especially where one chooses to spade out his own peat and burn it in the crude condition. For this purpose the consumer will find the peat of the tamarack and huckleberry marshes most satisfactory, but can get a fair fire from the peat of the grass marshes.

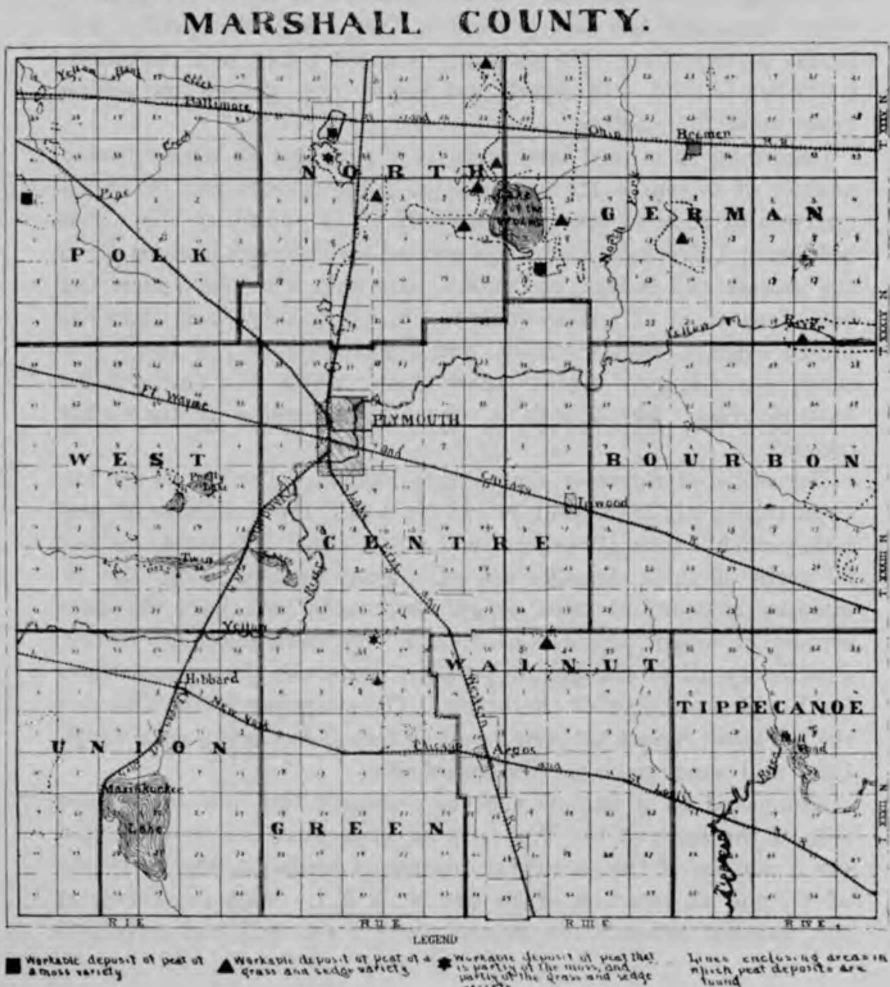
CASS COUNTY.

Cass County lies south of Fulton and east of Miami County. Of the peat-bearing counties, it is the least important.

In addition to the deposit, which occurs in both Miami and Cass Counties and is described on page 206, very few are found of sufficient size to justify the erection of even a small peat plant. A deposit of about 40 acres lies in section 22 (29 N., 3 W.). Its shallowness and large part of material above the ground-water level gives a quality hardly averaging fair. The origin has been from the grasses and sedges, and the color is a very dark chocolate brown.

MARSHALL COUNTY.

Marshall County lies in the middle portion of the second tier of counties from the north boundary of the State. It is south of St. Joseph County, west of Elkhart and Kosciusko, north of Fulton and east of Starke and Laporte. It contains numerous peat beds of economic importance, and a few, which rank among the best of the State.



PARTS OF TOWNSHIPS 34 AND 35 NORTH, AND RANGES 1, 2, 3 AND PART OF 4 EAST.

German Township (34 and 35 N., 3 and 4 E.).—A fair quality of peat lies in the eastern half of section 23 and the western part of 24 (35 N., 3 E.). The extent is 20 acres, the thickness about 3 feet, and 50 per cent. of the material is above the level of the ground-water. The chief source of origin has been the grasses and sedges, and the color is a dark chocolate brown. The stripping is 1½ feet.

In the eastern half of section 8 (34 N., 3 E.), is a bed of peat, having a length of one-half of a mile, and a width of one-eighth of a mile. Since one-third of the material is above the ground-water level and the bed is shallow (see map) the quality will hardly average fair. The stripping is about 1 foot, and the underlying bed is sand. Tamarack and maple trees, grasses and sedges grow upon the surface.

Occurring in an old lake basin is a peat bed in the southwest quarter of section 2, the southeast of 3, the eastern half of 10, all quarters of 11, and the northern half of 14 (34 N., 3 E.). This bed being fully half above the ground-water level, derived from the grasses and sedges, and mixed somewhat with the underlying bed of sand, is of a fair quality. It has a very dark chocolate brown color, a sandy sub-soil, and a stripping of 1½ feet. The stripping is largely a black sandy loam, which is a fair soil for pasture grass. The deposit is very much dissected by the higher ground.

German and Bourbon Townships.—Along Yellow River in sections 19, 20, 21, 28, 29 and 30 (34 N., 4 E.), are a number of peat beds, which, taken altogether, will cover about 250 acres. About 50 acres of these deposits are of a good quality, while the remainder is poor. Grasses, sedges and weeds have been the main sources of origin, and the color is a very dark chocolate brown. Practically all of the poorer portions are above the ground-water level, and about half of the better. The stripping is 1½ feet and the thickness ranges between 2 and 15 feet, 3 feet being an average. Clay and sand make up the sub-strata.

Connected by a narrow neck to a deposit that lies on the east side of the Lake of the Woods is an important peat bed, occupying a portion of the southwest quarter of section 8, the northwest of 17, and all quarters of 18 (34 N., 3 E.). With two-thirds of the material beneath the ground-water level, and the derivation

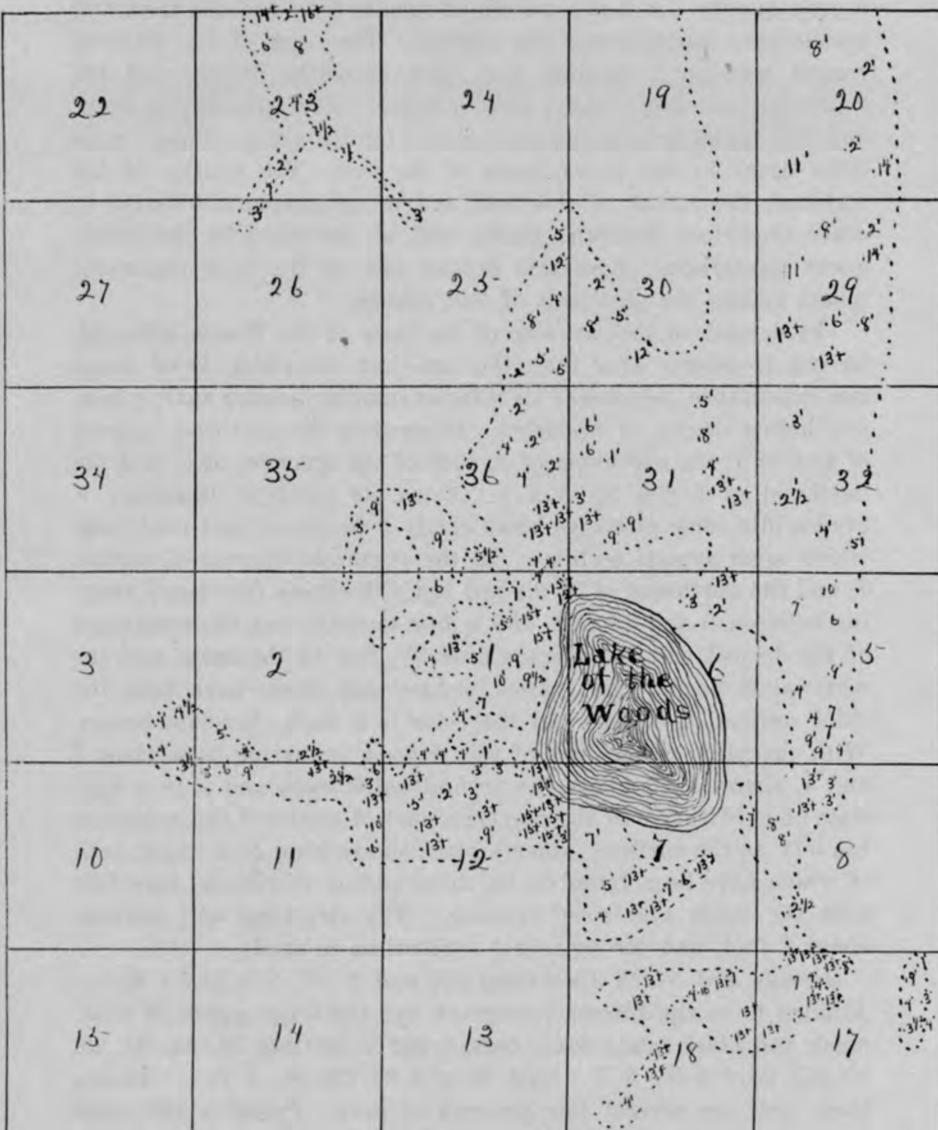


Fig. 11. Showing the thicknesses, where soundings were made, of the peat beds in the vicinity of the Lake of the Woods, Marshall County.

largely from the sphagnum mosses this deposit is, as a whole, of a good quality. A dense growth of tamarack and maple trees and huckleberry bushes cover the surface. The color of the material ranges between a medium and dark chocolate brown, and the thickness (see map) has a good average. The stripping is light, and the underlying formation sand. Large bodies of peat moss litter occur in the upper parts of the bed. The quality of the material, the extent of this bed, and its geographical relation to other important deposits, which will be described in the subsequent paragraphs, gives this deposit one of the most important places among the peat beds of this county.

The deposit on the east side of the Lake of the Woods, although having a greater area than the one just described, is of much less importance, because of its inferior quality, greater shallowness, and higher degree of oxidation. It occupies the northeast quarter of section 7, the northwest of 8, each of the quarters of 5, and the northeast of 6 (34 N., 3 E.). Along its northern boundary it grades into some extensive black sandy loam, muck and peat beds, which cover several sections. In the northeast quarter of section 7, and the northwest of 8, the bed has a thickness (see map) ranging between 6 and 13 feet, and a fair quality; but the remainder of the deposit will not average over 3½ feet in thickness, and the material is poor. The grasses, sedges and weeds have been the chief sources of origin, and the color is a dark chocolate brown. With exception of the part of this deposit, occurring in sections 7 and 8, almost all is above the ground-water level, and is in a high state of oxidation. In the northern part of section 8 the oxidation has left, at the surface, either a black sandy loam or a muck, both of which have been found to be, upon adding fertilizers, very fair soils for onion and corn growing. The stripping will average about 1 foot, and the principal substratum is sand.

German and North Townships (34 and 35 N., 2, 3 and 4 E.).—Alluded to in the former paragraph are the large scopes of peat, muck and black sandy loam beds, lying in sections 31, 32, 30, 29, 19 and 20 (35 N., 3 E.), and 35 and 36 (35 N., 2 E.). Among these beds are several fair deposits of peat. Probably 200 acres of such can be found in the western halves of sections 30 and 31, and the eastern halves of 25 and 36 Here the thickness (see map) will average 4½ feet, and 30 per cent of the material is beneath the level of the ground-water. A few similar deposits, but of only 25 or 30 acres, occur in sections 19, 20, 29 and 32. All of these have a sandy subsoil, and a dark chocolate brown color.

West of the Lake of the Woods, in the southwest quarter of section 36 and the southeast of 35 (35 N., 2 E.); the northeast, southeast and southwest of 2, the southeast of 3, the northeast of 10, the northern halves of 11 and 12, all quarters of 1 (34 N., 2 E.), and the northeast, southeast and southwest quarters of section 7 (34 N., 3 E.), is a large bed of peat, notably broken by the higher ground. The quality and the origin of the material are variable. That found bordering the Lake of the Woods, in the northeast quarter of section 1, the northeast of 12, and the western half of 7, and in the tamarack marshes in the northwest quarter of 12, the northeast of 11 and the southeast of 3, is of a good quality, being mostly beneath the ground-water level, of a good thickness (see map), and having its origin, for the most part, from the sphagnum mosses. The color of this material varies between a medium and a dark chocolate brown, and the stripping is almost nothing, if the peat moss litter and green mosses be utilized. These beds, taken together, will probably cover 75 acres.

The remainder of these deposits will cover several hundred acres, and are from poor to fair in quality. Since the thickness (see map) has a low average and the material is chiefly above the ground-water level, oxidation from atmospheric contact has left the surface decidedly decomposed. The color is a very dark chocolate brown, and the origin has been from the grasses, sedges and weeds. The stripping is about 1½ feet, and the sub-stratum is sand.

All of these beds about the Lake of the Woods were undoubtedly formed when this lake had a much greater extent, occupying all of the basins, now filled with the peat deposits. The accumulation[1], and partial decomposition of vegetation beneath the level of the water, and the lowering of the ground-water level, has given rise to the occurrence and topographical position of these beds.

The southern extremity of the large deposit of peat, occurring in St. Joseph County and described on page 238, lies in the northwest of the northwest quarter of section 25 and all quarters of 24 (35 N., 2 E.); and the northwest of the northwest of 30, and the southwest of the southwest of 19 (35 N., 3 E.). In the northern half of section 24 the deposit is of good quality, being of a fair thickness (see map), largely beneath the ground-water level, and of a medium to a dark chocolate brown color. Here the extent is one-half of a mile from north to south, and one-sixth of a mile from east to west. South of the central part of this section the bed becomes

[1]See page 83.

very narrow, shallow and of poor quality. The origin, like those in St. Joseph County, has been principally from the sphagnum mosses; especially is this true in the northern half of section 24. Sand is the leading subsoil. Potatoes and corn grown on the oxidized surface are said to yield fairly well.

North Township (34 and 35 N., 2 E.).—About 25 acres of a poor to fair quality of material occurs in the southwest quarter of section 22 and the northwest of 27 (35 N., 2 E.). This peat has a dark

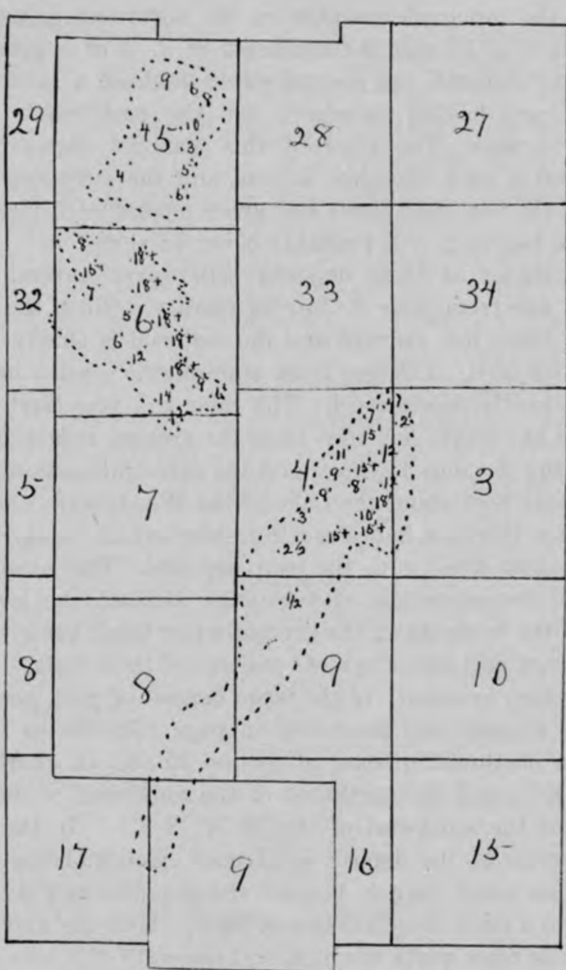


Fig. 12. Showing the thicknesses, where soundings were made, of the peat beds in the northwestern half of North township, Marshall County.

chocolate brown color, and has been formed from the grasses and sedges. The stripping is 1 foot, the average thickness is about 3½ feet, and the maximum 9 feet.

A bed of peat having an extent of over 200 acres, lies in the eastern half of section 4, and the western of 3 (34 N., 2 E.); and the southeast quarter of 33 and the southwest of 34 (35 N., 2 E.). The deposit is fully half beneath the ground-water level, and is of a good thickness (see map), and the quality will average fair. It has originated from the sphagnum mosses, grasses, sedges and weeds, has a dark chocolate brown color, and rests on a sandy subsoil. The stripping ranges between ½ and 2 feet, and is covered with grasses, sedges, weeds, and, in places, maple trees. The soil is well adapted to potato growing.

A bed of considerable extent, but of little economic importance, from a fuel point of view, connects with the bed, above described, and extends in a southwesterly course through the western half of section 9 and the eastern half of section 8 to the west-central part of 9 and the east-central of section 17 (34 N., 2 E.). The material is almost wholly above the ground-water level, highly oxidized and of poor quality. The average thickness is not over 1½ feet, and the stripping is heavy.

In the southern half of section 10 and the east-central part of section 20 (34 N., 2 E.), are 70 acres of a poor quality of peat, a few acres of good, and probably 20 acres of fair quality. The average thickness is about 2½ feet, and the maximum 15 feet. Taken as a whole, fully two-thirds of the material is above the ground-water level, and more or less sand is mixed with it. The stripping is about 1 foot, and the underlying bed is sand. Grasses, sedges and weeds have been the main source of origin, and the color is a very dark chocolate brown.

About 35 acres of a deposit similar in quality, color, stripping, thickness, impurities, amount of material above ground-water level, and topographical position, lies in the northeast quarter of section 20 (34 N., 2 E.). This bed has a sandy subsoil, and its surface is, in places, a black sandy loam.

Extending northeast and southwest, and occupying almost half of section 5, is a marsh covered with tamarack trees and huckleberry bushes. Underlying this vegetation are two feet of a good quality of peat moss litter, beneath which the peat occurs, resting upon the sand and clay. This peat, being formed from sphagnum mosses and occurring beneath the ground-water level, is of a good quality. (See map.) The bed is exceptionally shallow for one of its kind, and the stripping is very light. The color of the material is a medium chocolate brown.

Immediately south of this deposit, in the eastern half of section 32 and all of 6 (35 N., 2 E.); and the northeast quarter of 7, the southwest of 33 and the northwest of 4 (34 N., 2 E.), is a bed occupying a similar topographical position, and having similar substrata. Its material ranges between fair and good in quality, and some of it is almost wholly beneath the ground-water level, while other parts are about half above. The bed has been derived from the sphagnum mosses, grasses and sedges, and the color is a medium to a dark chocolate brown. The stripping is about ¾ of a foot, and in places, makes a good soil for potato growing. Four hundred bushels are reported to have been raised from one acre. However, the surface on which these were raised was one over which the fire had passed, burning deeply into the bed. This consumed a large part of the organic matter and concentrated the potash and other inorganic substances, thus leaving a very fertile soil.

Since the beds described in the two preceding paragraphs are of such suitable qualities and extents, and the B. & O. Railroad cuts the northern portion of the one in section 5, a suitable location for the erection of a peat plant might be found in this vicinity.

Polk Township (34 and 35 N., 1 E.).—A deposit of 80 acres, 50 of which will average fair and 30 poor, lies in the southeast quarter of section 19 and the northeast of 30 (35 N., 1 E.). Both the fair and the poor qualities have been derived from the mosses, grasses, sedges and weeds, and are more than half above the ground-water level. The underlying formation is a fine sand, and good pasture is found upon the surface.

Located in the southeast quarter of section 30 and the southwest of 29 (35 N., 1 E.), are 40 acres of a medium chocolate brown colored peat, which is of a good quality. The bed is covered by sphagnum mosses, tamarack trees, ferns, grasses and sedges, and is four-fifths beneath the ground-water level. The stripping is very light, and the thickness will average about 15 feet. Peat moss litter and some green mosses are found in the upper parts. This bed is of sufficient importance to justify the erection of a small peat plant.

A material, not quite as good as the above, but ranging between fair and good, lies in the northeast quarter of section 31 and the northwest of 32 (35 N., 1 E.). The deposit has about one-third of its volume above ground-water level, a very light stripping, and contains 80 acres. It is rather shallow (see map), and the color is a medium to a dark chocolate brown. Sand composes the underlying formation, and huckleberry bushes, sedges and some pasture grasses grow on the surface.

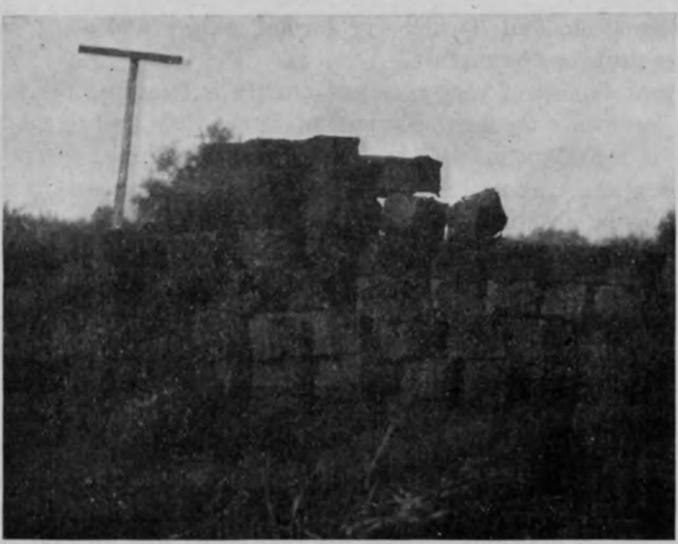
A peat deposit of very excellent quality is found on the farm of C. F. Brown, in the northeast part of Tyner City, and in the northeast quarter of section 10 (34 N., 1 E.). This deposit covers about 20 acres, has a known average thickness of 20 feet, and is mostly beneath the ground-water level. Its color is a dark chocolate brown, and the origin has been from the sphagnum mosses. The stripping is ½ of a foot, and the substrata are sand and marl. The analysis[1] of the Indiana peats by Dr. R. E. Lyons of the State University, showed this material to have the highest fuel value of the 29 samples which were taken from all of the principal peat counties of the State.

Mr. Brown, the owner of this deposit, is taking the material out in the crude condition. By means of a double-bladed spade[2], he throws the peats out in the form of blocks[3], about 1 foot long and 3½ inches in diameter. These are then piled up[4], so that the air can circulate between them and dry them out. However, this process of drying is very crude, at best; since 45 or 50 per cent. of the total weight still remains water. Mr. Brown prefers to have his place of spading so arranged that he can stand on the dry ground and spade the peat out from beneath the level of the water, since in this position it is very sectile; but when once dried out, it becomes hard, and is cut with difficulty.

After becoming as dry as possible in the atmosphere, the blocks of peat are hauled to the woodshed and stowed away for use. No other fuel is used by Mr. Brown, and the writer saw no cleaner and more comfortable fire in any stove in northern Indiana, than the one he saw in Mr. Brown's, at Tyner City. For his benefit, Mr. Brown kindly kindled a fire in an ordinary range stove, and the following phenomena were noted: A few pieces of light kindling were ignited. On these were laid some small pieces of peat, well dried, upon which were placed several of the larger blocks. Only 1½ minutes elapsed, after the kindling had been ignited, until the large blocks were well caught, and were giving off a very noticeable amount of heat. At this stage considerable smoke was passing off, and the flames were short and blue in color; but as the process advanced, the smoke became less and the flame took on a yellow color. The amount of heat given off rapidly increased. After seven min-

[1]See table on page 99.
[2]See picture on page 224.
[3]See picture on page 224.
[4]See illustration on page 224.

Plate V.



Peats stacked up for drying on the farm of C. F. Brown, near Tyner City, Indiana.

Tools used in the digging of peat at the bog of C. F. Brown, Tyner City, Indiana.

Plate VI.

Cat Tail Marsh on the Starke and Marshall County line, three miles west and one mile north of Tyner City

Huckleberry Marsh on the Starke and Masrhall County line, three miles west and one and a half miles north of Tyner City, Indiana.

utes had passed all of the dampers were closed, the stove lids removed, and the smoke and odors allowed to come into the room. The amount of the former was very small, and the latter could scarcely be detected. The amount of ashes is less than for soft coal, and more than for wood. Mr. Brown puts these ashes on his garden, and finds them to be an excellent fertilizer.

In the northern half of section 7 and all of 6 (34 N., 1 E.), and the southwest quarter of 31 (35 N., 1 E.), of Marshall County, and extending into Starke County, is an important body of peat. In Marshall County it extends over about 200 acres of surface, has a good average thickness (see map), a light stripping and a sandy subsoil. Since only one-seventh of its volume is above the groundwater level, and the material is in a very pure condition, the quality is good. The color is a medium to a dark chocolate brown, and the origin has been from the grasses, sedges and sphagnum mosses. However, the northern part has been almost wholly from the sphagnum mosses, especially from *S. acuminatum*. Even now the surface of this part is deeply carpeted by this moss. Between the green mosses of the surface and the peat, are a few feet of a good quality of peat moss litter. In addition to the green mosses, growing on the surface, are tamarack trees and huckleberry[1] bushes. As we advance southward the bed becomes more shallow, and is derived mainly from the grasses and sedges. Wool grass[2], poplar, cottonwood, briers, and various other grasses and sedges cover these portions. In the central part of section 6 is the site of a lake, which was drained a few years ago. It is now entirely grown over with cat tails[3], the extent being one-half of a mile from north to south, and one-quarter of a mile from east to west. Underlying these cat tails is a very thin sod, and then a very incompact mass of peat and water, having an average thickness of 15 feet.

West Township (33 and 34 N., 1 E.).—A shallow and impure peat deposit, of 20 acres, lies in the southeast quarter of section 28 and the southwest of 27 (34 N., 1 E.). It has been derived from the grasses and sedges and has a very dark chocolate brown color. The average thickness is 3 feet and the stripping is 1½ feet. Its only importance, as a fuel, would be to supply the immediate neighbodhood with a crude material.

Covered with grass and lying in the northern half of section 9 (33 N., 1 E.), are 20 acres of a very dark chocolate brown peat.

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[1]See illustration on page 225.
[2]See illustration on page 225.
[3]See illustration on page 225.

The deposit has an average thickness of 3 feet, and is more than one-half above the ground-water level, thus leaving the material oxidized and of hardly a fair quality. The stripping is 1½ feet, and the derivation is from the grasses and sedges.

Surrounding a small lake in the southeast quarter of section 10, the southwest of 11 and the northeast of 15 (33 N., 1 E.), is a deposit of peat of good quality[1]. Being derived from the sphagnum mosses, it has a medium to dark chocolate brown color, and its condition is very fresh, since five-sixths of the bed is beneath the ground-water level. The stripping is about one-half of a foot, and the thickness (see map) about 15 feet.

Immediately north of this bed, in the northeast quarter of section 10 and the northwest of 11 (33 N., 1 E.), are 35 acres of peat, ranging between poor and good, but averaging poor. In general it is shallow (see map), sandy, and highly oxidized. The color is a very dark chocolate brown and the stripping is 1½ feet. Several acres of this bed, however, are of a good quality and thickness, and will be very useful in supplying the local demand. The main source of origin has been the grasses and sedges.

South of Pretty Lake, in the southeast quarter of section 11 and the southwest of 12 (33 N., 1 E.), is a long, narrow bed of peat. It has originated from the grasses, sedges and sphagnum mosses, and has a medium chocolate brown color. Since it is almost wholly beneath the ground-water level, and is little oxidized from atmospheric exposure, the quality is good. The average thickness is about 10 feet, and the stripping is ½ of a foot.

A deposit, similar in quality, color, origin, oxidation and stripping, lies in the west-central portion of section 11 (33 N., 1 E.). Its extent is 6 acres, and the average thickness is 6 feet.

In an old lake basin, overgrown with tamarack trees, is a peat bed in the southeast quarter of section 16 (33 N., 1 E.). Since the material has been derived from the sphagnum mosses the color is a medium to a dark chocolate brown, and the quality is good, the deposit being mainly beneath the ground-water level. Having an extent of 35 acres and a thickness ranging between 8 and 15 feet, the deposit is suitable for a small peat plant, which could supply the local demand for fuel. The stripping is only ½ of a foot, and a good peat moss litter can be obtained from the upper part of the bed.

A similar deposit to the above in extent, thickness, stripping, quality, color, amount of material above ground-water level, and

[1]See page 84.

peat moss litter, occurs in the southern half, and near the center of section 21 (33 N., 1 E.).

On either side of the outlet to the Twin Lakes, in the northern half of section 21 (33 N., 1 E.), are 60 acres of peat, forming a long and narrow bed. The material, being more than half above the ground-water level, and having been derived from the grasses and sedges, ranges between fair and poor in quality. The average thickness is about 3½ feet, while the maximum is 15 feet, and the stripping is 1½ feet. The color is a very dark chocolate brown.

Six small tamarack marshes, underlain by an excellent quality of peat and peat moss litter, and containing more or less of green sphagnum, lie in the northern half of section 22, and the northwestern quarter of 23 (33 N., 1 E.). The number of acres covered by these various beds are as follows: 20, 12, 12, 15, 15 and 15, making a total of 87 acres. All of these deposits have been formed from sphagnum mosses, are almost wholly beneath the ground-water level, and are consequently of excellent quality. The color is a medium chocolate brown. The thickness of these beds will average, at least, 19 feet, and the stripping, if the peat moss litter and green mosses are utilized, is practically nothing. Several other beds of a similar quality, but of smaller areas, are reported to be present in this same neighborhood.

Center Township (33 and 34 N., 2 and 3 E.).—Extending in a northwest and southeast direction, in the northwest and southeast quarters of section 7 (33 N., 2 E.), are 30 acres of an inferior quality of peat. It has a dark chocolate brown color, and has been formed from the grasses, sedges and sphagnum mosses. Fully half of it is above the ground-water level, and the average thickness is only 3½ feet. This bed has a stripping of 1 foot, and a sandy subsoil.

Twenty acres of a poor quality of material, having a very dark chocolate brown color, occurs in the east-central part of section 29 and the west-central of 11 (34 N., 2 E.). The average thickness of this deposit is only 3 feet, and it is almost entirely above the ground-water level. The stripping is 1 foot, and the underlying formation is a sand. The origin has been from the grasses, sedges and weeds. Fair pasture is found upon the surface.

In the southern half of section 13 (33 N., 2 E.), is a peat bed, having an extent of 25 acres, and an average thickness of 3 feet. Since it lies almost wholly above the ground-water level, and has consequently become much decomposed by atmospheric contact, the quality will average poor. Having been formed from the grasses and sedges, the color is a dark chocolate brown. Sand comprises the underlying formation, and 1½ feet the amount of stripping.

At the junction of sections 1 and 12 (33 N., 2 E.), and sections 6 and 7 (33 N., 3 E.), occurs a peat bed, with an areal extent of 25 acres, and a thickness averaging about 3 feet. It is of a very dark chocolate brown color, and a grass and sedge origin. Since 80 per cent. of the material is above the ground-water level, and the more shallow portions of the bed have become mingled with the sandy subsoil, the average quality is poor. The stripping is 1½ feet. Fair crops of corn are raised on the highly decomposed surface.

Fifteen acres of a poor and very dark colored peat, lies in the northeast quarter of section 18 (33 N., 3 E.). The deposit, having only an average thickness of 3 feet, and being almost entirely above the ground-water level, will not average fair in quality. Its derivation is from the grasses, sedges and weeds, the stripping is 1½ feet and the underlying formation is sand.

Where an old lake basin once existed in the southern half of section 8, the southwest quarter of 9, the northwest of 16 and the northeast of 17 (33 N., 4 E.), is a peat bed, consisting of 250 acres. The average thickness being only 2½ feet, and the material being almost wholly above the ground-water level, the quality can only average poor. However, there are a number of limited areas of 4 or 5 acres, that will average fair in quality and a few will average good. Grasses and sedges have been the chief source of origin, and the color is a very dark chocolate brown. The stripping is 1½ feet and there is a sandy substratum.

A marsh containing 25 acres of tamarack trees and 15 acres of grasses and sedges, is found in the western half of section 21 (33 N., 4 E.). Underlying this marsh is a peat bed, which has an average thickness of 13 feet in the tamarack portion and 3 feet in the grass and sedge part. While 90 per cent. of these heavier beds occur beneath the ground-water level, only 30 per cent. of the shallow portion are so situated. This accounts for the former being little oxidized by air contact, and of good quality; while the latter is much decomposed, and of hardly a fair quality. Furthermore, the shallow portion has become mingled somewhat with the sandy subsoil. The heavier part of the bed is very largely of sphagnum moss origin, while the latter is more from the grasses, sedges and weeds. While the stripping of the tamarack is almost nothing and the color is a dark chocolate brown, the stripping of the grass and sedge part is about one foot, and the color a very dark chocolate brown.

Tippecanoe Township (32 and 33 N., 3 and 4 E.).—This township has been well drained by the Tippecanoe River and its tributaries, thus leaving all of the larger peat beds above the ground-water level, where they have undergone almost a complete decomposition in the presence of the atmosphere. The sites of these old deposits are now marked by black sandy loam and muck soils. However, there are a few very small beds that could be worked in a crude way to help supply the local demand.

Walnut Township (32 and 33 N., 2 and 3 E.).—A deposit of peat, which is very exceptional because of its topographical position, occurs in all quarters of section 31, the northwest, southwest, and southeast of 32, and the southwest of the southwest of 33 (33 N., 3 E.), and the northwest of 6, the northern half of 5, and the northwest of the northwest of 4 (32 N., 3 E.). The heavy peat beds compose terraces, wihch partially surround what was very recently a lake bed. Over the recent lake bed the peat deposit has an average thickness of about 2½ feet, but toward the northeastern shore the ground has a gradient of less than 1 degree, until near the terrace front, where the grade suddenly becomes greatly increased, ranging between 15 and 30 degrees. Above this higher grade is an altitude 10 feet greater than that of the lake bottom. At this point is the edge of a large peat terrace, with a width varying between one-quarter and one-half of a mile. Continuing northeastward is a comparative level plain, which is the surface of the peat terrace, until the shore of the old lake is reached, when a steep grade is again encountered, ranging between 15 and 30 degrees. This terrace is best developed on the northeast and northern shores of the old glacial lake, and probably consists of 150 acres. The plants from which its peat was formed were mostly the grasses and sedges. While the bed is very shallow on the recent lake bottom, it is from 9 to 15 feet in the terrace. The color for the entire deposit is a dark chocolate brown, the average quality is fair, and about one-half of the material is above the ground-water level. The stripping is 1 foot and the substratum is sand.

The development[1] of this peat bed commenced when the old glacial lake still existed, with its shore line about where the outer boundary of the terrace is at present. Mosses, grasses, sedges and other vegetation grew out a little ways upon the surface of the water, died and settled beneath the surface. Other vegetation grew upon the surface of the water, receiving some food from that which was submerged previously. This process of submergence

[1]See page 81.

and accumulation continued, until the basin has been well filled with partially decayed vegetation out to where the terrace edge occurs at present. Beyond this point the accumulation either took place much more slowly, or through a more brief period of time. Springs, a change in the temperature of the water, currents, and a lowering of the ground-water level might have been influential factors in either case.

Center and Green Townships.—Covering fully 200 acres of surface, which was once occupied by an old lake, is a peat bed in the eastern half of section 28, the western of 27, the northwest quarter of 34, and all quarters of 33 (33 N., 2 E.). The material having been derived from the grasses and sedges, and to a less extent from the sphagnum mosses, the predominating color is a dark chocolate brown. Since a little more than one-half of the bed is beneath the ground-water level, the quality will average fair. Sand and marl are the principal substrata, and one foot is the amount of stripping. The thickness (see map) is variable, the portion covered by tamarack being 15 feet, and the remaining not averaging over 4 feet. The quality of the peat in the tamarack parts is splendid. Here, also, is found some peat moss litter, and a small amount of the green mosses.

Green Township (32 and 33 N., 2 E.).—Another bed, very much broken by the higher ground and irregular in shape, lies in the southwest quarters of section 34 and 33 (33 N., 2 E.), all quarters of 4, the northwest of 3, and the northern half of 9. For extent, quality, origin, amount of stripping, amount of material beneath the ground-water level, and color, it is similar to the deposit last described. Its average thickness (see map) is probably 4½ feet, and the maximum is 13 feet. In the northern parts of sections 3 and 4, terraces occur, that are much more shallow than the deposits of a lower altitude, which they surround. This is a very common topographical relation[1], and is just the opposite from that considered under Walnut Township.

A peat bed having an extent of over 125 acres lies in the northern half of section 10, the southeast quarter of 3, the southwest of 2 and the northeast of 11 (32 N., 2 E.). Since about one-half of the material is beneath the ground-water level, and the average thickness is 4½ feet, the quality will average fair. The deposit has been derived mostly from the grasses, sedges and weeds, but somewhat from the sphagnum mosses. The color is a dark chocolate brown, and the stripping is about 1 foot. Sand and clay are the substrata.

[1]See page 83 for explanation.

About 150 acres of a poor quality of material lies in the northeast quarter of section 16, the northwest of 15, and the southern half of 10 (32 N., 2 E.). The underlying formation is sand. The thickness of the bed will not average more than 2½ feet, 6 feet being a maximum. The color is a very dark chocolate brown, and the origin has been from the grasses and sedges. Almost the entire deposit is above the ground-water level, and its stripping is 1½ feet.

About 60 acres of a poor to good quality of material occur in the north-central part of section 29, and the south-central of 20 (32 N., 2 E.). Tamarack, grasses, sedges, weeds and vegetation of various descriptions cover the surface of the deposit. Underlying the tamarack the deposit is of a good quality, having an excellent thickness, and most of the material beneath the ground-water level, while the remainder is largely above the level of the ground-water. Sphagnum mosses, grasses, sedges and weeds have been the main sources of origin.

Another deposit of similar size and topographical location occurs in the north-central and northwest quarter of section 30 (32 N., 2 E.). This deposit has a fair quality and thickness. The derivation of the material is largely from the grasses and sedges, and the color is a dark chocolate brown. Either this bed or the one mentioned in the preceding paragraph would furnish a small peat plant with sufficient crude material for operating.

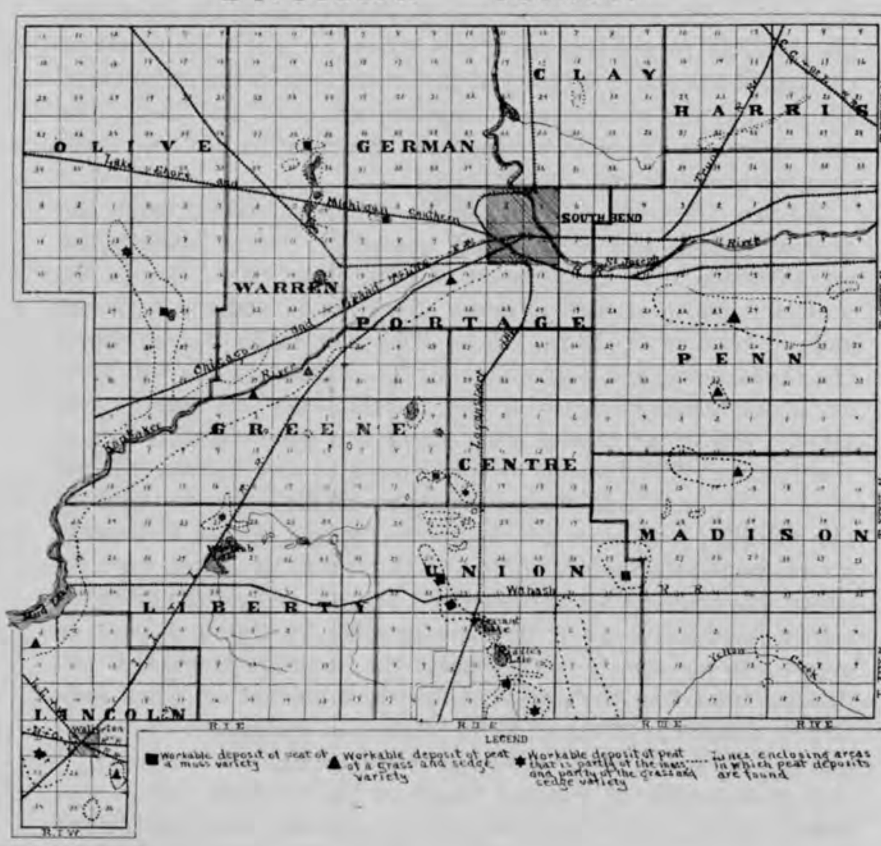
Union Township (32 and 33 N., 1 E.).—Occurring partly in Starke County and partly in Marshall is a rather extensive deposit, consisting of several square miles, which are considerably broken by the higher ground. The part in Marshall County is found in the western half of section 8, all quarters of 7, 18 and 19, and the northwest quarter of 30 (32 N., 1 E.), and covers about 450 acres. One hundred and fifty acres of these are either at present covered or have been with tamarack trees, and 300 with the grasses and sedges. The material underlying the tamarack is of good quality, being almost wholly beneath the ground-water level. It is formed mostly from the sphagnum mosses, and has an average thickness of 9 feet. The peat beneath the grasses and sedges will not average fair in quality, because of its high degree of oxidation. More than half of this is above the ground-water level, and the average thickness (see map) is only 3 feet. The stripping of the moss peat is one-quarter of a foot, while that of the grass and sedge variety is 1 foot. Both kinds of material are underlain by sand and a small amount of marl.

In all of the civil townships of Marshall County are small deposits that have not been described in this report. Some of these have extents of four or five acres, and are of good quality, being largely beneath the ground-water level and having their derivation from the sphagnum mosses. Such will be found very valuable for operating without machinery, in a way similar to that in which Mr. Brown[1] of Tyner City is handling his deposit at present.

ST. JOSEPH COUNTY.

Near the central part of the northern boundary of the State, with South Bend as its county seat, is St. Joseph County. It lies west of Elkhart County, north of Marshall and Starke, east of Laporte, and south of the State of Michigan. For quality and amount of peat, it is one of the best counties of the State.

ST. JOSEPH COUNTY.



[1]See page 223.

PARTS OF TOWNSHIPS 37 AND 38 NORTH, RANGES 1, 2, 3 AND PART OF 4 EAST, AND PART OF 1 WEST.

Harris Township (38 N., 3 and 4 E.).—In sections 27, 26 and 25 (38 N., 3 E.), and 30, 19 and 20 (38 N., 4 E.), are peat and muck beds, covering about 400 acres. However, this large extent will prove almost worthless as a fuel, since the material is almost entirely above the ground-water level and has thus become greatly oxidized by atmospheric contact. Its average thickness is not more than 1½ feet, and it is very extensively mixed with the sand, which is the underlying formation. The color is a very dark chocolate brown, and the derivation has been from the grasses, sedges and weeds. The surface of these deposits, which is a black sandy loam, makes a fair land for corn growing.

Clay Township (38 N., 2 and 3 E.).—A deposit, hardly fair in quality, lies in the central and north-central parts of section 19 (38 N., 3 E.). The surface covered by this bed is about 100 acres, and the thickness ranges between 2 and 5 feet. About seven-tenths of the material is above the level of the ground-water, the stripping is 1 foot, and the underlying formations are sand and clay. The color is a dark chocolate brown, and the derivation has been from the grasses, sedges and weeds.

Warren Township (37 and 38 N., 1 E.).—Derived from the grasses, sedges and weeds, and occurring chiefly beneath the ground-water level, are 60 acres of peat, about Bass Lake, in the northwest and southwest quarters of section 36 and the northeast and southeast of 35 (38 N., 1 E.). This material has a dark chocolate brown color, and is of a fair quality. The stripping will average about three quarters of a foot, the thickness (see map) varies greatly, with an average of about 5 feet, and the underlying formation is marl. The forming of this deposit, as was the case with all of the other peat beds around the shores of the numerous lakes of this vicinity, took place by the grasses, sedges, mosses and weeds growing upon the surface of Bass Lake, close to its shores, when its extent was greater than at present. Upon the dying of a particular species another species of the same or other kind grew upon it or over it. It was then pressed beneath the water level, where it underwent a partial decomposition, in which the carbon gases were largely retained. This partial decomposition resulted in an accumulation, which ultimately gave rise to the present peat beds.

A good quality of material occurs in the northern half of section 35 (38 N., 1 E.). It is overlain by tamarack trees, huckleberry bushes, sphagnum mosses and ferns, with its derivation largely from the sphagnum mosses. The thickness (see map) of the bed has a good average, the extent is 30 acres, and the amount of stripping is almost nothing. Practically all of this material is beneath the ground-water level, and it rests upon the sand. The color is a medium chocolate brown. In addition to the peat, considerable peat moss litter may be obtained from this deposit.

Another deposit of similar origin, color, quality and topographical position, lies in the southwest quarter of section 25 and the southeast of 26 (38 N., 1 E.). It covers 40 acres of surface, has a good thickness (see map), and a very light stripping, and is mainly above the ground-water level. The leading subsoil is clay.

Other deposits, small in extent, are found around the small lakes and ponds of sections 23, 14, 13, 12 and 11 (38 N., 1 E.). Most of these range between poor and fair in quality, and are shallow in thickness. The derivation of the material is largely from the grasses, sedges and weeds.

Two hundred and fifty acres of a dark chocolate brown peat, cover, what was once the greater extent of Chain Lake, in the west half of section 1, the east half of 2, the northeast quarter of 11 and the northwest of 12 (37 N., 1 E.). The thickness (see map) varies between 1 and 19 feet, and the stripping is from $\frac{1}{4}$ to $1\frac{1}{2}$ feet. The origin has been, principally, from the grasses and sedges, and less than one-half of the material is above the ground-water level. A fuel determination[1] by Dr. R. E. Lyons showed a sample of this material to be of a good quality. The color is a dark chocolate brown, and the underlying bed is marl.

A good quality of material occurs in the central part of section 1 (37 N., 1 E.). It is overlain by tamarack trees, huckleberry bushes, ferns and sphagnum mosses, and is practically beneath the ground-water level. The stripping is light and the thickness will average 14 or 15 feet, providing the green sphagnum and peat moss litter, both of which occur in considerable abundance, are included. The color is a medium chocolate brown, and the underlying formations are clay and sand.

Forming a narrow belt around Fish Lake, and occurring in several small basins from one-eighth to one-half of a mile west of the southern part of this lake, are peat beds having a continued extent of 25 acres, and an average thickness of $5\frac{1}{2}$ feet. Since the material is almost wholly beneath the ground-water level and is derived largely from the sphagnum mosses, the quality is good. The stripping is very low, the color a medium chocolate brown and the sub-

[1]See page 99.

soil is sand. Some green mosses and peat moss litter can be gotten from these deposits.

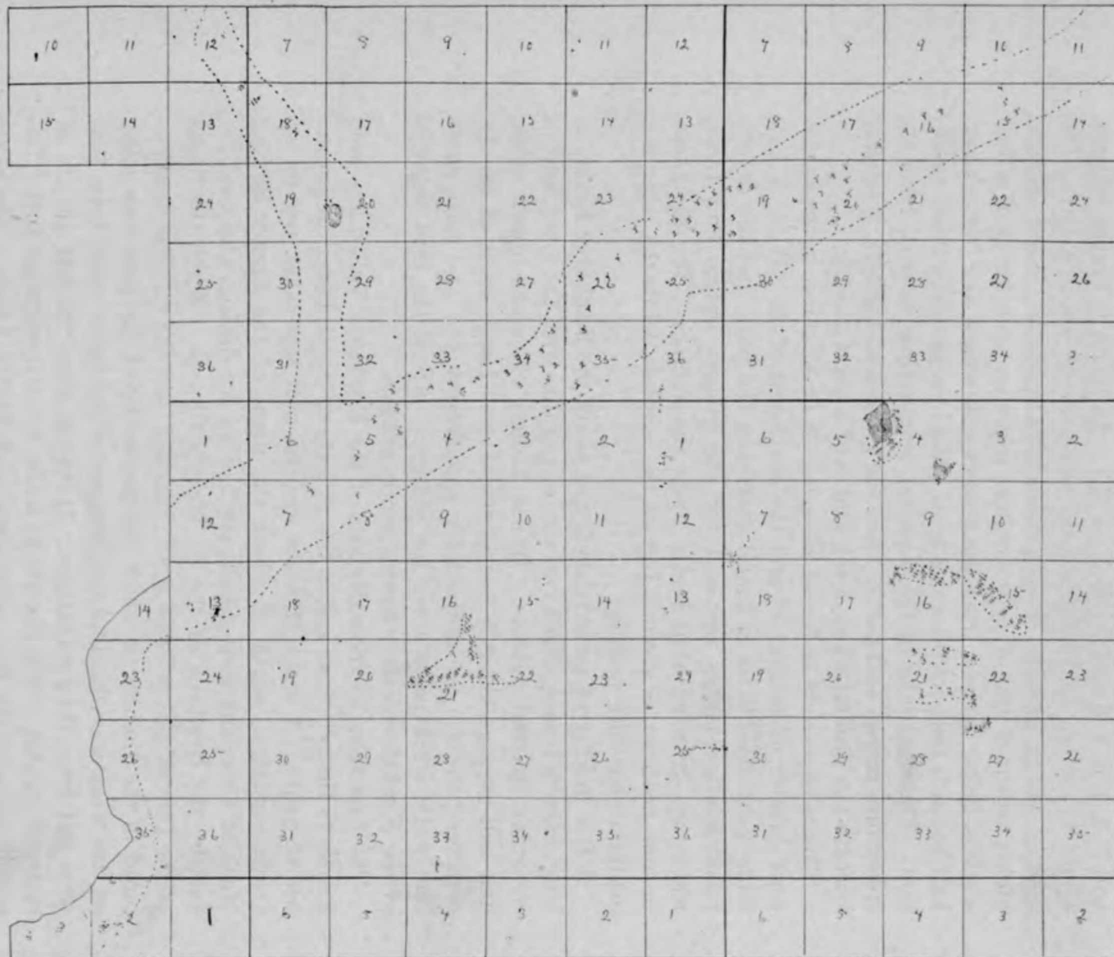
Small, shallow and rather unimportant deposits occur along a stream running N. 20° E. through the southeast quarter of section 16, the northwest of 15, and the west halves of 10 and 3 (37 N., 1 E.). The material averages poor in quality, being almost entirely above the ground-water level, and more or less impure.

Olive Township (37 and 38 N., 1 W. and 1 E.).—Extending north and south are a chain of peat beds in sections 12 and 13 (37 N., 1 W.), and 18, 17, 19, 20, 30, 29, 31 and 32 (37 N., 1 E.). About 150 acres of these have been largely derived from the sphagnum mosses, and 300 acres have originated from the grasses and sedges. The former has a medium chocolate brown color, a good quality, and is almost entirely beneath the ground-water level; while the latter is of a dark chocolate brown color and of a fair quality, and is not more than one-half beneath the ground-water level. Further, the thickness of the former ranges between 4 and 10 feet. The greater part of the material derived from the sphagnum mosses lies about Lost Lake, and is covered with tamarack, but in small beds it is scattered, more or less, throughout the entire area. A bed of probably 40 acres occurs in the southeast quarter of section 12, the northeast of 13 and the northwest of 18. Being nine-tenths beneath the ground-water level and in a very fresh condition, this moss peat is of good quality. Its color is a medium to a dark chocolate brown, and the thickness varies between 4 and 10 feet. The stripping is almost nothing, and sand and marl make up the underlying formations. Considerable peat moss litter and green moss can be obtained from the upper portion of these beds.

The grass and sedge variety will hardly average fair in quality, because of its being more than half above the ground-water level, and somewhat mixed with the sandy subsoil. The bed will not average over 3 feet in thickness, and the stripping is about $1\frac{1}{4}$ feet. The color is a very dark chocolate brown, and the surface is used for pasture and corn growing, for which purposes it seems to serve fairly well.

Part of Township 37 North, and the Northern Half of 36 North, Ranges 1, 2 and 3 East, and Parts of 4 East and 1 West.

The largest deposit of this area, and probably the largest in the State of Indiana, occurs in the valley of the Kankakee River. This large peat bed has its beginning in the southwest part of the City



ST. JOSEPH COUNTY.—Outline Map showing the thicknesses, where soundings were made, of peat beds in the Kankakee marsh, and in Olive, Greene, Liberty and Union Townships.

of South Bend, near the Singer Sewing Machine Works, and extends southwest through sections 15, 16, 21, 17, 20, 19 and 30 (37 N., 2 E.); 24, 25, 23, 26, 27, 36, 35, 34, 33, 27 and 32 (37 N., 1 E.); and 2, 3, 4, 5, 8, 6 and 7 (36 N., 1 E.). In width it ranges between 1 and 1½ miles, and in thickness will average about 4 feet. The quality varies greatly, two-thirds of the material being impure, highly oxidized and of poor quality; while one-quarter is of a fair quality, being derived from the grasses and sedges and being about half beneath the ground-water level, thus in a partially fresh condition. The remainder of the material, originating, in part, from the sphagnum mosses and partly from the grasses and sedges, is largely beneath the ground-water level, and is of a good quality.

This moss variety is found, covering 25 or 30 acres, in the northwest quarter of section 36 and the southwest of 25 (37 N., 1 E.). Some peat moss litter is found overlying the peat, and the decomposed surface makes fair soil for the grasses, sedges and ferns, which are growing abundantly upon the surface. The thickness, in such portions, is about 6 feet on the average, while the color is a medium chocolate brown.

A fair quality of material is found along the Kankakee River, in long, narrow lenses, which run almost parallel with the river, and in irregular isolated patches. It has a dark chocolate brown color, and will average about 5 feet in thickness. Large areas of the decomposed surface are utilized for peppermint, hay and corn growing, while other parts serve for pasture. All of the peat deposits of the Kankakee Valley have a sandy subsoil.

The fuel value of these deposits of the Kankakee Valley has been known to the people at and in the vicinity of South Bend for a number of years. A score of years ago the peat was taken out in the crude condition, south of where the plant of the Singer Sewing Machine Company now stands, stacked up for drying, and used for fuel by the Brethren of the St. Mary's Church. When the limits of the City of South Bend were extended, and the citizens began to build in the vicinity in which the procuring of the peat was going on, the work was discontinued, because of the large water holes that were left from the excavations. However, even the fair quality of material in this crude condition, made a fairly suitable fuel. Determinations of the fuel value were made by Dr. Lyons of the State University, which showed the material of sections 3 and 4 (36 N., 1 E.) to be of an excellent quality for a grass and sedge peat, and that of section 15 (37 N., 2 E.) to be of a fair quality.

Since two-thirds of the Kankakee Valley, in the area described in the preceding paragraphs, is covered with peat deposits, and one-quarter of the material is of a fair, and one-twelfth of a good quality, an excellent location can be found for establishing a peat plant. South Bend alone would consume the output of a large plant of this kind.

Portage Township (37 N., 2 and 3 E.).—A peat deposit of good quality and thickness (see map) lies in the southeast quarter of section 6, and the southwest of 5. It covers 90 acres, has a medium chocolate brown color and a very light stripping. Almost all of the material is beneath the ground-water level, and a fine grained and light colored sand composes the underlying formation.

Green Township (36 and 37 N., 1 and 2 E., and 1 W.).—A 12-acre peat bed, of good quality, lies in the southeast quarter of section 2 (36 N., 1 E.). It has a medium chocolate brown color, and has originated from the sphagnum mosses Nos. 1 and 2. These mosses, in the green state, still form the upper portion of the deposit, and occur in large quantities. Immediately beneath these green mosses are several feet of peat moss litter. The thickness of the bed is good, the stripping is almost nothing, and the peat is wholly beneath the ground-water level. The underlying formations are sand and clay.

A bed of peat, with four-fifths of its material above the ground-water level, lies at the junction of sections 1, 2, 11 and 12 (36 N., 1 E.). The deposit covers 40 acres, has an average thickness of 2½ feet, and a stripping of 1½ feet. The derivation of the material is from the grasses and sedges, the color is a dark chocolate brown, and the quality is poor. The bed rests upon the sand.

Surrounding a small lake in the southeast quarter of section 4 and the northeast of 9 (36 N., 2 E.), is a 35-acre bed of peat of a good quality of material. This bed is of good quality, since it is four-fifths beneath the ground-water level, is derived mostly from the grasses and sedges, and has a good thickness (see map). The color is a medium to a dark chocolate brown, and the stripping is 1 foot.

A 60-acre peat bed, having five-sixths of its material beneath the ground-water level and a fair to a good quality, surrounds Wharton's Lake, in the northeast and southeast quarters of 5, and the northwest and southwest of 4 (36 N., 2 E.). The color is a medium chocolate brown and the origin is principally from the grasses and sedges. For thickness (see map), this deposit ranks well, and the stripping is from 1 to 1½ feet. The grass growing on the surface affords a fair pasture.

Along a small stream valley, in the northwest quarter of section 7 (36 N., 2 E.), are 10 acres of a poor to fair quality of peat. The thickness ranges between 1½ and 4 feet, the color is a very dark chocolate brown, and the material is almost wholly above the ground-water level. The grasses and sedges have been the main sources of origin, and the sand and clay form the underlying beds.

Plate VII.

Huckleberry Marsh, three and a half miles north and one and a half miles west of Lakeville.

A peat deposit, having a length of nine-tenths of a mile and a width of one-tenth to one-quarter of a mile, lies in the northwest and northeast quarters of section 16 (36 N., 2 E.). The peat is overlain by several feet of an excellent quality of peat moss litter, and this, in turn, by 1½ feet of green mosses. The total thickness will average 12 feet, the stripping almost nothing, and practically all of the material is beneath the ground-water level, thus giving it a fresh and good quality. The derivation has been from the sphagnum mosses. In addition to the sphagnum mosses growing upon the surface, is a dense growth of huckleberry bushes. Over the central and larger part of the deposit, these bushes range between 2 and 3 feet in height, and are so close together, that one may walk on the tops of them. Blue clay and sand are the subsoils.

Center Township (36 and 37 N., 2 and 3 E.).—Within 200 yards, and immediately east of the deposit described in the preceding paragraph, is a deposit of almost equal size, occurring in all quarters of section 15 (36 N., 2 E.). This bed is covered with blackberry briers, tamarack and maple trees, and has a length of two-thirds of a mile and an average width of one-fifth of a mile. Since the material is derived largely from the sphagnum mosses, is in a pure and fresh condition, and is largely beneath the ground-water level, the quality is good. The thickness varies from 2 to 15 feet, and the color is a medium to a dark chocolate brown. This deposit, together with the one described in the preceding paragraph, affords a good location for the erection of a peat plant. The railroad facilities are good, and the timber, the only native fuel, is scarce and expensive.

Penn Township (36 37 and 38 N., 3 and 4 E.).—Fifty acres of muck and a very poor quality of peat lie in the southeast quarter of section 17, the northeast of 20 and the southwest of 16 (37 N., 4 E.). The thickness of this bed will average 2½ feet and the stripping is 1½ feet. Practically the entire deposit is above the ground-water level, and it rests upon the sand. The origin has been from the grasses, sedges and weeds.

A large bed of black sandy loam, muck and peat begins in the southeast quarter of section 20 and the northeast of 29, and extends westward through sections 19 and 30 (37 N., 4 E.), 24, 25, 23, 22 to the eastern part of 21 (37 N., 3 E.). The peat is found in small patches and will probably, all taken together, amount to 300 acres. Its average thickness ranges between 1 and 10 feet and the stripping about 2½ feet. Since the material is almost entirely above the ground-water level, the quality is poor. The derivation has been from the grasses, sedges and weeds, and the underlying bed is a sand. The stripping will average 1½ feet. This stripping, however, affords a good soil for peppermint, which is grown upon it extensively.

In the southwest and southeast quarters of section 35 (37 N., 3 E.), and the northeast of 2 (36 N., 3 E.), are 90 acres of a fair to good quality of peat, having a dark chocolate brown color. About three-quarters of this deposit is beneath the level of the groundwater, and the upper one-quarter is stripping. The thickness ranges between 3 and 19 feet, and the underlying stratum is sand. The surface is covered with maple trees.

PARTS OF TOWNSHIPS 35 AND 36 NORTH, RANGES 1, 2 AND 3 EAST, AND PARTS OF 1 WEST AND 4 EAST.

Madison Township (35 and 36 N., 3 and 4 E.).—Partly formed from the sphagnum mosses, and partly from the grasses and sedges, are several hundred acres of peat in the northeast quarter of section 13, the southeast of 12, the north half of 14, the south half of 11, the north half of 15, and the south half of 10 (36 N., 3 E.). This deposit is very much broken by the higher ground, and only patches of 30 or 40 acres have thicknesses of much importance. Probably 100 acres have an average thickness of 13 feet, and another 100 of 6 feet. Only the heavier beds are of good quality. Here the material is mainly beneath the ground-water level, has a medium to a dark chocolate brown color, and is in a very fresh and pure condition; while the shallow parts, of 4 feet or less in thickness, is above the ground-water level, highly oxidized and more or less mixed with the sand, which is the underlying formation. The beds intervening between these two in thickness, contain a fair quality of material. The origin of the material has been from the sphagnum mosses, grasses, sedges and weeds. A peat plant, erected in this vicinity, could be furnished with a sufficient supply of the crude material for operation.

Having a medium chocolate brown color and a fair to good quality, are 60 acres of peat in the southwest quarter of section 15 and the northwest of 22 (36 N., 3 E.). The thickness (see map) of this bed ranges between 3 and 12 feet, and the stripping is ¾ of a foot. Over one-half of this material is beneath the ground-water level, and its derivation has been from the sphagnum mosses, grasses and sedges. The subsoil is sand.

In the northeast quarter of section 22 and the northwest of 23, is a peat bed, comprising about 30 acres. The quality, thickness (see map), stripping, topographical position, amount of material below the ground-water level, the color and the subsoil are similar to the same of the preceding paragraph. Both deposits are covered with maple trees.

One hundred acres, of a poor to fair quality of material, having a very dark chocolate brown color, and being more than half above the ground-water level, occur in the southeast quarter of section 1, and the northwest of 12 (35 N., 3 E.), and the southwest of 6 and the northwest of 7 (38 N., 4 E.). The thickness of this bed ranges between 2 and 10 feet, and the stripping is 1½ feet. Grasses, sedges and weeds seem to have been the main source of origin, and the underlying bed is sand. Fair pasture and corn grow upon the surface.

Occurring at the junction of sections 12 and 13 (35 N., 3 E.), and 7 and 18 (35 N., 4 E.), are 20 acres of a rather poor quality of peat. The bed has an average thickness of 3 feet, and is beneath 1½ feet of stripping. About one-half of the material is beneath the ground-water level, and the subsoil is sand. The origin of the deposit has been from the grasses, sedges and weeds.

Madison and Union Townships.—In all quarters of sections 28, 29, the northeast of 32 and the northwest of 33 (36 N., 3 E.), are 600 acres of tamarack marsh, almost entirely underlain by a medium to a dark chocolate brown colored peat. This bed being derived principally from the sphagnum mosses, and having four-fifths of its material beneath the ground-water level, is of a good quality. The stripping is very light and the thickness (see map) has a good average. Considerable peat moss litter can be obtained from the surface of this deposit. Since the southern part of this marsh is cut by the Wabash Railway, the location is a good one for building a peat plant.

Union Township (35 and 36 N., 2 and 3 E.).—Commencing in section 31 (36 N., 3 E.), and extending in a southwesterly direction through all quarters of sections 6 and 7, the southwest of 8, the northwest, northeast and southeast of 18 and all of 17 into Marshall County, is a very large body of muck and peat. The maximum thickness (see map) is about 7 feet and the average 2½ feet, and 80 per cent. of the bed is above the ground-water level. In places, considerable sand is mingled with the peat, thus leaving it in an impure condition. This, with the high amount of oxidation, makes the average quality poor. The deposit is greatly dissected by the higher ground, which probably occupies 60 per cent. of the extent, outlined in the beginning of the paragraph. The color of the material is a very dark chocolate brown, and the origin has been from the grasses, sedges and weeds. The stripping is about 1½ feet and the underlying formations are clay and sand. The soil overlying this deposit has been found to be fair for onions, corn and pasture.

Considering the vegetation growing on its surface and its extent, a very exceptional bed of peat, for thickness, occurs in the east-central part of section 12 (35 N., 2 E.). This bed is covered by a very heavy growth of tamarack trees, huckleberry bushes, and some maple trees; the vegetation that is generally found over a bed of considerable thickness. In this case, however, the thickness (see map) is only 8 feet at maximum and will not average over 2 feet.

The extent is about 50 acres, the stripping is 1 foot, and the deposit is almost entirely above the ground-water level. With this atmospheric contact, the oxidation has left the quality poor. The origin has been mainly from the sphagnum mosses and the color is a medium to a dark chocolate brown. The subsoils are blue clay and sand.

Fifteen acres of a fair to good quality of material lies in the northeast quarter of section 22 (36 N., 2 E.). It has a medium chocolate brown color, and has originated largely from the sphagnum mosses. The thickness of the bed is from 2 to 10 feet and 75 per cent. of it is beneath the level of the ground-water. The subsoil is sand.

About 130 acres of peat, now covered by tamarack and maple trees, and huckleberry bushes, lie in the east half of section 21 and the west half of 22 (36 N., 2 E.). This material has been derived, mostly, from the sphagnum mosses, and is of a medium to a dark chocolate brown color. Since 75 per cent. of it is beneath the ground-water level and the thickness (see map) is of a fair average, these deposits are of good quality and will ultimately become to be of considerable economic importance. Portions of the surfaces are covered with the sphagnum mosses, which are underlain by several feet of a good quality of peat moss litter. Three beds contain almost all of this material.

Immediately south of these deposits, in the northwest quarter of section 27, are 45 acres of a similar material for quality, color, topographical position and stripping. It also is almost entirely above the ground-water level, and rests, for the most part, upon the sand. The thickness (see map) ranges between 3 and 15 feet.

Taking into consideration both quality and extent, one of the first peat deposits of the State begins in the north-central part of section 28, and extends southeast through the central and southeast quarters of the same section, the east half of 33, the west half of 34 (36 N., 2 E.), the northwest quarter and east half of 3, the west half of 2, the northwest quarter and east half of 11, all quarters of 14, the southwest of 12, and the west half of 13 (35 N., 2 E.), and for over one mile south into Marshall County. The surface of this peat bed is either covered by marshes or lakes, Pleasant and Riddles Lakes being found within its limits. The old glacial lake, which once occupied the same topographical position, undoubtedly had a much greater extent than the existing lakes, comprising not only these, but, in addition, all of the peat beds and marshes that have been mentioned in this paragraph. In the marshes are found tamarack, maple, cottonwood and sumac trees, various grasses, sedges, weeds and sphagnum mosses.

The main sources of origin have been from the sphagnum mosses.

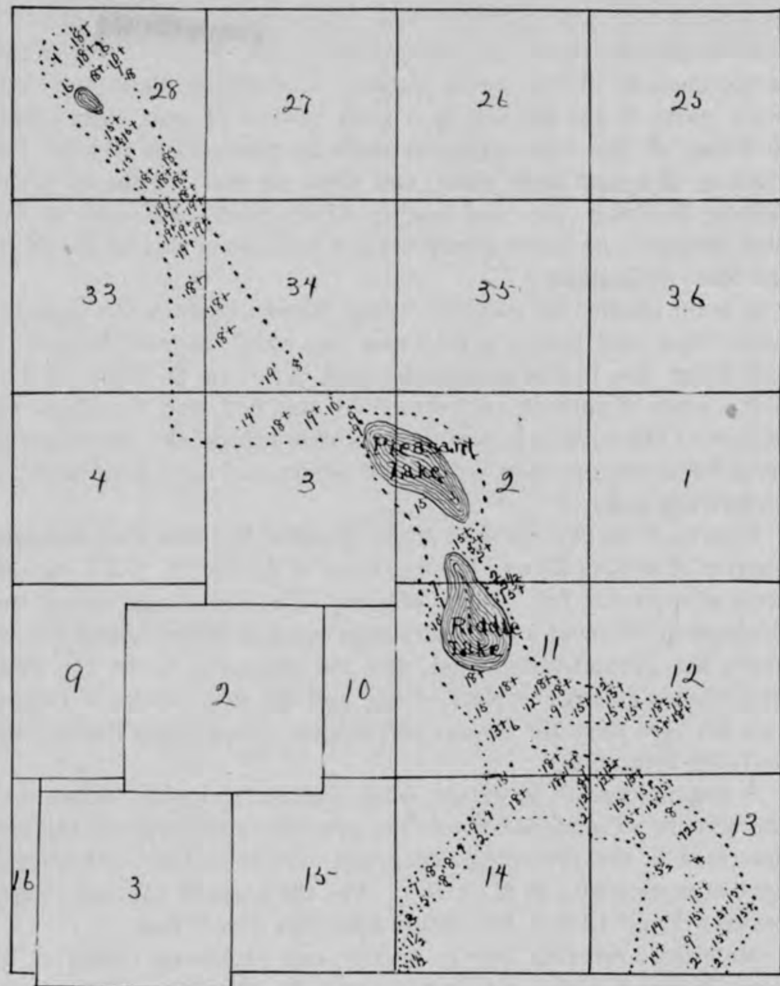


Fig. 13. Showing the thicknesses, where soundings were made, of peat deposits in the vicinity of Pleasant and Riddle Lakes, Union township, St. Joseph County.

but somewhat from the grasses, sedges and weeds. Tamarack logs and stumps occur frequently, imbedded in the deposit. These were encountered in sinking the sounding auger. The color of the material is a medium to a dark chocolate brown. Since the thickness (see map) of the deposit is very good, and 90 per cent. of the material is below the level of the ground-water, the quality will average good. A general sample, tested[1] by Dr. R. E. Lyons of the State University, shows a very high fuel value. The stripping is, in general, very light, and the chief underlying formation is sand.

At numerous points on the surface of this peat bed are found large amounts of the green mosses. Underlying these and also other parts of the surface, is a good quality of peat moss litter. Sufficient of this material could easily be procured to pay for the erecting of a peat moss plant, and when we consider the excellent railway facilities, the good quality of the peat itself, and its extent, probably no better location for a peat plant can be found in the State of Indiana.

A good quality of material, being largely beneath the ground-water level, and having a thickness (see map) varying between 4 and 7 feet, lies in the east-central part of section 2 (35 N., 2 E.). Fifty acres of surface are covered by this bed, and the stripping is light. The color is a medium chocolate brown, the derivation is from the mosses, grasses, sedges and weeds, and sand comprises the underlying bed.

Liberty Township (35 and 36 N., 1 and 2 E.).—In the northeast quarter of section 25 and the southeast of 24 (36 N., 1 E.), are 30 acres of a poor to fair quality of peat. Two soundings showed the thickness to be about 5 feet, more than one-half of the material to be above the ground-water level, and the stripping to be 1½ feet. The color is a dark chocolate brown, and the chief source of formation has been from the grasses and sedges. Sand is the leading underlying formation.

A similar deposit, in extent, color, quality, stripping, origin and the amount of material above the ground-water level, to the one described in the preceding paragraph, occurs in the north-central part of section 26 (36 N., 1 E.). The thickness of the bed ranges between 1 and 12 feet, but will not average over 3 feet.

Material, averaging fair in quality and having an extent of 25 acres, is found in the southwest quarter of section 23 and the southeast of 22 (36 N., 1 E.). Its color is a dark chocolate brown, and derived from the grasses and sedges. Fully 65 per cent. of this deposit is above the ground-water level. The stripping is 1 foot, and the thickness (see map) ranges between 6 and 11 feet.

Covered with tamarack and maple trees, grasses and sedges, are 170 acres of peat in the southwest quarter of section 22, all quarters of 21, and the southeast of 16 (36 N., 1 E.). The derivation

[1]See page 99

of the material of the southern half of this deposit is mainly from the sphagnum mosses, while that of the northern half is largely from the grasses and sedges. The quality ranges between fair and good and the color is a medium to a dark chocolate brown. About 75 per cent. of the bed is beneath the ground-water level, and the average thickness (see map) is good. The stripping is from almost nothing to 2 feet, while the underlying beds are clay and sand. In the tamarack portion of this deposit is a large amount of peat moss litter, overlying the peat.

With an extent of 150 acres and its location in the southwest quarter of section 17 (35 N., 1 E.) is a peat bed, one-tenth of which is covered with tamarack and nine-tenths with the grasses, sedges and weeds. Since about one-half of the deposit is above the ground-water level, the thickness (see map) is from 1½ to 13 feet, and the derivation is from the sphagnum mosses, grasses, sedges and weeds; the average quality is about fair. This bed also has a medium to a dark chocolate brown color, a stripping of 1 foot, and both sand and clay subsoils.

Lincoln Township (36 N., 1 W.).—In the eastern half of section 25, in all quarters of section 3, the northern half of 10, and the western half of 2, is a deposit containing a quality of peat which will hardly average fair, originating from the grasses and sedges and having its topographical position in the flood plain of the Kankakee River, and what was once the greater extension of Mud Lake. The extent of this deposit is approximately 400 acres, and the average thickness about 3½ feet, while the maximum is about 10 feet. The material being about half exposed to the atmospheric weathering, and more or less of the sandy subsoil being mingled with it, the quality will hardly average fair. The stripping, which makes a good soil for marsh hay, has an average thickness of 1 foot.

An excellent bed of peat for size, thickness and quality occurs in the western halves of sections 23 and 26, all the quarters of sections 22 and 27, and extends slightly over into LaPorte County. The surface covered by this deposit contains about 700 acres, 300 of which are or have been covered by tamarack, and 400 by the grasses, sedges and weeds. The material underlying the 300 acres has been formed largely from the sphagnum mosses, while that underlying the 40 acres has been derived, to a considerable extent, from the grasses, sedges and weeds. Fully 90 per cent. of the former bed occurs beneath the ground-water level, while only about 50 per cent. of the latter is found so situated, thus causing the former, because of slight oxidation through atmospheric contact, to be of a good quality, and the latter to be only fair. Another reason for the difference in quality is that the relative amount of mingling with the sandy subsoil is less for the moss variety than for the grass. This is due to the fact that the former deposit has an average thickness of 6 feet and the latter only 4. The color of the material derived from the mosses is a medium to a dark chocolate brown, while that from the grasses and sedges is a dark chocolate brown. The stripping ranges between $\frac{1}{4}$ and $1\frac{1}{2}$ feet.

A peat bed covering about 80 acres of surface occurs in the eastern half of section 36 and the western of 35. The material of this bed has a dark chocolate brown color, and has been derived from the sphagnum mosses, grasses and sedges. Its quality will average fair, the stripping is about $\frac{3}{4}$ of a foot, and the thickness of the bed ranges between 3 and 10 feet. Sand makes up the underlying formation.

At least 3,000 more acres of peat can be found in this county, other than that which the writer has described in this report; but the extent of the deposits will be found to be either very small or the quality of the material is poor. Either of these conditions make these unmentioned deposits undesirable for the erection of even a small peat plant. However, there are some of these deposits, especially the small beds of 4 or 5 acres, which contain a good quality of material; they may be of great economic importance to the farmers if they will spade out the peat, stack it up for drying, and burn it in the crude form. These small deposits of good quality can generally be located by the vegetation growing on the surface, such as huckleberry and cranberry bushes, sumac and tamarack trees, sphagnum mosses and ferns. Then by noting the amount of the material beneath the ground-water level, and getting the thickness of the bed by thrusting down a pole or pipe, one can obtain a very fair idea as to the nature of their deposit.[1]

LAPORTE COUNTY.

Being the third county east of the State of Illinois and bordering on the Michigan State line, is LaPorte County. The moraines of the eastern half of the county contain many small peat beds. A few large peat deposits occur in old lake basins, which have been drained, and very extensive deposits, of poor quality, lie in the Kankakee Valley. As a peat county, Laporte ranks among the less important.

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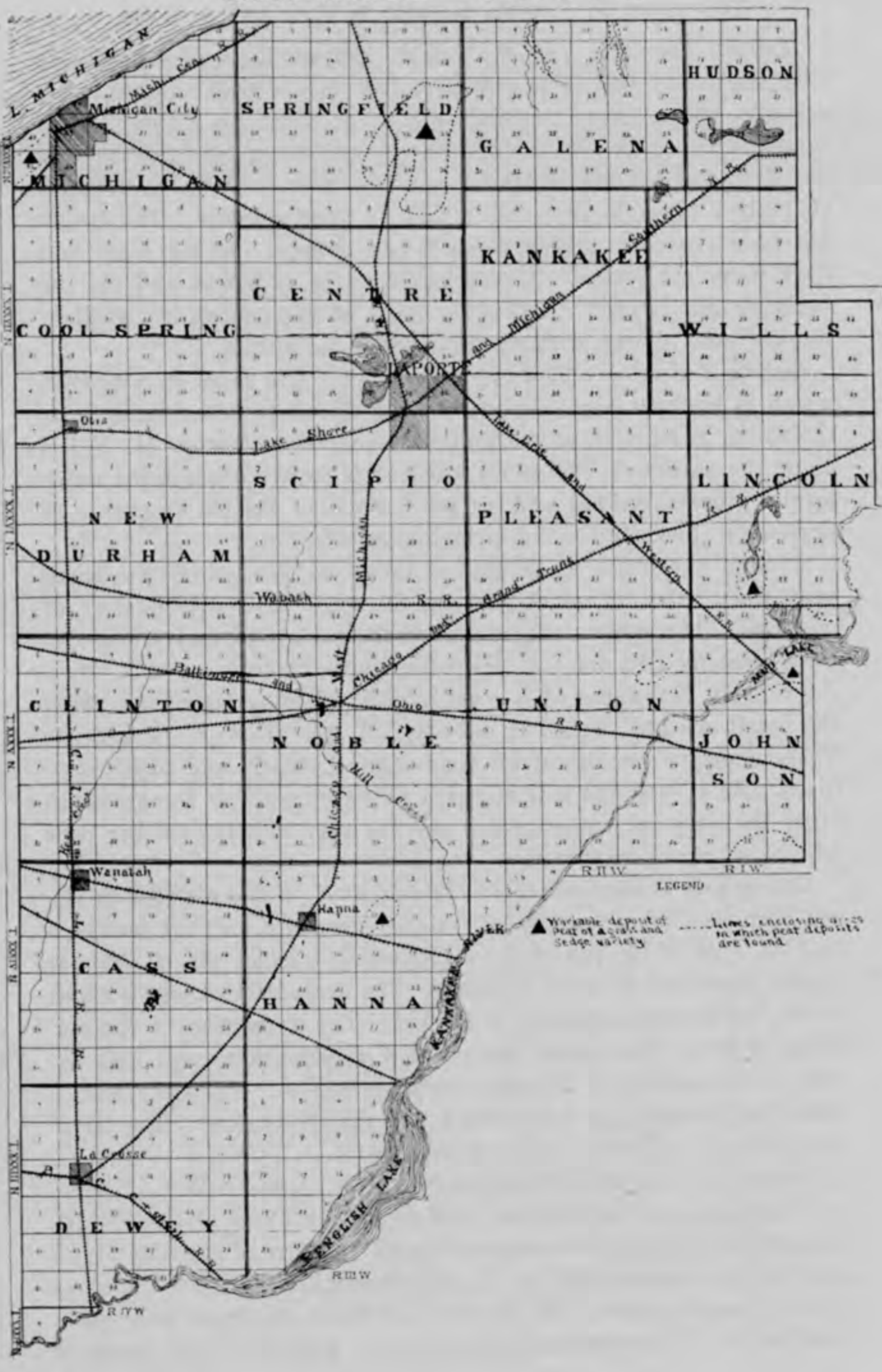
[1]See page 109 for the criteria used in determining the economic importance of a peat bed.

LAPORTE COUNTY.



Township 38 North, Ranges 1, 2, 3 and 4 West.

Hudson Township (38 N., 1 W.).—Surrounding Hudson Lake, with the heavy and most extensive bed on the west side, are peat deposits, which, taken together, will cover 100 acres. The 80 acres lying on the west side of the lake, have an average thickness of 5½ feet, and are four-fifths beneath the ground-water level. These characters give the material a fair to good quality. The origin has been from the grasses, sedges and mosses, and the color is a dark chocolate brown. The stripping is ½ of a foot and the underlying bed is sand. The other parts of the deposit are shallow, impure and almost without importance as a fuel.

Galena Township (38 N., 2 W.).—Thirty-five acres of a deposit, which is slightly more shallow and of about the same quality as the above, is situated in the southeast quarter of section 24. It lies along the north side of a small lake and is mostly beneath the water level. Mosses, grasses and sedges have been the chief sources of derivation, and sand is the principal substratum.

Around the other small glacial lakes of this county are small peat beds, some of which contain 30 acres of a fair quality of material. The general character of these beds is very similar to those described in the two preceding paragraphs.

Probably 300 acres of a poor quality of material occurs along the small streams, found in sections 14, 15, 11, 8, 9, 17 and 16. These deposits are almost all very shallow, sandy and highly oxidized. As a fuel, the material will never be suitable for anything other than a local consumption, and for this only the thicker beds will be of much importance.

Galena and Wills Townships (38 and 37 N., 2 and 1 W.).—In the southern half of section 36 of Galena Township and the northern half of 7 of Wills Township, surrounding a small glacial lake, is a peat deposit of 40 acres in extent. The average thickness is about 5 feet, while the maximum is 10 feet. The derivation of the material is from the grasses, sedges and sphagnum mosses, and the color is a medium to a dark chocolate brown. Since the bed is almost all beneath the water level, the quality is good. The stripping is ¼ of a foot and the subsoil is sand.

Galena and Springfield Townships (38 N., 2 and 3 W.).—Slightly extending into the western half of section 19 of Galena Township, but having its main expanse in all quarters of sections 24, 25 and 26, the western half of 36, the eastern of 35 and 34, also in the southeast quarter of 27, and the northeast, southeast and southwest of 27 of Springfield Township, are probably 1,000 acres of peat. The thickness of the deposit varies greatly, and the heaviest beds are much scattered. However, if all of these could be combined, probably 100 acres would have an average thickness of 5 feet, 200 of 4 feet and 300 of 2½ feet. The remainder are very shallow and impure, being sandy and greatly decomposed. The grasses and sedges have been the main sources of origin, but the sphagnum mosses and other vegetation have played a small part. The heavier beds are mostly beneath the ground-water level, and are of fair quality. The color is a very dark chocolate brown, and the stripping ranges between one-third and 2 feet. Considerable corn is raised on the oxidized surface, and fair crops are obtained.

Michigan Township (38 N., 4 W.).—A very extensive deposit has its beginning at Michigan City, and extends southwest, through the southeast quarter of section 30 and all quarters of 31, into Porter County. The part of the deposit in this township has a length of 1¼ of a mile, and a width ranging between ¼ and ½ of a mile. The material, being chiefly under the ground-water level, has not become oxidized from contact with the atmosphere, and is consequently of a fair to good quality. The thickness of the bed will average 4½ feet, and the derivation has been mostly from the grasses and sedges. The material is light, and the underlying bed is sand. The topographical position of this bed is very interesting. On its northwest side are very pronounced sand dunes, towering 150 feet above the level of Lake Michigan, which bounds them on the north, while on the southeast side are sand hills ranging between 30 and 50 feet in height. These topographical relations continue, more or less noticeable, for a number of miles westward, along the shore of Lake Michigan.

Township 37 North, Ranges 1, 2, 3 and 4 West.

Center Township (37 N., 3 W.).—The important deposits of this township occur immediately north of the city of LaPorte, around Pine, Stone and Clear Lakes. If all of these deposits could be combined they would cover about 150 acres. Probably 40 acres lie on the west side of Pine Lake, 30 acres between Pine and Stony and 20 acres south of Stony. All of these deposits are largely beneath the ground-water level, or are suspended in the lakes. Under both circumstances the material is in a very fresh condition and is consequently of a fair to good quality. The origin has been principally from the grasses and sedges, and the color is a dark chocolate brown. The thickness of the beds varies greatly, but 4½ feet is probably close to the average, while 15 feet is less than the maximum. Sand and marl are the underlying formations.

Numerous small deposits of fair and even good quality occur about the many little lakes, and in the kettle basins of Kankakee and Wills Townships. East of Rolling Prairie small glacial kettle basins are very common and are invariably filled, more or less, with peat. Most of this peat is of the sphagnum moss origin, and the beds often have an average thickness of 7 or 8 feet, although the extent is only a few acres. The writer gave particular attention to these kettle basin beds in section 1 of Wills Township. The small lakes, forming a chain, extending from the town of Hudson, south of Fish Lake, are all, to some extent, surrounded by peat deposits of a fair to good quality.

Lincoln and Johnson Townships (35 and 36 N., 1 W.).—Occurring more or less on all sides of Fish Lake, but with especially large developments at the northern and southern ends, are 400 acres of peat. The 250 acres, which lie about the southern end, are mostly of grass and sedge origin, are about one-half beneath the ground-water level, and have a maximum thickness of 10 feet, and an average of 3 feet. Fifty acres of these, however, will average 7 feet in thickness, and fifty more about 5 feet. These heavier portions are of fair quality and have a rather light stripping. The stripping is from ½ to 1½ feet and the color is a dark chocolate brown.

The 75 acres about the northern end of the lake have an average thickness of 6 feet, are largely beneath the ground-water level, and are from fair to good quality. Sphagnum moss No. 2 has been the main source of origin, and to a lesser extent sphagnum moss No. 1, the grasses and sedges. The stripping is very light, the color is a medium to a dark chocolate brown, and the subsoils are marl and sand. Tamarack trees cover a large part of this northern extension.

Around Mud Lake, in sections 8, 5, 9 and 4 of Johnson Township are over 1,000 acres of a material which will not average fair in quality. It is two-thirds above the ground-water level, has an average thickness of 2½ feet and is derived from the grasses and sedges. The stripping is 1 foot and the underlying bed is sand, which is more or less mingled with the peat. The color is a very dark chocolate brown. Several patches, however, of 35 or 40 acres occur at various points in this deposit that have an average thickness of 4 or 5 feet, are over half beneath the ground-water level and are of fair quality.

Township 35 North, Ranges 1, 2, 3 and 4 West.

Continuing on to the southwestward along the Kankakee River one meets with vast sandy loam and muck deposits, and with small patches of peat. These patches seldom cover more than 50 acres and are generally shallow and of poor quality.

A chain of small deposits, surrounding small glacial lakes in Noble Township (35 N., 3 W.) extend in a northwesterly and southeasterly course, through sections 18, 17, 20, 29, 28 and 33. All of these are rather shallow and of less than an average quality. The material has been derived from the grasses and sedges, and most of it is above the level of the ground-water.

Township 34 North, Ranges 2, 3 and 4 West.

Hanna Township (33 and 34 N., 2 and 3 W.).—Almost wholly bneath the ground-water level, and with an average thickness of 4½ feet, is a peat deposit in the southwest quarter of section 2, the northwest of 11 and all quarters of 10 (34 N., 3 W.). While one-third of this material is of a poor quality, the remainder will average fair. The origin has been mostly from the grasses and sedges, and the color is a dark chocolate brown. Sand is the underlying formation.

Probably 50 acres of a fair quality of peat can be obtained in section 5 (34 N., 2 W.). The thickness is fair and 60 per cent. of the material is below the ground-water level. The sources of origin have been the grasses and sedges, and the color is a dark chocolate brown.

In addition to the deposits already described are numerous others of smaller extents, occurring somewhat in all of the civil townships. Some of those along English Lake and in the Kankakee flats have extents of 40 or 50 acres and are almost fair in quality. Other deposits lie in old lake basins and around small lakes in all of the townships of this county. Some of these cover 25 or 30 acres of surface and are from fair to good in quality.

STARKE COUNTY.

Starke County, with Knox as its county seat, is bounded on the east by Marshall County, on the south by Pulaski, on the west by LaPorte, and on the north by LaPorte and St. Joseph. For amount of peat it will probably rank first for the State of Indiana; but taking into account both the amount and quality, it only ranks among the best, since it has not so much peat of the good quality as Marshall, St. Joseph, Kosciusko and Noble Counties.

TOWNSHIP 34 NORTH, RANGES 1 AND 2 WEST.

Oregon Township (34 N., 1 W.).—In the southwest quarter of section 4 is a tamarack marsh, underlain by a peat bed. Since this bed is mainly beneath the ground-water level and the origin has been from the sphagnum mosses, grasses and sedges, the quality ranges between fair and good. The thickness is from 6 to 10 feet, the stripping is very light, and the areal extent is 60 acres. The color is a dark chocolate brown, and the subsoil is sand.

Occupying each quarter of sections 3 and 4, and extending into Laporte County, is a deposit of peat of somewhat less than fair quality. The portion found in Starke County consists of 300 acres, very much separated by the higher ground. The color is a very dark chocolate brown, and the material has been formed from the grasses and sedges. The thickness has an average of about 4 feet and a maximum of 10 feet, while the stripping is 1 foot, and 50 per cent. of the bed is above the ground-water level. Sand is the predominating substratum.

The deposit about Woodworth Lake, in the northern half of section 12 and the southern of section 1, has its main extent in Marshall County, and is described on page 226. In Starke County there are about 100 acres of material about this lake, 40 of which are of an excellent quality. These lie in the southeast quarter of section 1 and are covered with a dense growth of huckleberry bushes, old tamarack trees and considerable of the sphagnum mosses, especially No. 2. Beneath this vegetation are several feet of an excellent quality of peat moss litter, which, in turn, is underlain by the medium chocolate brown peat, entirely beneath the ground-water level. This material is of very good quality. Extending north from this huckleberry marsh is a 40-acre bed of the very dark chocolate brown peat, derived from the grasses and sedges and covered with cottonwood trees, briars and weeds. This bed is poor to fair in quality, being mostly above the ground-water level and being more or less mingled with the sand which underlies it. The thickness (see map) of the moss bed will average 15 feet, while that of the grass and sedge variety will not average over 3 feet, and the stripping of the former is one-sixth of a foot, and that of the latter 1 foot.

One hundred acres of a very dark chocolate brown material lies in the southwest quarter of section 24 and the southeast of 23. This bed being shallow and a large part of the material lying above the ground-water level, the quality will not average fair. The grasses and sedges have been the chief sources of origin.

Oregon and Washington Townships.—A peat bed commences in the southeast quarter of section 4, Washington Township, and extends northward through the northeast and northwest quarters of this same section, and all quarters of sections 33, 27 and 28, Oregon Township, where it branches. One of these branches extends due north, passing through all quarters of section 22 to the southwest quarter of 15, and the other follows Hailstorm Creek, passing through the eastern half of 21, the western of 20, the southern of 17, and terminating in the northwest quarter of this same section. Although greatly dissected by the higher ground, at least 1,000 acres of this area are peat deposits. But, taken as a whole, the deposit is very shallow, impure and highly oxidized, and only parts of it can be considered of much importance as a fuel. One of these parts, having an extent of over 100 acres, lies in section 27. Here the thickness will average 5½ feet and the material is over one-half beneath the ground-water level, thus giving a fair quality. The other areas of fair quality are small and very much scattered. The main source of origin for the entire deposit has been mostly the grasses and sedges.

Oregon and Davis Townships.—In sections 5 and 6 of Oregon Township, and 1, 2, 3, 4, 11, 10, 9, 8, 17 and 18 of Davis Township, are the broad expanses of black sandy loam, muck and peat deposits of the Kankakee lowlands. In sections 5 and 6 of Oregon Township are 100 acres of a fair quality of material, in patches, ranging between 4 and 25 acres, varying in thickness from 4 to 7 feet. Beds of less than 4 feet in thickness are largely above the ground-water level, and are too much oxidized to be of great value as a fuel. However, about 700 acres of a poor quality of fuel could be obtained in these two sections.

Davis Township (34 N., 2 and 3 W.).—It is probable that not over one-eighth of the peat beds of Davis Township would be of economic value as a fuel, and the greater portion of these would be of a poor quality. There are 70 acres of a fair to good quality of peat lying principally south of the Pennsylvania Railway, in the southeast quarter of section 16 and the southwest of 17. This bed, having a maximum thickness of 15 feet and an average of 5 feet, lies largely beneath the ground-water level. The predominating subsoil for all of these beds is sand. Over the deep peat, very fair crops of onions are raised. The shallow peat beds, as well as the muck and black sandy loam, are largely planted to corn. Since a number of dredge ditches and smaller open ones occur in this area, the thickness and quality of the material can be easily determined by following these and noting the sections along the sides.

TOWNSHIP 33 NORTH, RANGES 1, 2 AND 3 WEST.

Jackson Township (33 N., 3 W.).—Large scopes of black sandy loam, muck and peat occur in the vicinity of English Lake. These beds, however, are in general shallow, impure and very much decomposed. Only in small patches of a few acres, scattered more or less over this entire extent, is material to be found that is of a fair quality.

Center Township (33 N., 2 W.).—Extending slightly southward into California Township is a peat deposit in the southern half of section 36. The bed contains about 50 acres and the thickness will average 3½ feet. Grasses, sedges and sphagnum mosses are the chief sources of origin, and, the material occurring about one-half beneath the ground-water level, the quality will average fair. The stripping is 1 foot and the color is a dark chocolate brown.

TOWNSHIP 32 NORTH, RANGES 1, 2, 3 AND 4 WEST.

North Bend Township (32 N., 1 W.).—The deposit about Manitou Lake, occurring in both Marshall and Starke Counties, has been partly described on page 232. The portion found in Starke County lies in the northeast, southwest and southeast quarters of section 13, the northwest, northeast and southeast of 24, and the northeast of 25. Both at the north and south ends of the old lake are tamarack marshes, together covering over 100 acres, and both are underlain by a good quality of peat. In these places the bed is of a good thickness, the material is largely beneath the level of the ground-water, and the stripping is light. The color is a medium to a dark chocolate brown. Extending westward from the lake are 150 acres of a very dark chocolate brown peat, which is principally above the ground-water level, and is of a poor to fair quality. This portion is shallow and the material is, in places, impure.

A very dark colored and shallow peat deposit is located in the northeast quarter of section 23. It has an extent of 50 acres and a stripping of 1½ feet. The quality is poor and the origin has been mainly from the grasses and sedges.

In what was once an old lake basin, in the southeast quarter of section 17, near the center of the section, are 30 acres of a dark colored peat. The bed has an average thickness of about 3½ feet, and a maximum of 8 feet. Since about one-half of the material is above the ground-water level, and the origin has been from the grasses and sedges, the quality will almost average fair. The underlying bed is sand.

In the northeast quarter of this same section, resting upon a sandy substratum and covering an extent of 50 acres is a peat bed which will average slightly better than the preceding in thickness and quality. The color is a very dark chocolate brown and the origin has been, for the most part, from the grasses, sedges and weeds. One-half of the bed is above the ground-water level, the stripping 1 foot.

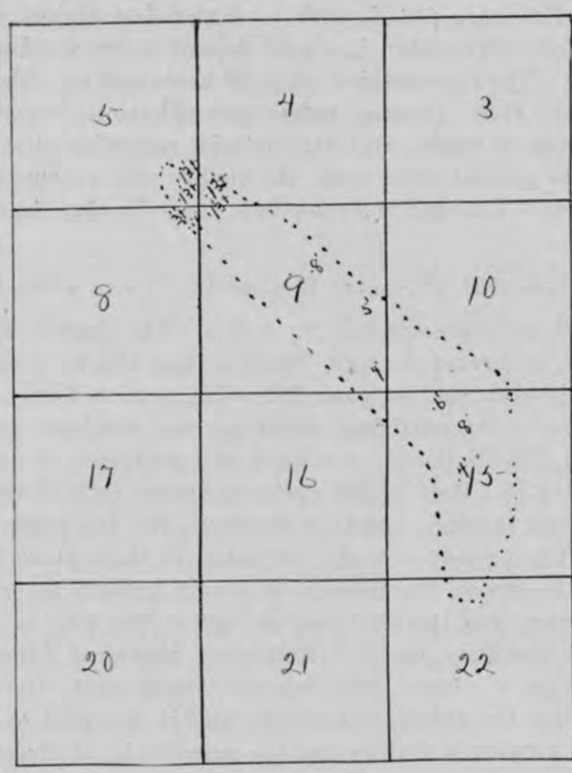


Fig. 14. Showing the thicknesses, where soundings were made, of peat beds in the northern half of North Bend township, Starke County.

A rather extensive bed of peat, having a length of 3 miles, and a width varying between ¼ and ½ of a mile, lies in each quarter of sections 15 and 9, the southeast of 5, the southwest of 4, the northeast of 8, the southwest of 10, the northeast of 16 and the north-central part of 22. The northwestern part of this bed, which is found in sections 4, 5, 8 and the northwest quarter of 9, is of a very good quality. It surrounds several small lakes, and is covered with tamarack trees and some sphagnum mosses. The color of this portion of the material is a medium to a dark chocolate brown, and the derivation is mostly from the sphagnum moss No. 2, and to a less extent from the grasses, sedges and sphagnum moss No. 1. The thickness (see map) of the bed is here very good, and the material is almost wholly beneath the ground-water level. Some of the green mosses are yet to be found on the surface, and immediately beneath these are several feet of a good quality of peat moss litter.

The remainder of the deposit contains a very dark chocolate brown colored material, which has been derived, mainly, from the grasses, sedges and weeds. The thickness (see map) of this part of the bed will not average over 4 feet, the stripping is 1 foot, and the material is fully half beneath the ground-water level, thus giving a quality about fair. Sand is the leading subsoil.

A number of other small deposits, ranging from 5 to 20 acres, exist in this township. Some of these occur about the small lakes in sections 35 and 36.

California Township (32 N., 2 W.).—There are about 150 acres of a fair quality of material in an extent of peat and muck, which covers a portion of the western half of section 35, the northern of 34, the southwest of 27 and the east-central of 28. This material is very much scattered and can be located most easily by following the open ditches on the sides of which the sections are exposed. The average thickness is about 3 feet and about one-half of the material is above the ground-water level. The color is a very dark chocolate brown and the origin is from the grasses and sedges. Sand is the principal subsoil.

Extending westward from the southwest corner of Bass Lake, in the northwest quarter of section 23 and the northeast of 22, are 50 acres of a dark chocolate brown colored peat. The material being about two-thirds beneath the ground-water level, and the average thickness 6 feet, with a maximum of 13 feet, gives a fair to good quality. The stripping is light, and the underlying formation is sand.

Probably 600 acres of peat, ranging from poor to good in quality, but averaging fair, lie north of the western part of Bass Lake, in the northern half of section 14, the eastern of 10, all quarters of 11, the southwest of 12 and the northeast of 13. The average thickness of this bed is about 6 feet, and 70 per cent. of the material is beneath the ground-water level. The color is a dark chocolate brown, and the origin has been mostly from the grasses and sedges, and somewhat from the sphagnum mosses. The stripping is, in general, light, and the substratum is sand.

Bounding Round Lake, on the eastern and southern sides, and extending in a southeastern direction, are 300 acres of a dark chocolate brown material, which rests upon the sand and has a stripping of about one-third of a foot. Since the thickness of this bed will average at least 6 feet, and four-fifths of the peat is under the

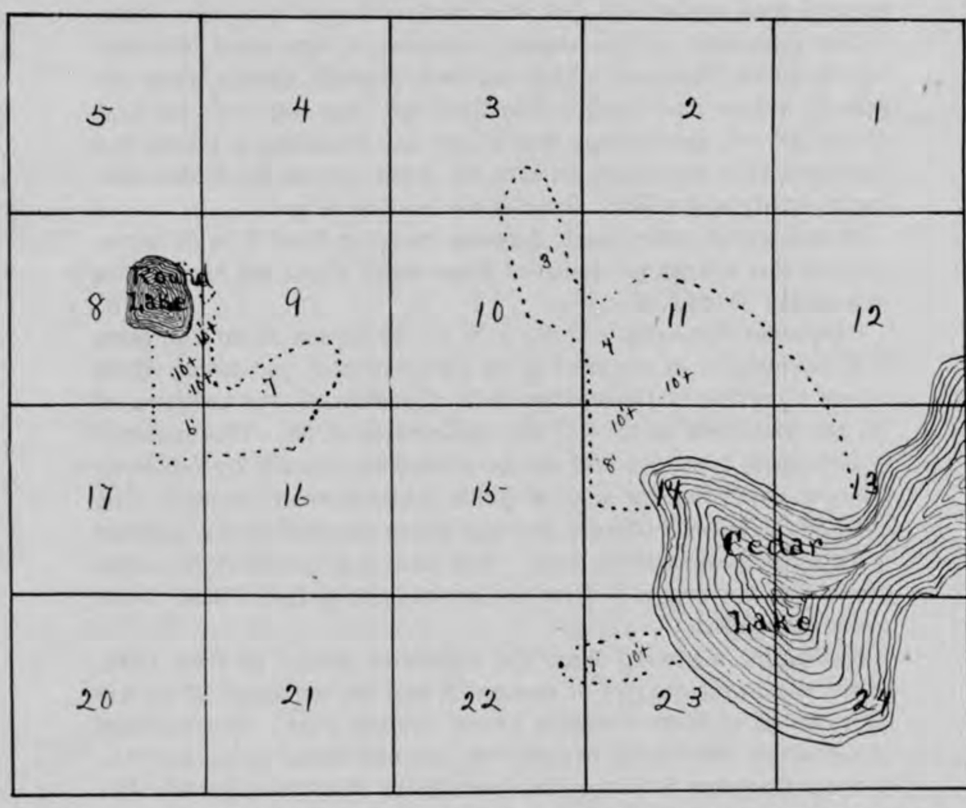


Fig. 15. Showing the thicknesses, where soundings were made, of peat beds in the vicinities of Bass and Round Lakes, Starke County.

ground-water level, the quality is almost good. The origin of the material has been mainly from the grasses and sedges, and to a less extent from the sphagnum mosses. This deposit and the one extending northwest from Bass Lake, are connected by a rather large stream of water, and a broken chain of shallow and small peat beds. These conditions, together with the large amounts and quality of material found in these deposits, makes a point between these two beds a very desirable one for a large peat plant.

One hundred acres of material, which will average poor in quality, is found in the northeast quarter of section 30, the northwest of 29 and the northeast of 31. This bed connects up with another of 100 acres at the northeast and one of 200 acres at the southwest. It has an average thickness of $2\frac{1}{2}$ feet and a maximum of 10 feet. Almost one-half of the deposit is above the ground-water level, the stripping is 1 foot and the underlying bed is sand, which is more or less mingled with the peat.

The 200 acres which lies immediately southwest of this bed also averages poor in quality, and is about one-half above the ground-water level. Its color is a very dark chocolate brown. The average thickness is only 2 feet, and the underlying formation is sand, which is notably mingled with the peat. Considerable grass for packing purposes is obtained from the surface.

California and Wayne Townships.—Very heterogeneous in thickness and quality is the peat bed occurring in the southeast quarter of section 24 and the northeast of 25 (32 N., 3 W.), and the southwest of 19 and the northeast of 30 (32 N., 2 W.). The average thickness is $2\frac{1}{2}$ feet and the maximum 10 feet, and about one-half of the bed is beneath the ground-water level, thus giving a poor to fair quality. Grasses and sedges have been the prevailing sources of origin, and a very dark chocolate brown is the color. The stripping is about 1 foot, and the substratum is sand.

Extending over several hundred acres and resting mainly upon the sand and somewhat upon the marl, is a peat deposit in the southeast quarter of section 25, and the northeast of 36 (32 N., 3 W.), and all quarters of 31, the southwest of 30 and the western half of 32 (32 N., 2 W.). Since most of the bed is beneath the ground-water level, and the average thickness (see map) is good, the quality is fair to good. The color is a dark chocolate brown and the origin from the grasses and sedges has been most prevalent.

Wayne Township (32 N., 3 W.).—A peat deposit, with an extent of 300 acres, occurs in the southeast quarter of section 21, the southwest of 22, all quarters of 28, the western half of 27, the northeast quarter of 33 and the northwest of 34. The material is very much separated by the higher ground and occurs in patches, ranging from 10 to 60 acres. One of these 60-acre patches having a very good quality of material, lies in sections 33 and 34. This material has been derived mainly from the sphagnum moss No. 2, but somewhat from sphagnum moss No. 1, and the grasses and sedges, and it is almost wholly beneath the ground-water level. This is a material of good quality, and the thickness of the bed ranges between 4 and 13 feet, and the stripping is almost nothing, providing the value of the peat moss litter, which occurs in abundance, covering the peat, is taken into consideration. A large amount of the green sphagnum mosses, such as are used by nurserymen, is also found growing on portions of this bed. Sand is the predominating subsoil. Some of the grass that is used for packing is cut, annually, from the surface of this bed.

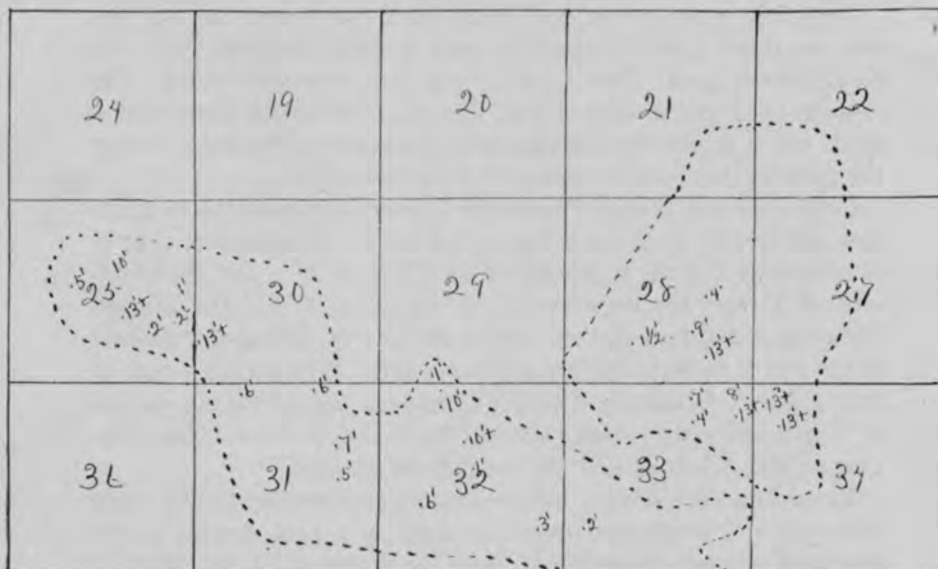


Fig. 16. Showing thicknesses, where soundings were made, of peat beds in the southern half of Wayne township, Starke County.

Another patch belonging to this large deposit and of considerable economic importance, lies one-fourth of a mile north of the one mentioned above. It covers about 50 acres, has a good thickness, and is largely beneath the ground-water level. The material is of good quality and the color is a dark chocolate brown. Several other parts of this deposit, similar to the two mentioned above but of less acreage, occur in sections 27, 28, 21 and 22.

Found in the southeast quarter of section 14 and the northeast of 23, are 100 acres of peat, resting upon the sand. The bed, being between 4 and 13 feet in thickness, and two-thirds beneath the ground-water level, is of a fair to good quality. The derivation is mostly from the grasses and sedges, and the color is a dark chocolate brown. The stripping is about 1 foot.

Along Pine Creek, in the southwest quarter of section 15 and the northwest of 22, is a body of peat, with an extent of 75 acres, and an average thickness of 3 feet, while the maximum is 15 feet. Less than half of the bed is beneath the ground-water level, and the stripping is 1½ feet. These characteristics, together with its origin being, for the most part, from the grasses and sedges, gives a poor to fair quality of material. The color is a dark chocolate brown and the subsoil is sand.

About three-quarters of a mile east of the town of North Judson, in the northeast quarter of section 21 and the southeast of 16, is a peat bed, which will hardly average fair in quality. It has an extent of 50 acres, and an average thickness of 3 feet. The color of the material is a dark chocolate brown, and it has had its source largely from the grasses and sedges. Less than one-half of the deposit is beneath the ground-water level, the stripping is 1 foot, and the underlying formation is sand.

Another deposit of about the same extent, thickness, quality, stripping, amount of material below the ground-water level, color and origin as the above mentioned, lies in the northwest quarter of section 21 and the southwest of 16, and is partly within the North Judson corporation.

A good quality of material occurs in the northeast quarter of section 17, the northwest of 16, the southeast of 8 and the southwest of 9. Its extent is 125 acres, and the thickness (see map) from 4 to 13 feet. Since this bed is mostly beneath the ground-water level, and the origin is from the grasses, sedges and sphagnum mosses, the quality is from fair to good. Marl and sand are the underlying formations, and ½ of a foot is the amount of stripping.

On land owned by Jacob Keller in the southwest quarter of section 10 are 70 acres of a very good quality of peat, which ranked in its fuel test[1] (made by Dr. Lyons, Chemist at the State University), as one of the best of the State. The deposit has an average thickness of about 7 feet, as was learned through a number of tests by Mr. Keller and a few by the writer. About three-fourths of it is beneath the ground-water level, and the stripping is very light. The main sources of origin have been the sphagnum mosses, especially No. 2. Even at present these mosses are growing abundantly upon parts of the surface and would be very valuable to nurserymen. Underlying these mosses are a couple of feet of a good quality of peat moss litter, and beneath this is found the peat. Sand is the principal subsoil.

[1]See page 99.

Occurring in an old lake basin in the northeast quarter of section 14, and the southeast of 11, are 35 acres of a poor to fair quality of peat. The thickness of the bed ranges between 3 and 10 feet and has an average of 3½ feet, while about one-half of the material is above the ground-water level. The stripping is 1 foot, and the underlying stratum is sand. A dark chocolate brown is the predominating color.

Along Bogus Ditch, in the eastern halves of sections 10 and 15, is a peat deposit covering about 60 acres and having an average thickness of 3 feet. The quality of the material will hardly average fair, since more than half of it is above the ground-water level and the lower portion is more or less mingled with the sandy subsoil. The stripping is 1½ feet and the color is a dark chocolate brown. Continuing on south along this ditch one will find a number of small peat beds occurring every one-twentieth to one-half of a mile, until a point several miles south of the Starke County line, in Pulaski County, is reached. At least 500 acres of this material would be found in this township, but the quality would be variable, ranging between very poor and good, and the average would hardly be fair.

About 200 acres of a material, not averaging fair in quality, lies in the eastern half of section 33, and the western of 31. The thickness of this bed will not average over 2½ feet, and the material is largely above the ground-water level. The stripping is 1 foot, the derivation has been from grasses and sedges, and the color is a very dark chocolate brown. Large amounts of grass for packing are annually obtained from the surface.

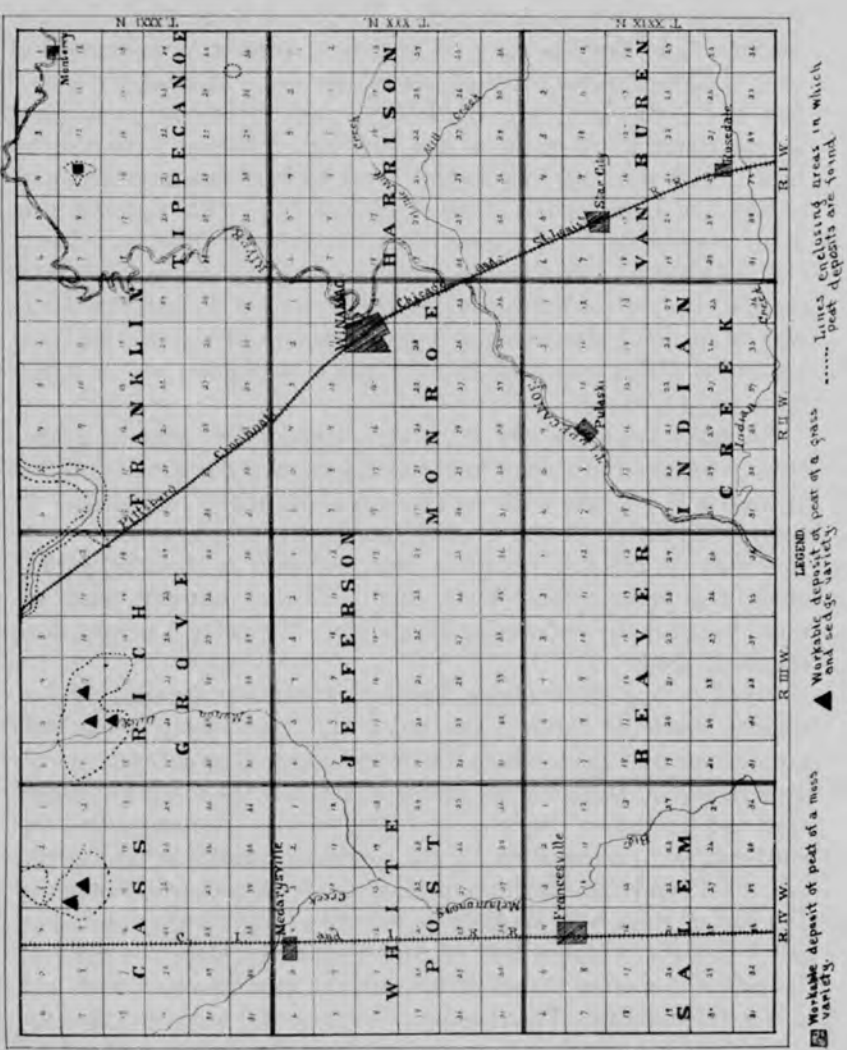
Wayne and Railroad Townships.—Covering 600 acres of surface, and averaging fair in quality, is a peat bed in the eastern half of section 22, all quarters of 31, and the southwest of 30 (32 N., 3 W.), and the northeast of 36 and the southeast of 25 (32 N., 4 W.). The average thickness is 3 feet, and the maximum is 15 feet, while less than one-half of the material is above the ground-water level. The stripping is 1 foot, the material has been derived from the grasses and sedges, and the color is a very dark chocolate brown. Many tons of packing hay are taken each year from the surface of this bed.

In both of these townships are a number of beds of 30 or 40 acres in extent, and of poor to fair quality, that have not been mentioned in this report, and if those of 4 or 5 acres be taken into account probably 2,000 acres more could be added to the total area of the heretofore described deposits.

PULASKI COUNTY.

This county occurs in the northwestern part of the State, south of Starke and east of Jasper Counties. Like Starke, its surface configurations are largely due to the sand ridges and marshes. Although small and shallow peat deposits are found in every civil township, the important deposits are confined wholly to the northern tier of townships.

PULASKI COUNTY.



TOWNSHIP 31 NORTH, RANGES 1, 2, 3 AND 4 WEST.

Tippecanoe Township (31 N., 1 W.).—Occupying an old lake basin, in the northwest, northeast and southeast quarters of section 9, is a tamarack marsh, underlain by a peat bed. The extent is about 120 acres, and the average thickness is 13 feet, if the green moss and peat moss litter are considered as part of the deposit. Since, in addition to these characters, the stripping is very light and the material is almost wholly beneath the ground-water level, the quality is very good. The material has been derived from the sphagnum mosses, especially No. 2. It has a medium chocolate brown color. Besides the good quality of peat, a large amount of very good peat moss litter occurs in this bed. At least the 2 or 3 feet of the upper portion of the bed, underlying the green moss, is this material. Because of the scarcity of fuel and the remoteness from a railroad, this deposit could become very useful in supplying the immediate vicinity. A company with a small peat plant would likely find a home market for almost all of its product.

A deposit of less than half the size of the above, and more shallow, lies in the northeast quarter of section 35 and the northwest of 36. It contains a fair to good quality of material and will become a useful source of fuel for the consumption of the immediate neighborhood.

Franklin Township (31 N., 2 W.).—About 160 acres of a poor quality of material occurs in the northeast and northwest quarters of section 6. It forms the southern end of a deposit that has its greater extent in Starke County, and is described on page ——. The part of the bed found in this township is shallow, mainly above the ground-water level, and somewhat mingled with the sand, which is the underlying formation. The color is a very dark chocolate brown.

Franklin and Rich Grove Townships (31 N., 2 and 3 W.).—Greatly scattered through the muck and black sandy loam beds are 500 acres of peat, which are found along Bogus Ditch, in the western half of section 5, all quarters of 8, and the southeast, southwest and northwest quarters of 7 of Franklin Township, and the southeast and northeast of 12, the southeast, southwest and northwest of 1, and the northern half of 2 of Rich Grove Township. The best of these beds occur in section 12 of Rich Grove Township, and 7 and the southern half of 8 of Franklin. Here 250 acres of the material is more than half beneath the ground-water level, and is of a fair quality. The thickness for these 250 acres will average 4 feet, and the peat has been derived from the grasses and sedges.

The stripping is ½ of a foot, and the subsoil is sand. The color is a dark chocolate brown. The remainder of the deposits will hardly average fair, being rather shallow and mostly above the ground-water level. The color of these are a very dark chocolate brown, and the average stripping is 1½ feet.

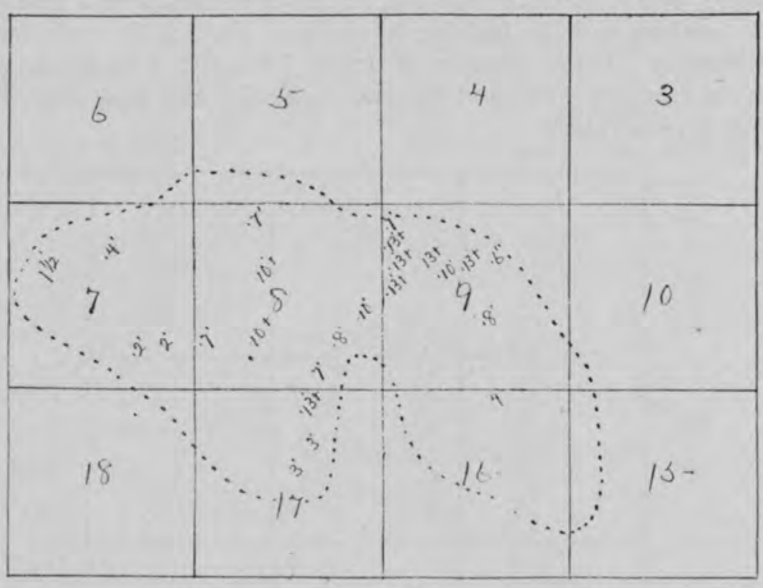


Fig. 17. Showing the thicknesses, where soundings were made, of peat beds in the northwestern part of Rich Grove township, Pulaski County

Rich Grove Township (31 N., 3 W.).—Ranking as one of the most important deposits of the State of Indiana, is the peat bed found in all quarters of sections 7, 8, 9, 16, 17, the eastern half of 15, the southern of 5, the southwest quarter of 10 and the north-east of 18. Almost one-third of this area, as shown in the map, is high ground, thus leaving about 1,000 acres of peat. The thickness of this bed varies greatly, probably in sections 17, 8 and 9, 200 acres could be found which would have an average of 7 feet, and 200 acres more would average 4½ feet. The average for the remainder of the deposit might be 2½ feet. The heavier beds are almost entirely beneath the ground-water level and are in a very fresh condition. Consequently, are of a good quality. A fuel test[1] by Dr. Lyons of the State University, showed for the oven dried material 9,064.65 B. T. U., which is considerably above the average for the State. The beds average 4 feet in thickness, are at least one-half

[1]See page 99.

beneath the level of the ground-water and are of fair quality, while the shallow beds are largely above the ground-water level and are of poor quality. Originating, for the most part, from the grasses and sedges, and to a small extent from the sphagnum mosses, the predominating color is dark. The stripping for the heavy beds is scarcely anything, but is three-fourths of a foot for the medium and 1½ feet for the shallow. Sand is the underlying formation. Large amounts of grass, for packing purposes, are taken from the surface of the peat, annually, and some corn of a fair type is raised.

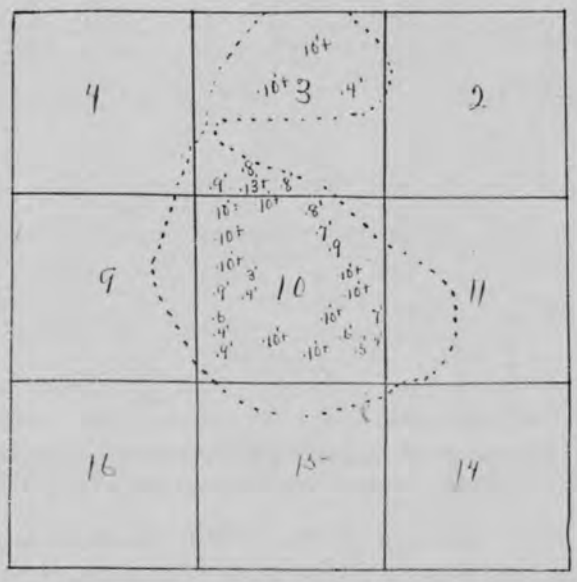


Fig. 18. Showing the thicknesses, where soundings were made, of peat beds in the north central portion of Cass township, Pulaski County.

Cass Township (31 N., 4 W.).—Of almost equal importance to the bed described in the preceding paragraph, is the one found in all of the quarters of sections 3 and 10, the eastern half of 9, the northern of 15, the western of 11, and the southeast of 4. Probably 40 acres of the northern portion of this bed lie in Starke County. The average thickness for 100 acres is 10 feet, that of another 100 is 7 feet, and 200 more is 4 feet. The remainder, which is about 350 acres, has an average thickness of 2½ feet. The quality of the two heavier portions is good, both of which are largely beneath the ground-water level. The fuel test[1] of a sample

[1]See page 99.

taken from the better material of the deposits was made by Dr. Lyons of the State University. It showed the heat value of that which was oven-dried to be 8,472.80 B. T. U. This is about an average test for a good peat. The quality of the portion of the deposit having a thickness of 4 feet, is fair, and that of the shallow portion is poor. Grasses and sedges have been the principal sources of origin, while the mosses, weeds and other vegetation have been minor sources. The color is a dark chocolate brown, the subsoil is sand. For the erection of large peat plants, both this deposit and the one described in the preceding paragraph will afford good locations.

Other deposits of smaller size, but of fair quality, lie in the western part of this township. These, also, though rather shallow and somewhat impure, will become valuable in time for local consumption.

WHITE COUNTY.

White County, which lies immediately south of Jasper and Pulaski Counties, has some small beds of a fair quality of peat, but probably none of sufficient size for the erecting of a peat plant. One of the best deposits occurs in the northern portion of section 33 (28 N., 5 W.). It is the southern extension of a deposit[1] which is found in Jasper County. The portion in White County probably consists of 50 acres. The quality of this bed ranges between poor and fair, and the average thickness is about $2\frac{1}{2}$ feet.

JASPER COUNTY.

This county is in the second tier of counties east of the Illinois State line, in the northwestern portion of the State. It lies immediately east of Newton County and south of the Kankakee marshes. Its northern third is covered by the Kankakee marshes and sand ridges, while the central portion is traversed by a moraine that crosses Newton County. The southern third is a plain covered extensively with sand, which is somewhat drifted into dunes. For amount and quality of peat it is about an average among the peat counties of the State.

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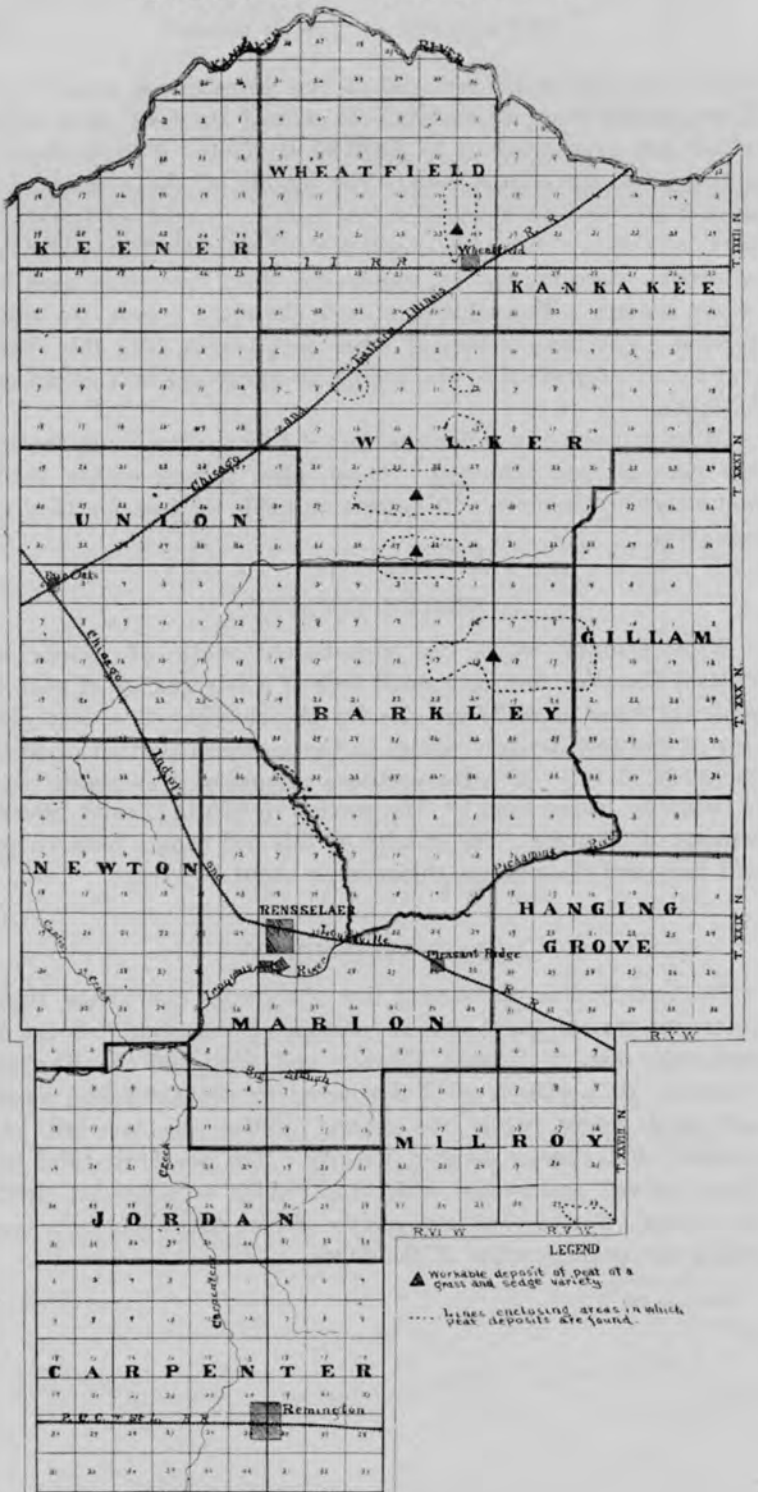
[1] See page 273.

JASPER COUNTY.



TOWNSHIP 32 AND 33 NORTH, RANGES 5, 6 AND 7 WEST.

All of the area lying within 2 miles of the Kankakee River contains more or less small peat deposits, and very extensive muck and black sandy loam beds. The peat found in these beds is almost invariably of a poor quality, being impure and decidedly oxidized. The color is a very dark chocolate brown and the average thickness of the bed is seldom over 3 feet.

Covering 800 acres of surface is a peat deposit in the eastern halves of sections 14, 23 and 26, and the western of 13, 24 and 25 (32 N., 6 W.) of Wheatfield Township. Since only one-half of the material is above the ground-water level and has consequently become oxidized by the atmospheric contact, the quality will average about fair for a material derived from the grasses, sedges and weeds. The color is a dark chocolate brown, the thickness will average 3 feet, having a maximum of 17 feet, and the stripping is 1 foot. Sand is the main subsoil, and fair crops of corn and hay have been grown upon the decomposed surface.

Walker Township (31 N., 5 and 6 W.).—A peat bed hardly averaging fair in quality lies in the northeast quarter of section 11 and the northwest of 12 (31 N., 6 W.). The bed resting upon the sand extends over about 75 acres. Its thickness has an average of 2 feet and the material is mainly above the ground-water level, thus being of poor quality, because of decomposition. The origin has been from the grasses and sedges, and the stripping is about 1 foot. The color is a dark chocolate brown.

Occupying what was once an old lake basin, and occurring about one-half above the ground-water level, is a deposit of a fair quality of peat in the eastern half of section 8, the southern of 4 and all quarters of 9 (31 N., 6 W.). The extent of this bed is 250 acres, the average thickness $2\frac{1}{2}$ feet, and the stripping $\frac{3}{4}$ of a foot. The color is a dark chocolate brown, and the derivation has been mostly from the grasses and sedges.

A peat bed in the eastern half of section 14 and all quarters of 13 (31 N., 6 W.) has an area of almost 150 acres, and an average thickness of $2\frac{1}{2}$ feet. Probably two-thirds of the material is above the level of the ground-water, and the sources of origin have been principally the grasses and sedges. These characteristics give a quality of material which will hardly average fair. The color is a dark chocolate brown, the stripping is 1 foot and the subsoil is, for the most part, sand.

Covering an area of 500 acres, with an average thickness of 3 feet, is a peat bed in the southern half of section 22, and the western of 26, the southwestern quarter of 23, the southeastern of 21, and all quarters of 27 and 28 (31 N., 6 W.). About two-thirds of the material is beneath the ground-water level, consequently permitting a comparatively low amount of decomposition, and giving a fair quality of material. The deposit has been derived from the grasses and sedges and has a dark chocolate brown color. The stripping is ¾ of a foot.

Barkley Township (30 and 31 N., 5 and 6 W.).—Lying in the southern halves of section 34 and 35, the southwestern quarter of 36 (31 N., 6 W.) are 450 acres of a fair quality of peat. Two-thirds of the bed is beneath the level of the ground-water, and the thickness (see map) ranges between 2 and 10 feet, with an average of 3¼ feet. The color is a dark chocolate brown, and the origin has been from the grasses and sedges. The stripping is one-third of a foot, and the underlying beds are sand, clay and gravel. Fair crops of onions are raised on the highly oxidized surface, 200 bushels to the acre being a common crop. Corn also grows fairly well.

About 150 acres of peat, which is about one-half above the ground-water level, and is of a poor to fair quality, occur in the

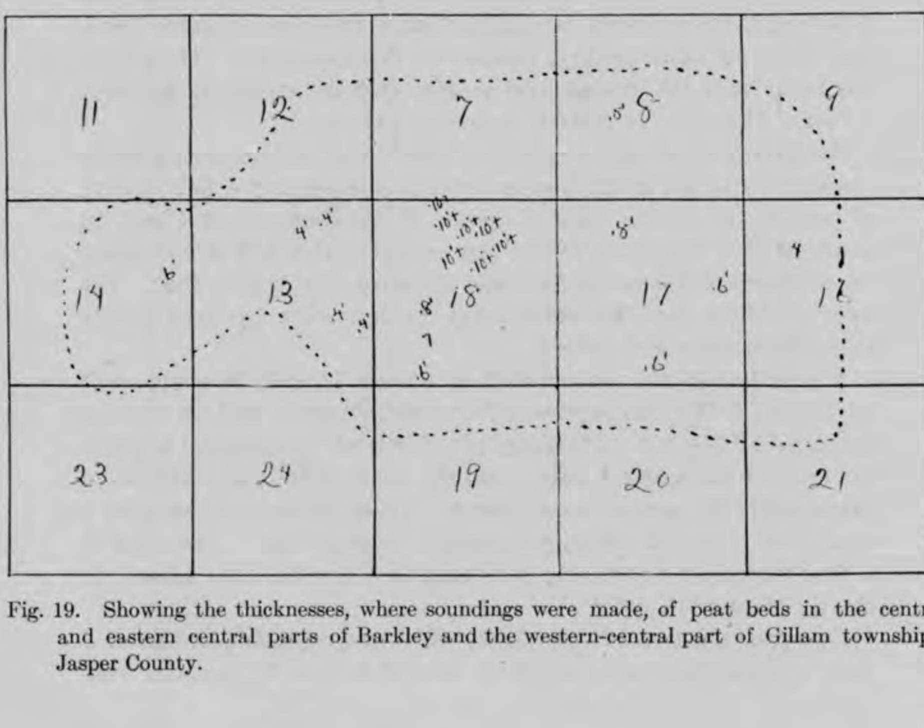


Fig. 19. Showing the thicknesses, where soundings were made, of peat beds in the central and eastern central parts of Barkley and the western-central part of Gillam townships, Jasper County.

southern portions of sections 31 and 32 (31 N., 5 W.), and the northern of 6, 5 and 4 (30 N., 5 W.). This bed is greatly dissected by the higher ground and has an average thickness of 2½ feet. It has a dark chocolate brown color and is derived mainly from the grasses and sedges. The average stripping is 1 foot, and the underlying beds are clay, gravel and sand.

Similar in color, origin, stripping and underlying beds, is the extensive bed of peat occupying all quarters of sections 17 and 18, the southern halves of 7 and 8, the northern of 19 and 20, the western of 16, the southwest quarter of 9 and the northwest of 21 (30 N., 5 W.), and all quarters of 13 and 14, the southern half of 12 and the northeast quarter of 24 (30 N., 6 W.). This is among the largest and more important beds of the State. Two hundred acres of the portion of this bed found in sections 17 and 18 range between 4 and 10 feet in thickness (see map). Beyond these limits, such a thickness is only attained in small patches, but 3 feet is not an overestimate for the average of the entire deposit. The stripping for the heavier beds is about ½ of a foot and the quality is good for a peat derived from the grasses and sedges. This was learned through a test* made by Dr. R. E. Lyons of the State University, which showed an average sample, procured from a number of different points in this bed, to have a fuel value, after being oven-dried at a temperature of 105° C., of 8,273.44 B. T. U. The quality for the remainder of the deposit will average almost fair.

Numerous other beds of peat are found in Walker and Barkley Townships which have not been mentioned because of their limited extents. These are connecting links to the beds mentioned in the six preceding paragraphs and are similar in quality to the more shallow deposits. The combined area covered by these would probably be, at least, 800 acres.

Along the Iroquois River, several miles north of Rensselaer, the county seat, are a number of beds of a fair quality of peat. These follow the river for a distance of 3 miles and vary between ⅛ and ½ of a mile in width, and all taken together will cover 300 acres of surface. The average thickness is about 2½ feet, with 10 feet as a maximum. The sources of origin have been mostly the grasses and sedges and the color is a dark chocolate brown. The quality ranges between poor and fair, and the stripping is 1 foot.

A bed of about 25 acres lies in Milroy Township, in sections 28 and 29 (28 N., 5 W.). It has a thickness of 2½ feet on the

*See page 99.

average and a maximum of 10 feet, while the stripping is 1 foot. The origin of the material has been from the grasses and sedges, and the color is a dark chocolate brown. The quality ranges between poor and fair.

Beds of peat ranging between 5 and 20 acres can probably be found in all townships of this county. But for a general thing these beds are of poor quality, being shallow and mostly above the ground-water level. Consequently, they would not be suitable for even a very small peat plant and could only be economically utilized in a crude way. The material might be spaded out, stacked for the purpose of drying, and burnt in the stoves without going through any further process.

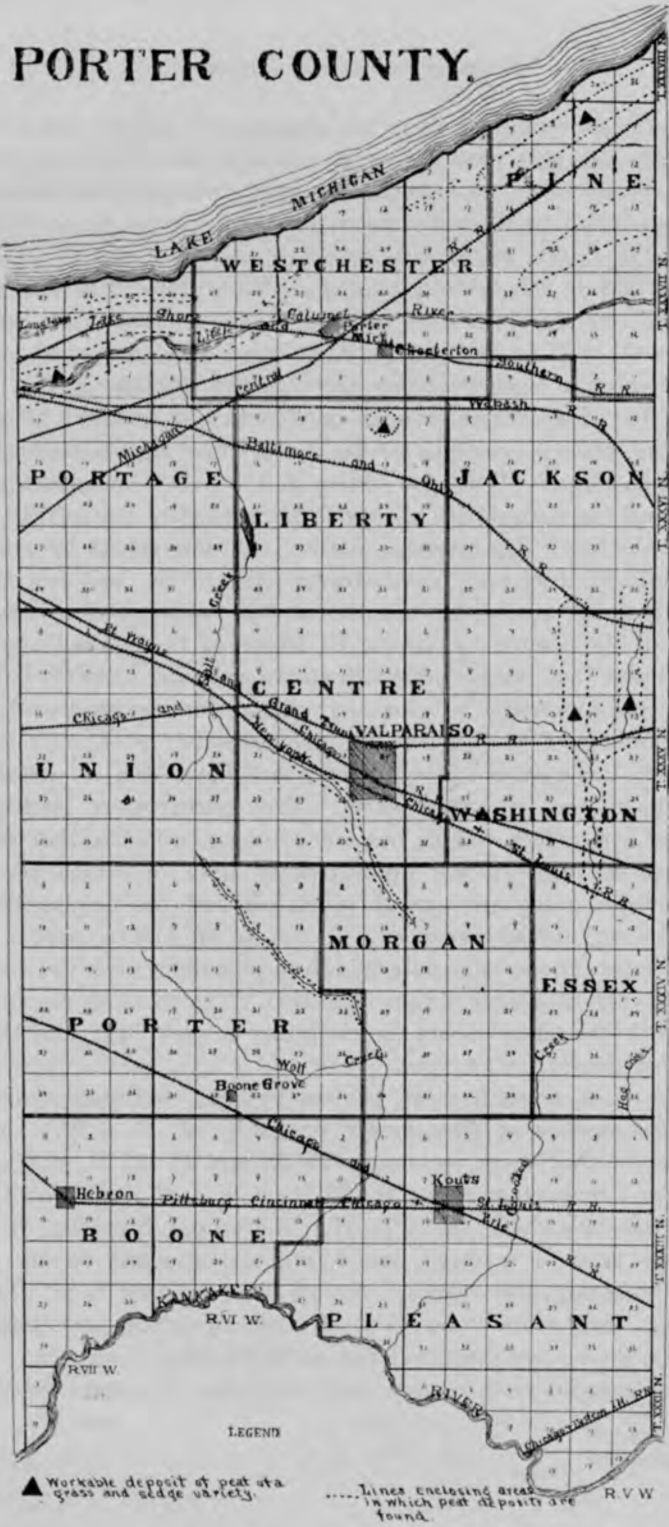
For the erection of a large peat plant, the location described on page 273 would be the most suitable of the county. Through the western portion of this deposit is the Gifford Railroad, and within it is the town of Newland, and one-fourth of a mile north of it is Gifford. Since several other large peat beds lie only a short distance north of this one and are also traversed by the Gifford Railroad, these might also become a source of supply for such a plant.

PORTER COUNTY.

This county, with Lake Michigan as its northern boundary and the Kankakee River as its southern, lies immediately east of Lake County and west of Laporte. Its principal peat deposits occur in the northern congressional townships, and along Crooked Creek Ditches, east and northeast of Valparaiso.

Townships 36, 37 and 38 North, Ranges 5, 6 and 7 West.

Pine Township (37 and 38 N., 5 W.).—Very extensive muck and peat deposits occupy all quarters of sections 28, 22, 13, the northwest quarter of 27, the southeast of 21, the southwest, southeast and northeast of 23, the southern half of 14 and the northern half of 24. About 750 acres of this extent may be classed peat, 200 of which are of a fair quality, and the remainder poor. The fair quality of material occurs in small deposits of 15 or 20 acres and are scattered over the entire area, but is generally associated with the poor peat rather than the muck. The average thickness of the fair beds is about 4½ feet and over half of the material is beneath the ground-water level. The other beds will not average more than 2½ feet, are largely above the ground-water level, where they have


PORTER COUNTY.
LAKE MICHIGAN
WESTCHESTER
PINE
PORTAGE
JACKSON
LIBERTY
CENTRE
VALPARAISO
UNION
WASHINGTON
MORGAN
ESSEX
PORTER
Boone Grove
BOONE
Hebron
Kouts
PLEASANT
KANKAKEE
RIVER
R.VI W.
R.VII W.
R.V W.
Chesterton
Calumet River
Lake Shore
Michigan Central
Wabash R. R.
Baltimore and Ohio R. R.
Chicago and Grand Trunk
New York Chicago and St. Louis R. R.
Pittsburg Cincinnati Chicago St. Louis R. R.
Chicago and Erie R. R.
Wolf Creek
Salt Creek
Crooked Creek
Hog Creek
LEGEND
Workable deposit of peat of a grass and sedge variety.
Lines enclosing areas in which peat deposits are found.

become highly oxidized from the atmospheric contact and are considerably mingled with the sand, which is the underlying formation. The color of the material is a very dark chocolate brown and the origin has been mostly from the grasses and sedges. The decomposed surface is found to be a fair soil for corn.

Bounded on the northwest by great sand dunes, which in places rise 200 feet above the level of Lake Michigan, that meets them on the north, and on the southeast by sand hills, is a peat deposit which extends entirely across the northern portion of this township. Its width varies between one-fourth and one-half of a mile. It is the western extension of the deposit that has its beginning at Michigan City.* With five-sixths of it beneath the ground-water level and the material in a very fresh condition, the quality averages only fair. The average quality was determined by selecting a sample for fuel test, from various parts of the bed, and in this way obtaining an average sample. A fuel determination† was then made of the sample by Dr. R. E. Lyons of the State University, who found that the oven-dried material gave off 5,635.03 B. T. U. Since this fuel value is below the average for the grass and sedge peat obtained from beneath the ground-water level, with no impurities, the sources of origin may not have been as suitable as they have been in other parts. The sources were largely the grasses and sedges. It is, however, just as probable, that the decomposition beneath the ground-water level in which the non-combustible gases are largely given off and the combustible retained, had not advanced sufficiently to produce a good quality of material. Especially does this seem plausible, since the material is in a very loose and fibrous condition. The color of the material is a dark chocolate brown, the stripping is very light, and the underlying formation is sand.

This same deposit, more or less broken, continues across the northern portion of Westchester Township (37 N., 6 W.). In the vicinity of Bailytown, in sections 22, 28 and 29 (37 N., 6 W.), and westward through sections 30 (37 N., 6 W.), 25 and 26 (37 N., 7 W.), and 34 and 35 (36 N., 7 W.) of Portage Township, it again becomes very pronounced, but is not a continuous deposit as in Pine Township, but rather a broken chain of peat beds. The individual beds range from 10 to 60 acres in extent, and similar in quality to the one described for northern Pine Township. Much of the material is in a very loose condition, in places being sus-

*See page 251.
†See page 99.

pended in lakes, and for this reason will shrink very notably upon drying. The average thickness of these beds is probably 4 feet and the stripping is almost nothing. Combining all of the beds of this character of northern Portage and Westchester Townships, the area covered would likely be 1½ square miles.

Portage anl Westchester Townships (36 N., 6 and 7 W.).—On either side of the Little Calumet River, in the northern part of this township, are rather extensive beds of a poor quality of peat. These, combined, would cover 500 acres, but they are very much scattered from the Lake County line to the town of Hageman. Although in areas of 25 or 30 acres, the quality is fair, the material is mainly beneath the ground-water level, and the average thickness is 5 or 6 feet; as a whole the material is mingled with the sandy subsoil, and the beds will not average over 2 feet in thickness. Possibly 150 acres of the 600 could be termed fair.

Occupying all quarters of section 12 in the northern part of Liberty Township (36 N., 5 and 6 W.), are 150 acres of peat. With four-fifths of its material beneath the ground-water level and in a very pure and fresh condition, the deposit will average fair in quality. The grasses and sedges have been the chief sources of origin, and the color is a dark chocolate brown. The stripping varies between ¼ and 1 foot, and the substratum is sand. The thickness of the bed ranges between 4 and 10 feet, 5 feet being an average.

In section 15 of this same township are 60 acres of a poor to fair quality of peat. The bed has an average thickness of 3½ feet, and about one-half of the material is beneath the ground-water level. The stripping is 1 foot. The color is a dark chocolate brown.

Washington Township (35 N., 5 W.).—Extending entirely across this township, from north to south, is a chain of peat beds which occur along the Crooked Creek Ditches. The deposits commence just south of the township line in section 2 of Essex Township (34 N., 5 W.), and extend northward through sections 35 and 26 to the central part of 23, where they branch, one branch passing through sections 13, 12 and 1 to 36 of Jackson Township (36 N.), and the other through 14, 11, 10, 2 and 3 to 34 of Jackson Township. In the extent of this chain of peat beds, probably 500 acres of surface are covered. Two hundred acres are of a fair quality, while the remainder is poor. The better portion occurs in deposits that have thicknesses ranging between 4 and 10 feet, and 65 per cent. of the material is beneath the ground-water level, while the beds of less than 4 feet in thickness are almost wholly above the ground-water level, and consequently are much decomposed. The stripping of the heavier beds is from $\frac{1}{4}$ to 1 foot, and the color is a dark chocolate brown, while the stripping of the shallow beds is from 1 to 2 feet, and the color is a very dark chocolate brown. Grasses and sedges have been the main sources of origin. The texture of the better material is very fibrous and incompact. The oxidized surface makes, in general, a fair soil for pasture grass, and in places has been found suitable for hay and corn.

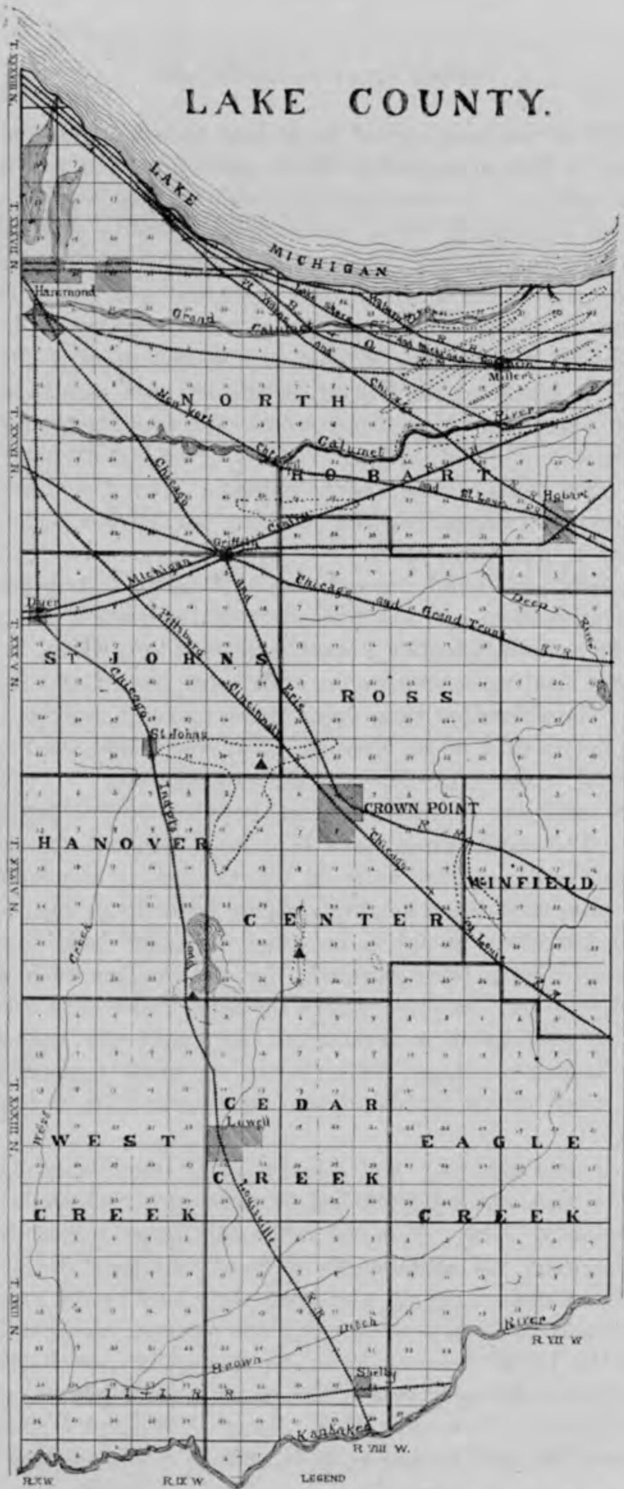
Center and Morgan Townships (34 and 35 N., 5 and 6 W.).—A series of long, narrow peat beds having their beginning in section 22 of Center Township, and extending in a southeasterly course through sections 23, 26, 35 and into sections 1, 2 and 12 of Morgan Township, consist of about 200 acres. Only in spots of 8 or 12 acres is the material of even a fair quality. Combining these small areas of fair quality, the total extent will not exceed 60 acres. These better portions have a thickness ranging between 4 and 7 feet, while the poorer are less than 4, not averaging over $1\frac{1}{2}$ feet. The color of the heavier beds is a dark chocolate brown, and their derivation has been from the grasses and sedges. This material is more than one-half beneath the ground-water level, while the average stripping is three-fourths of a foot. Sand is the underlying stratum.

Small beds of peat of fair quality also occur along the ditch passing through sections 9, 16, 15 and 23 (34 N., 6 W.); but none are of sufficient size to be of economic importance other than for use in the crude form. In the Kankakee flood plains are some small peat beds of fair quality, and many of poor quality. Unmentioned deposits of 3 or 4 acres, which could be used in the crude condition, occur more or less in all of the civil townships of this county.

LAKE COUNTY.

Lake County is situated in the northwest corner of the State of Indiana. The northern portion has a sand dune topography, the central a gently rolling and the southern the flats of the Kankakee Valley. The glacial drift of the Pleistocene period is the chief formation expressing itself on the surface.

The main peat beds of the county are found in long sloughs among the sand dunes in the northeastern portion, in the flood plains of the Little Calumet River, in the Cady Marsh, near Ross, and in old lake basins and in stream valleys in the central part.



LEGEND

▲ Workable deposit of peat of a grass and sedge variety

..... Lines enclosing areas in which peat deposits are found

The quality of the material of these peat beds is about the same, being from a fair to a good grade of grass peat, but poorer than the moss variety. No moss peat is found in this county.

The Long Lake beds, which are situated in the northeast corner of the county and extend over into the northwest corner of Porter County, are in the southeast and southwest quarters of sections 33, 32 and 31 (37 N., 7 W.), northeast and northwest of 4 and 5, and northeast, northwest, southeast and southwest of 6 (36 N., 7 W.), and 1 northeast, northwest, southeast and southwest; 12 northeast, northwest, 2 northeast, northwest, southeast, southwest; 11 northeast, northwest (36 N., 8 W.). This bed of Long Lake, together with small isolated beds, which are found in basins surrounded by sand dunes, consists of about 1,000 acres, which could be utilized by one peat plant.

These beds are found beneath one-half foot of stripping, rest upon a sand bottom and are formed from the grasses and sedges. They have a dark chocolate brown color, are very loose, in many places, just floating in the water, and range from fair to poor in quality. The thickness runs from three to eight feet, but probably 4½ feet would be an average. Not more than one-fourth of the material is above the level of the ground-water.

A very singular feature of these beds is their topographical position. The sand dunes have in places assumed the form of great wind rows, several miles in length and from one-tenth to one-fifth mile wide, with heights ranging from 30 to 150 feet. In the great furrows, the lakes, in which the peat beds have been found, are or have been situated. Long Lake has such a topographical position. In other places the sand dunes have given rise to a relief phenomena something of the hummocky nature of a terminal moraine. Many kettle basins or small depressions are found in these places, which contain small peat beds of from 2 to 40 acres.

Between Indiana City and Clarke, along the Grand Calumet River, is a shallow and loose bed of grass peat, which is mostly poor in quality. This bed is not sufficiently large in extent to pay a peat company for establishing a plant, but may be of use to the poorer classes of people who burn their fuel in the crude condition. Areas of from 2 to 20 acres are common along this river.

Along the Little Calumet River, in this county, probably 2,000 acres of peat beds are present. The much greater portion of these beds are found in Township 36 N., Range 7 W., and sections 4, 9, 8, 17, 7 and 18, and Township 36 N., Range 8 W., sections 12, 13, 14 and 15. These beds occur as pockets in the hard ground of the flood plains, and range in thickness from 1 to 8 feet, but will average about 3 feet. The stripping is about one-half foot, and probably one-third of the material is above the ground-water level. This leaves a large part in a very loose condition. The soil is largely sand, and the quality will hardly average fair, because of the sandy condition of the material and the amount of decomposition near the surface. The color is a very dark brown, and the derivation is mainly from the grasses and the sedges. Fair hay and pasture are found upon large scopes of the surface. At various points in this extent fair locations for peat plants exist, especially because of the most excellent transportation and nearness of the best markets.

As we advance westward in the flood plains of the Little Calumet the peat beds become more and more scarce, of more limited extents, less thickness and more sandy. Few, if any, can be found suitable for putting in a peat plant, but many small ones of 3 or 4 acres, and of fair quality, can be found, which would serve very well where the consumer wishes to dig out his peats with a spade and burn them in the crude condition.

The main beds of the Cady Marsh are found in the southwest and southeast quarters of section 25 (36 N., 9 W.), and the southwest and southeast of section 30, southwest and southeast of section 29, and the southwest of section 28 (36 N., 8 W.), Hobart Township. These beds will probably aggregate 250 acres, with an average thickness of 3 feet and a maximum of 10 feet. About one-fourth of these beds are above the ground-water level, the stripping is 1 foot, the subsoil is sand, the quality is fair and the derivation has been from the grasses and the sedges.

About one-half mile northeast of Ross are the old excavations left from the removing of peat some forty-one years ago for commercial use as a fuel. For about one year it was taken out and used in the crude condition, and only a few men were employed in the work.

The remainder of the Cady Marsh, extending westward on into Illinois, will likely contain 200 acres of peat, very much scattered in small pockets of 25 or 30 acres. The thickness of the beds are generally small and the quality of the material is hardly fair. Only in the vicinity of Ross are the Cady Marsh deposits of sufficient size and quality to pay a peat company to put in a plant, and these beds would need to be carefully sounded.

One of the largest and most promising peat beds of this county is the one situated about a mile north and west of Crown Point. As can be seen from the map, it covers portions of sections 1, 2, 12, 11 and 14 (T. 34 N., R. 9 W.); 33, 34, 35 and 36 (35 N., 9 W.), and 31 and 32 (35 N., R. 8 W.). The peat of this bed is of a fair quality and has a thickness ranging between 3 and 20 feet. The extent has been determined by Mr. Fisher of Crown Point, who made a number of soundings a few years ago relative to seeing if a satisfactory location could be found for a peat plant. He found that the portion indicated by the dotted line, in the map, has an average thickness of 20 feet, and from this line to the borders there is a gradual decrease in thickness. The bed is largely beneath the level of the water, and for this reason is in a very incompact condition and will shrink greatly upon draining. The stripping of this bed is ½ foot, and the derivation largely from the grasses and sedges. Because of a large extent of the deposit, the fair quality and the excellent transportation facilities, this is probably the best location for a peat plant in the county.

From two to three and one-half miles south of Crown Point, in sections 19, 30 and 31 (34 N., 8 W.), are 250 acres of peat, which is fair in quality, and is formed from the grasses and the sedges. The thickness of the bed ranges between 3 and 13 feet, probably averaging 5 feet, and the stripping is ½ foot. The subsoil is sand, and about nine-tenths of the material is below the water level, which gives it a very loose texture. It is very fibrous and the blades of grass are very prominent. Considerable hay is grown on the surface. This deposit, as well as the one a mile north and west of Crown Point, is a suitable site for a peat plant.

In portions of sections 11, 12, 13, 14, 23 and 24 (34 N., 8 W.), 3 miles southeast of Crown Point, are 150 acres of peat, with an average thickness of 2 feet, and a color ranging from a very dark to a dark chocolate brown. About one-half of the bed is above the ground-water level, the stripping is 1 foot, and its derivation is from the grasses and the sedges. The quality ranges between poor and fair, being, in many places, sandy and decomposed.

A deposit of similar quality and thickness and of about 60 acres in extent, is found in the southeast quarter of section 28 and the northeast of 33 (34 N., 8 W.). The stripping is 1 foot, about one-fourth of the material is above the ground-water level, and it is derived from the grasses and the sedges. Because of shallowness, neither this deposit nor the one three miles southeast of Crown Point are suitable for putting in a peat plant, but would serve for spading out and using in the crude condition.

At the south end of Cedar Lake, in the southwest and southeast quarters of section 34 (34 N., 9 W.); northwest, northeast and southeast quarters of section 3, and the northwest and southwest quarters of 2 (33 N., 9 W.), is a bed of peat, which is almost all beneath ground-water level, and comprises an area of 300 acres. The average thickness is 3½ feet and the maximum more than 10 feet, while the stripping is ½ foot. The color is a dark chocolate brown, and the material is derived from the grasses and the sedges. The quality is largely fair, and the position is the site of the former greater extent of Cedar Lake. Since this material is mostly in the water and in a very loose condition, only a portion of the present thickness would exist if the bed were to be drained. Enough material is present about this lake to satisfy a peat plant, and the transportation facilities are good, the Monon Railroad passing north and south through the marsh.

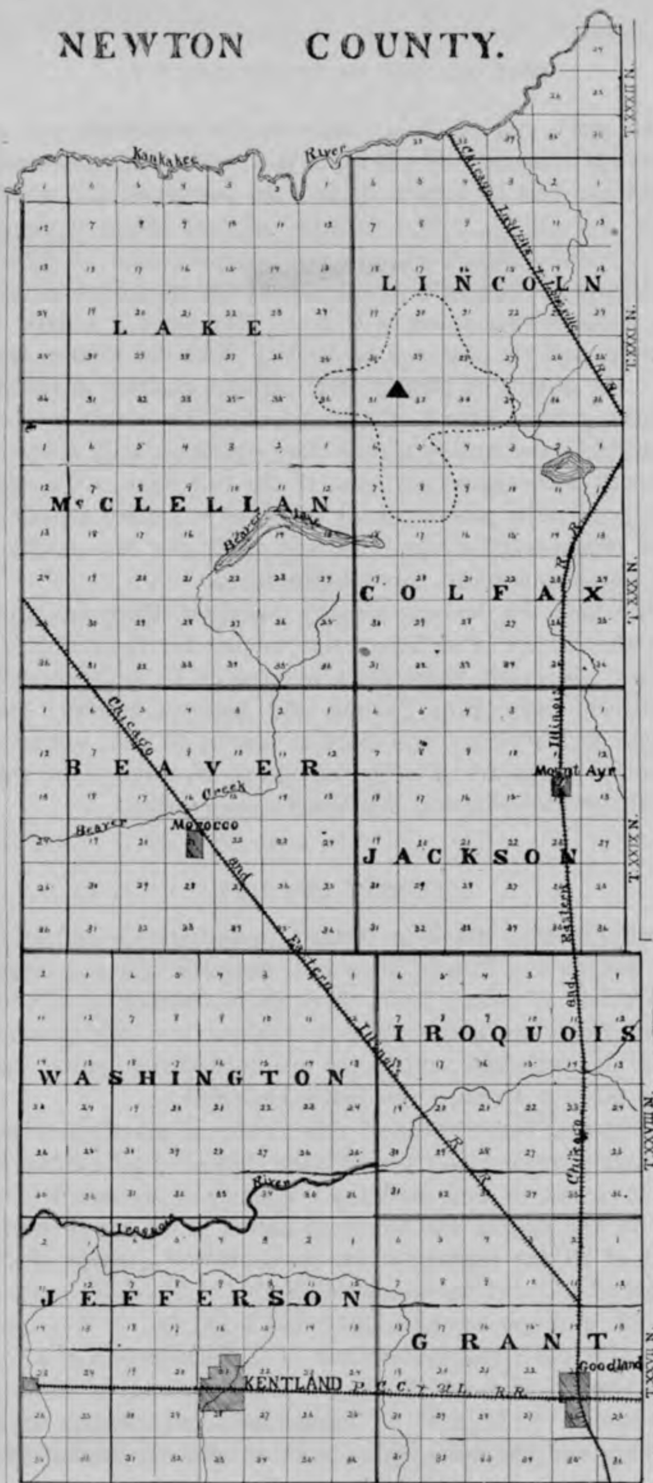
Further than the deposits already described, there are probably none in the county of sufficient size to pay for the building of a peat plant. However, there are a number of 15 or 20 acres in extent between Gary, Pine Station and Indiana Harbor, between Hammond and Whiting, and more or less in all civil townships of the county. These are of sufficient extent to warrant the spading out, in the crude condition, for home consumption.

NEWTON COUNTY.

Newton County, which is located immediately south of Lake County and on the Illinois State line, contains only one large and important bed of peat. True, there are a number of other small beds, but these are generally very shallow and highly oxidized. Only for domestic use, and in the crude condition, could the material be taken out with any practicable value.

The principal bed of peat of this county is greatly interrupted by the higher ground and lies in Lake, Lincoln and Colfax Townships. It covers, to some extent, all quarters of sections 20, 29, 31, 32 and 33, the eastern and southern halves of 30, the western and southern of 28, the western of 34, the southwest quarter of 27, the southwest of 21, and the southeast of 19 (31 N., 8 W.); all quarters of 36, and the southern half of 25 (31 N., 9 W.), and all quarters of 5 and 8, the western half of 9, the northern of 17 and 4, and the eastern of 6 and 7, the northeast quarter of 18 and the northwest of 3 (30 N., 8 W.). Taking into consideration the black sandy loam and the muck beds, together with the higher ground,

NEWTON COUNTY.



LEGEND

▲ Workable deposit of peat of a grass and sedge variety

------ Lines enclosing areas in which peat deposits are found.

probably not more than one-fifth of this area will be of value as fuel. The average thickness (see map) of this portion of the area is about $2\frac{1}{2}$ feet, and the quality averages poor. However, there are many limited areas of 15 or 20 acres where the beds have a thickness of 5 or 7 feet, are largely beneath the ground-water level and range from fair to good in quality. From several of these better areas a sample was obtained which was tested* by Dr. R. E. Lyons of the State University, and was found to have a very high fuel value for a material derived from the grasses and sedges. The results of the determination, showed, where the peat had been oven-dried at a temperature of 105 degrees C., a fuel value of 9,033.50 B. T. U. The color of the better portions is a dark chocolate brown, while that for the poorer is almost a black. The deposit has a stripping that will average about 1 foot, and a sandy subsoil. Large amounts of corn are raised on the highly decomposed surface, and the crops range from 30 to 45 bushels to the acre.

*See page 99.

MUCK BEDS OF NORTHERN INDIANA.

The muck* beds of Indiana occur most extensively in the four tiers of northern counties and particularly in the localities where the peat deposits are largest and most numerous. Since the muck is merely an impure form of peat, resulting either from a concentration of the inorganic matter from decomposition in the presence of the atmosphere, or a mixing with the underlying formation or the sand and silt carried and deposited by the streams, its origin will vary as that of the peat from which it is derived.

Recent years, it seems, have disclosed the fact that the muck land, which was formerly considered almost worthless, is rapidly becoming valuable. Some of it, where onion, celery, potato, peppermint and cabbage growing are carried on, sells as high as $150 per acre. But, without fertilizer or being mixed with other salts, it produces small crops. The improvement of the muck soil is brought about in the following ways: By mixing it with clay, sand, manure or straw; by adding fertilizer, and by burning several inches of the surface off, where the thickness of the bed is three feet or more.

Chemical analysis of the muck by the Agricultural Station of Indiana shows a typical muck soil of Indiana, when dry, to contain about three-tenths per cent. of potash, the same amount of phosphoric acid, and from three and one-half to four per cent. of nitrogen; while a clay subsoil of the state has about two per cent. of potash, and one-tenth per cent. each of phosphoric acid and nitrogen. This indicates that the muck runs very low in potash and high in nitrogen, while the clay has a fair amount of potash, but becomes, in a few years, deficient in nitrogen. Sand runs much higher in potash and lower in nitrogen than the muck; and straw and barnyard manure contain considerable amounts of potash.

Straw and manure, in addition to enriching the muck by supplying potash, probably has another effect. We know that the muck soil, a few inches beneath the surface, is always wet. This is due to the capillary rising of the water from the ground-water level. The plowing under of these fertilizers will interfere with

*See page 82 for definition.

this capillary action and permit the soil to dry out. Sand and gravel would also interfere with the capillary action in the muck.

When muck is added to clay or sand, the improvement of the soil may result from the power of the muck to absorb and retain water, thus, to some extent, replacing the dry condition by a moist one, and influencing the temperature of the soil. The various organic acids* attack the complex silicates, breaking them down, through solution, into the more simple forms. Solution and weathering brings on disintegration, which produces a more comminuted form of the material. Ammonia is added, which gives nitrogen to the soil.

The effect of mixing muck, clay and sand is very well illustrated in Allen County, on the farm of Thomas Ellison, in the southeast quarter of section 26, the southwest of 25, the northwest of 36 and the northern half of 35 (30 N., 11 E.). Here, where Lost Creek empties into Little River, 200 acres are composed of a mixture of muck, clay and sand. This association resulted from the fact that Lost Creek has a fall of 7½ feet to the mile, while Little River has only 1½ feet. At times of flood, the steeper grade developed a strong current in Lost Creek, which, upon meeting the more quiet waters of Little River, slackened its rate and deposited sand and silt upon the muck beds that fill the river valley. Corn crops raised on this mixed soil are reputed to average at least 70 bushels to the acre, while the adjacent land, composed of either muck or sand, will scarcely yield 47 bushels to the acre. This seems to indicate that none of these soils alone contain all of the constituents necessary for plant growth, but the combination furnishes the necessary food. Numerous other cases were brought to the writer's notice, where the farmers would haul sand or clay onto the muck, or vica versa. In all of these instances, the results are said to have been very good.

Although the burning of the surface, in order that the inorganic material contained by the muck may be concentrated, is frequently resorted to, with good results, yet the waste of fuel is enormous, and the improvement in the soil will not begin to recompense for the loss of peat. Mr. H. Fancher, whose farm is located 5 miles west and 1 mile north of Hamlet, Starke County, experimented, by burning 1½ acres to a depth of 6 inches. Afterwards he put on 300 pounds of Armour's High Grade Potato Grower Fertilizer, which is said to contain 8 per cent. of potash. The yield on this 1½ acres was 1,030 bushels of onions, while, on ground adjacent

*See page 288.

to it, that was not burned but treated with the same amount of fertilizer, the crop was less than 400 bushels to the acre.

In section 30 (33 N., 13 E.) of Dekalb County, about 4 inches of muck was added to a clay soil that was very cloggy. During the first season the muck dried out and did not mix with the clay, the clogs still remained and the production was lower than previously. But when the fall rains came on, followed by the freezing and thawing of the winter and then the spring rains, the muck and clay became well mixed. The clogs rapidly disappeared and the annual yield was decidedly increased. The kernel of corn, instead of being mealy and thick-shelled, like that raised on the pure muck in this vicinity, was firm and large like that produced on a clay soil.

Farmers who have both sand and clay underlying their muck, say, in general, that they prefer the clayey subsoil. Where the land has been drained, the muck overlying the clay requires less fertilizer to keep it in a good condition, and seems to improve with age. The writer will suggest two possibilities that may account, in part, for this improvement. It is to be noted, where the muck bed does not exceed 2½ or 3 feet, that the cray fish carry up the clay to the surface much more than they do the sand. This permits a more thorough mixing of the muck and clay than of the muck and sand, and consequently a greater addition of potash to the former than to the latter. Again, it is known that both the clay and sand are products of the drift and have originated from the dissolving and disintegration of crystalline and sedimentary rocks. The crystallines are the granites, diorites, andisites, gabbros, basalts, etc., which were picked up by the ice in the northern part of the United States and Southern Canada. Each one of these crystallines is made up of a number of minerals, the principal of which are as follows:

Orthoclase feldspar	$K_2OAl_2O_36SiO_2$.
Soda orthoclase feldspar	$(KNa)_2OAl_2O_36SiO_2$.
Microcline feldspar	$K_2OAl_2O_36SiO_2$.
Soda microcline feldspar	$(KNa)_2Al_2O_36SiO_2$.
Oligoclase feldspar	$Na_2OAl_2O_36SiO_2$.
Andesine feldspar	
Labradorite feldspar	$2CaO2Al_2O_34SiO_2$.
Anorthite feldspar	$CaOAl_2O_34SiO_2$.
Biotite mica	$(HK)_2(MgFe)_2(AlFe)_2(SiO_4)_3$.
Muscovite mica	$(K_2H_2)_2OAl_2O_32SiO_2$.
Olivine	$(MgFe)_2SiO_4$.
Augite pyroxene	$CaO(MgFe)O2SiO_2$.

	Hornblende	$CaO_3(MgFe)O4SiO_2$.
	Magnetite	Fe_3O_4.
	Hematite	Fe_2O_3.
	Quartz	SiO_2.
Secondary minerals.	Serpentine	$H_4Mg_3Si_2O_9$.
	Kaolin	$H_4Al_2Si_2O_9$.
	Talc	$H_2Mg_3(SiO_3)_4$.
	Chlorite	$H_8Mg_5Al_2Si_3O_{18}$.

A glance at the chemical compositions of these various minerals shows that the first four contain potash, and the second, fourth and fifth have soda. The micas also contain potash. It would be no exaggeration to say that 35 per cent. of the minerals found in these crystalline rocks are those that have potash. An examination of several hundred chemical analyses* shows the average amount of potash (K_2O) in crystalline rocks to be about 3.4 per cent. and soda (Na_2O) about 3.2 per cent. However, the potash is in combination with other salts, and is useless for a soil until it can be separated through solution and disintegration. A microscopical examination of sand shows it to contain considerable of the potash and soda feldspars. Clay also contains some of these, but not as high percentage as sand, since it is made up largely of kaolin and other secondary minerals. However, the feldspar grain in clay is much smaller than that in the sand and has a decidedly higher percentage of surface as compared with its volume. This gives the solutions of the ground-water, in the clay, a better chance to dissolve out the more soluble salts that go to make up the alkali feldspars. Since the potash and soda are the most soluble, these are taken into solution first, and by the capillary movement of the water, find their way into the overlying muck. In the sand, this going into solution of the potash and soda is less, and consequently the ground-water does not have so large amounts of these salts to add to the overlying muck.

Charles Fairfield, whose farm lies several miles southwest of Ft. Wayne, experimented by putting the muck on a sandy soil, which previously had grown twelve bushels of oats to the acre. The same soil, after manuring, yielded 35 bushels to the acre. The first year, after putting on several inches of muck and plowing it in, the production was less than 12 bushels. The muck did not seem to dry out and did not become well mixed with the sand. The next year there was a great improvement in the soil and a yield of

*Professional Paper No. 14 of the U. S. Geol. Sur.

35 bushels to the acre, and for several succeeding years the crops were no smaller.

In the following table the writer is giving the experience of some of the leading onion, celery and peppermint growers of the State as to the kind of soil best adapted, how to fertilize it, the size and value of crops, and the remedies for failures:

Plate VIII.

Celery Farm belonging to Hoogenboom & Son, near Goshen, Indiana.

Onions that have just been pulled, near Milford, Indiana.

Plate IX.

Hoeing and Weeding Onions near Milford, Indiana.

Plate X.

Crating Onions near Bremen, Indiana.

Plate XI.

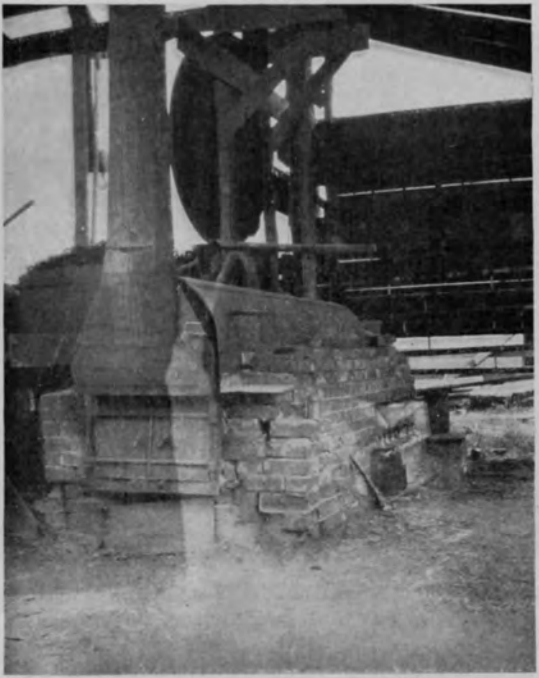
Weeding Onions near Milford, Indiana.

Plate XII.

Peppermint Distillery on the farm of P. F. Nye, four miles north and one mile east of Goshen, Indiana.

Peppermint Distillery on the farm of P. F. Nye, four miles north and one mile east of Goshen, Indiana.

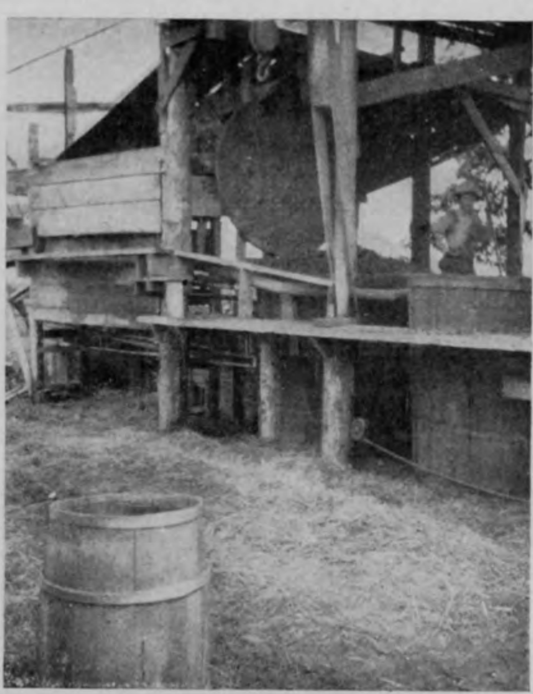
Plate XIII.



The Peppermint Still, Boiler and Vats belonging to the Distillery of P. F. Nye.

The Peppermint Still belonging to the Distillery of P. F. Nye

Plate XIV.



Vats belonging to the Distillery of P. F. Nye.

A vat filled with Peppermint.

Plate XV.

Removing the contents from a vat after the oil has been taken from the peppermint by the Distilling Process.

THE IRON ORE DEPOSITS OF INDIANA.

By Chas. W. Shannon, Bloomington, Indiana.

A striking feature of present industrial conditions all over the civilized and commercial world is the great activity of the iron trade, which is now in the fourth year of its advance. Increase in production and consumption are reported everywhere, except in a few countries—Russia, for instance—where special conditions have checked prosperity.

Iron is the most useful, and, next to aluminum, the most abundant of metals, and is mined and reduced in almost every country in the world. In its native form iron is found chiefly in meteoric stones occurring with nickel and cobalt, and in certain ores of platinum, and is consequently of comparatively rare occurrence, but the so-called iron-ores, the oxides, sulphides, etc., are very widely distributed. Iron as an original constituent of igneous rocks is found in more numerous forms than almost any cther element. While the iron-ore deposits themselves contain much the higher percentage of iron, the main mass of the segregated iron is in the iron-bearing formations rather than in the iron-ores. The amount in the iron-ores is probably insignificant as compared with the amount in the iron-bearing formations. For example, in the Mesabi district in Minnesota, where the iron-ore deposits are larger than in any other region, Dr. Leith has calculated that in the part of the iron-bearing formation which is exposed at the surface, including no part which passes below the overlying slate, the amount of disseminated iron is probably one hundred times as great as that contained in the ore deposits, and the amount of this formation below the slates, in which there are no known ore deposits, is certainly many times, probably hundreds of times, that exposed. This calculation in reference to the Mesabi range shows how insignificant is the amount of iron ore in the ore deposit compared with the widely distributed lower grade products of the iron-bearing formations. Such formations are illustrated by the great Pre-Cambrian iron-bearing formation, of various Lake Superior localities; by the very extensive iron-bearing members and the ores of the Clinton Horizon of the Silurian; by the great iron-bearing horizon of the Carboniferous, and by the bog deposits of the Pleistocene.

There is a general impression that the world's supply of iron ore is approaching exhaustion. The principal argument against this is that improved methods of smelting will enable the lower grades of ore to be successfully used as a source of iron. The total production of iron ore for 1903 was 100,900,000 tons, and for 1905 was 147,500,000 tons. The basis of the trade is in the production of pig iron; and in the table below will be found the output for the first half of 1906 of the chief iron-making countries, which, together, furnish about 80 per cent. of the world's supply. The figures for Great Britain and our own county are in long tons of 2,240 pounds; those from Germany in metric tons of 2,204 pounds.

	1905.	*1906.*	*Changes.*
United States....	11,163,175 T.	12,602,901 T.	I. 1,439,726
Germany	5,098,588 T.	6,073,936 T.	I. 975,348
Great Britain....	4,621,600 T.	4,905,424 T.	I. 283,824
Total	20,883,363 T.	23,582,261 T.	I. 2,698,898 T.

The United States shows an increase of 12.9 per cent. over the first half of 1905, while the gain in Germany was 19.1, and of Great Britain 6.1 per cent. Germany shows the largest proportional increase. The total gain was 12.9 per cent.

Growth and Demand for Iron and Steel.—At the beginning of the last century comparatively little iron or steel was made in any country. There was but little demand for these products. In time railroads became, as they still are, the greatest of all the consumers of iron and steel; yet the Stockton and Darlington R. R. in England, the first railroad in the world to be built for general freight traffic and passenger travel, was not opened until 1825. The general use of iron and steel bridges and iron and steel steamships came later. Next followed the general use of steel in the construction of large buildings, especially those of great height. Last of all we have the steel car for freight purposes. These are the most prominent uses of iron and steel today, but simultaneously with the development of these leading uses there has been a constantly increasing use of agricultural machinery, textile machinery, mining machinery, electrical machinery, machine tools, iron and steel pipe, hardware, stoves, shovels, tin plates, wire and many other articles which are made wholly or in part of iron or steel.

The railroad era began at the close of the first quarter of the 19th century, but it was not until the third quarter of the century was well under way that an extraordinary demand for other than railroad purposes began to manifest itself in any progressive country. In our own country we built more miles of railroad in 1887 than any year before or since. The building of iron and steel vessels received a great deal of attention, particularly in Great Britain, in the third quarter of the century; but it was in the fourth quarter that the greatest progress was made in substituting iron and steel ships for ships of wood. As late as 1868 only five iron steamships were built in one year in this country for ocean service. We have since built over one hundred steel merchant vessels in one year and we have in late years built a magnificent fleet for the American navy, the frames and hulls and armor being of American steel. Armor plate for warships was not made in Great Britain until 1887. Iron and steel buildings already referred to, date from the third quarter, but they did not receive much attention from architects and builders until the fourth quarter, while steel cars were virtually unheard of until the century was nearing its end. The manufacture of tin plates was not introduced into the United States until 1890, except experimentally.

In a word, while the 19th century witnessed the development of the iron age, which was succeeded before its close by the steel age, it would be more exact to say that the last year of the first quarter of the century when the railroad era began, witnessed only the beginning of this development, and the last quarter has seen its ripest fruits, even the last few years of the last quarter.

The rapid growth of the world's iron and steel industries in the 19th century, particularly in its last quarter, could have been possible only by substituting improved methods of manufacture for the slow and expensive methods that were in use at its beginning. The railroads of today could not have been supplied with one-half the rails they needed, indeed the half of these roads would never have been built, if the invention in 1855 of the Bessemer process for making steel had not resulted in giving to the world steel rails which would last longer and could be more cheaply and rapidly made than the rails made of puddled iron. Nor could the steel that is used today in such large quantities for various structural purposes, bridges, buildings, ships, cars, etc., have been made at all but for the Bessemer process and its companion, the Siemens open-hearth process, the latter process dating from 1864. Nor could the pig iron that has been required by the Bessemer and open hearth processes have been supplied, not even the half of it, if reliance had been placed upon the small furnaces, the lean ores, and the charcoal fuels that were in common use less than 100 years ago.

The present wonderful development of the world's iron and steel industries is, therefore, due to the abundance of iron ores and mineral fuel which has been so easily obtainable.

Summary.—The aggregation of large iron ore mines and the control of many prominent producers by consolidated interests has attracted attention to the iron ore reserves of the country, with the effect of awakening some anxiety as to a sufficiency for the future, but an investigation will satisfy an observer that such anxiety was unfounded.

Most of the well-known worked mines, or those producing the best or most desirable grades of ore, which are conveniently accessible for existing blast furnaces, have been secured by the larger steel plants. There are, however, important mines owned or operated independently of consolidation.

Material advance in the price of the mineral will encourage the development of mines which are inactive or operated upon restricted scale, and also the opening of deposits heretofore unworked. Such a condition will also secure the transportation of ores from localities now considered too remote for economical use.

A decided advance in selling prices will also stimulate larger importations of ores from foreign countries, upon which a duty of about 40 cents per long ton is levied.

The known existence of iron ores in all the States of the Union has been reported. In some the mineral is lean or impure or in such thin or widely distributed bodies as to discourage operation, but there are many iron ore deposits of excellent composition existing in large quantities which have as yet been undeveloped, and there are other deposits exploited in former years and found to be limited, which under advanced conditions could be revived.

Immense bodies of magnetites in the East can meet a heavy demand for ore, and the reduction by roasting of sulphur in such as need it, or of phosphorous and gangue material by concentration, can be carried on profitably if the selling prices of ores are much advanced.

It is not improbable that large deposits of titaniferous magnetites may be brought into demand if the supply of ores free or nearly free from titanium is restricted. Many deposits of brown hematite and red hematite ores, which have been worked on a small scale, can be augmented, and the output be cheapened, materially swelling the country's total.

The basic treatment of iron, which is advancing rapidly, may also be expected to remove the limitations which have been placed upon ores for steel productions.

In the central and western portions of the country there are important deposits of excellent iron ore which await the extension of the iron and steel industry or of transportation facilities, and if these ores can not be conveyed to existing furnaces the plants will be placed nearer to the ores as rapidly as the country's demand makes such a course advisable.

Iron and concrete must largely take the place of our rapidly disappearing forests, and in consequence the consumption will undoubtedly increase at a greater rate than in the past. Low grades, as well as inaccessible deposits like those of Utah and possibly Alaska, will be in demand, and very likely this country may be forced to draw upon Mexico and South America for part of its ore supply before the middle of the present century, but the consumption would be hard to predict.

The World's Production of Iron Ore.

The latest authentic statistics at hand of the production of iron ore in all countries are for the year 1904. In the list below the countries are named in the order of their production: United States, Germany, Great Britain, Spain, France, Russia, and Finland, Sweden, Austria-Hungary, Cuba, Algeria, Italy, Greece, Canada, Belgium, Australasia, India, Japan, New South Wales and New Foundland, with all other countries producing about 1,400,000, or a little more than one-half as much as Austria-Hungary.

The United States has far surpassed any other country, the production now being almost twice that of Germany, and three times that of Great Britain. At least 25 of the States and Territories may be classed as iron ore producers. No complete report has yet been published for the last two years to show the rank of the various States in the production of iron ore, but from information given out there will be but little if any change in the order of importance. Minnesota.—This State leads in the quantity of ore mined. Much has been said in regard to the early exhaustion of the iron ore supply of the Lake Superior district, but in Minnesota alone, in the Mesabi Range, there are reported to be known and explored reserves approximating 500,000,000 tons, practically twice the combined shipments from all the ranges of the Lake Superior region since 1854. Michigan takes second place and nearly all the ore is red hematite and is obtained from the Marquette, Menominee and Gogebic ranges. Alabama, as third in rank, contributes three varieties of ore—red hematite, brown hematite and magnetite. New York.—Activity in the Port Henry and Lake Champlain districts have advanced the State to fourth position. Large cargoes of ore for the manufacture of basic pig, were exported to Germany. Virginia and West Virginia.—The chief ore of these States is brown hematite; small quanties of red hematite and magnetite were also obtainable. Tennessee produces both brown and red hematite. New Jersey produces chiefly ores of the magnetite variety. Wisconsin shows a steady advance, as the Baraboo district is extending its production nearer first place. Pennsylvania.—This State in late years has shown a constant decrease in its production of iron ore. It produces red and brown hematites and magnetite. Georgia is a producer of brown and red hematites. It has declined somewhat in the last year or two. Colorado.—This State furnishes brown and red hematite. But the production has declined on account of the decrease in the brown hematite variety. Montana, Nevada, New Mexico, Texas, Utah, and Wyoming are small producers of magnetite and red and brown hematites. New finds are reported in Utah. Other States.—Of the remaining States contributing small amounts, Connecticut furnishes brown hematite; Missouri, red and brown hematite; Maryland, brown hematite and carbonate; North Carolina, brown hematite and magnetite, and Ohio, carbonate and brown hematite ores.

Some of the famous and extensive deposits will be described in the following pages to show the extent of the iron ores, and from which we may be able to determine to what degree lower grade ores and inaccessible deposits will be utilized in the near future.

In the United States.

Production and Development.—Most of the iron ore reduced in the United States, which yields about one-fifth of the world's supply, comes from the Lake Superior region, from the Appalachian region and the Ozarks, but great quantities of ore exist throughout the west.

In 1866 less than 3,000,000 tons of iron ore were mined in this country. In 1870 the output was 3,031,891 tons; in 1880 it had reached 7,120,362 tons; in 1890 the total output was 16,036,043 tons; in 1900 it had reached 27,553,161 tons. Five years later.

1905, the total output was 43,000,000, and in 1906 a total of 49,000,000 tons was reached. This practically represents an increase in the past forty years of about 1,300 per cent. But even more impressive than the marvelous development of the iron ore industry in this country are the improvements made in the methods of mining and handling the iron ore and its products. Formerly practically all mining was done by manual labor, while today in our hard ore mines a compressed air drill turns out as much ore as was formerly mined by nine men, while in the soft ore mines a steam shovel, with three or four men, will mine and load a car in five minutes. The use of explosives, the loading and unloading machines at the great ore docks, the more extensive use of waterways and the development of water powers, and the transportation facilities of our railroads and the saving in fuel charges have all contributed largely to reduce mining costs. Impure and lean ores, especially the magnetites of the East, have been made available and very rich in yield of metallic iron by magnetic separation (this process is briefly described) and a large proportion of the gangue is removed without the use of fuel. In the early days of the iron industry the average car load was less than 15 tons, now cars are built to carry over 50 tons. Before 1870 the Lake Superior ore boats did not reach a capacity exceeding 1,000 tons, while today boats are built to carry 10,000 tons.

Exports and Imports.—Exports of iron and steel and of machinery from the United States for the ten months ending October 31, 1906, are valued by the Bureau of Statistics of the Department of Commerce and Labor as follows:

	1905.	*1906.*	*Changes.*
October........	$12,673,947	$15,910,437	I. $3,236,540
Ten months....	115,596,224	142,609,320	I. 27,013,096

The increase for October was 25.5 per cent.; for the ten months it was 23.4 per cent. The leading item of the iron and steel exports for the ten months were in long tons.

	1905.	*1906.*	*Changes.*
Pig iron	41,212 T.	65,463 T.	I. 24,351 T.
Billets, ingots and blooms	179,880 T.	180,632 T.	I. 752 T.
Bars	44,661 T.	72,094 T.	I. 27,433 T.
Rails	249,941 T.	273,009 T.	I. 23,068 T.
Sheets and plates	59,780 T.	90,673 T.	I. 30,893 T.
Structural steel..	63,401 T.	93,460 T.	I. 30,059 T.
Wire	110,244 T.	144,193 T.	I. 33,949 T.
Nails and spikes.	40,828 T.	52,731 T.	I. 11,903 T.

The large exports of rails this year were to South America, 101,357 tons; Canada, 65,237 tons; West Indies, 29,760 tons; Japan, 20,011 tons; Mexico, 19,145 tons.

Iron and Steel Imports.—Imports, including machinery, into the United States for the month ending October 31, are valued by the Bureau of Statistics as follows:

	1905.	*1906.*	*Changes.*
October	$2,225,194	$3,407,763	I. $1,152,569
Ten months....	21,820,949	27,784,650	I. 5,963,701

The increase in October was 51.1 per cent.; for the ten months it was 27.3 per cent. The more important item of the imports for the ten months were in long tons.

	1905.	*1906.*	*Changes.*
Pig iron	170,891 T.	265,665 T.	I. 94,774 T.
Scrap	12,604 T.	11,203 T.	D. 1,401 T.
Ingots blooms, etc.	11,501 T.	17,067 T.	I. 5,566 T.
Bars	29,186 T.	28,754 T.	D. 432 T.
Wire rods	14,413 T.	15,080 T.	I. 667 T.
Tin plates	58,788 T.	48,846 T.	D. 14,942 T.

The chief points are the large comparative increase in pig iron and the decrease in tin plate.

Exports and imports of the iron ore in the United States for the ten months ending October 31 are reported as follows in long tons:

	1905.	*1906.*	*Changes.*
Exports	179,919 T.	256,384 T.	I. 76,465 T.
Imports	709,766 T.	908,366 T.	I. 198,600 T.

Most of the exports were to Canada. Cuba furnishes the greater part of the imports, but some ore came from Canada and a little from Spain.

Imports of manganese ore for the ten months were 218,225 tons in 1905 and 185,281 tons in 1906, a decrease of 32,994 tons. This ore came from Russia, India and Brazil.

Summary for 1906.—The actual production of pig iron in the United States for the first half of 1906 was 12,602,901 long tons, being a gain of 1,439,726 tons, or 12.9 per cent., over the first half of 1905, and 6.5 per cent. over the last half. The amount made in the half year was greater than that for any entire year prior to 1889. These results emphasize the continued increase in the use of steel.

For the half year 92.3 per cent. of the iron produced was made with coke as fuel. This would be increased to over 95 per cent. if allowance were made for the coke used by the anthracite furnaces, nearly all of which mix some coke with their coal. The total number of furnaces in blast during the half year was 323 and the average 318, showing an average of 39,632 tons of pig iron made per active furnace. The total number of blast furnaces under construction August 1, 1906, was twenty-one, the total production capacity being 2,642,000 tons pig iron and 20,000 tons spiegeliesen yearly. Four of them at Gary, Indiana, with a capacity of 150,000 tons each.

The total make of rails was 3,372,257 tons, of which 3,188,675 tons were made from Bessemer steel; basic open hearth steel furnishing the balance. Iron rails have almost disappeared, only 318 tons having been made in 1905, and those were mine rails of light section.

For opening 1907 deliveries coke is very scarce and prices remain high, being $6.65@7.00 for the best Connellsville, with Virginia cokes 25@50c lower.

MANUFACTURE OF IRON.

History.—The increasing use of iron is a prominent characteristic of the present age, and every day sees some new application in the arts of life. Although the most useful of metals, it was not the first known. Difficulty in reducing it from its ores would naturally make it a later acquisition than gold, silver or copper.

We are informed by the Roman historians that this metal was employed by the ancient Britons for the manufacture of spears and lances. The Romans, during their occupation of Britain, manufactured iron to a considerable extent, as is evidenced by the cinder heaps in the forests of Dean and other places. The process then in use left so much iron in the cinder that those of Dean forest furnished the chief ore supply to twenty furnaces for between two hundred and three hundred years. In those early times the iron ores were reduced in a simple conical furnace, called an "air-bloomery," erected on the top of a hill, in order to obtain the greatest blast of wind. The furnaces were subsequently enlarged and supplied with an artificial blast. Charcoal was the only fuel used in smelting until 1618, when Lord Dudley introduced coal for this purpose, but the ironmasters being unanimously opposed to the change, Dudley's improvement died with him. It was not reintroduced until Abraham Derby, in 1713, employed it in his furnace at Coalbrook Dale. But as this method was not properly understood the production of English iron declined with the change of fuel, till, in 1740, it was only three-fourths what it had been. About ten years after this, however, the introduction of coke gave renewed vigor to the iron trade, and then followed in rapid succession the great improvements in the manufacture, which gives to the history of iron its greatest interest. The introduction of Watt's steam engine in 1770, the processes of puddling and rolling invented by Henry Cort in 1784, and the employment of the hot blast by Neilson of Glasgow in 1830, have been each of inestimable service. The greatest improvement introduced into iron manufacture in recent years is the "Bessemer process" for the production of steel, patented in 1855. The "Siemen's-Martin" method of making steel has also of late come into extensive use. And an important new process has been patented by S. G. Thomas.

Until recently, when it has dwindled down to an insignificant industry, iron ore was reduced direct to iron, with the use of charcoal as a fuel, in forges called Catalan forges, from the district in Spain where they originated.

One of the principal seats of the industry in this country was in the Adirondack Mountains, in New York, where the process still survives in a few isolated localities.

Smelting.—The greater portion of iron is produced by smelting in a blast furnace, the product being pig iron, an alloy of iron, carbon and silicon, containing generally some sulphur and phosphorus, often manganese, and occasionally copper in notable quantities. In this process the ore is deprived of its oxygen by the action of incandescent carbon, and the hot reducing gases resulting from its combustion brings it to a liquid mass which is either allowed to run into ladle cars to be hauled by locomotives to adjacent steel works, or puddling mills, or it is allowed to flow into a series of sand molds from which it is taken when cool, this product being commercially known as "pig" or "cast" iron; as such, pig iron can only be used in the manufacture of castings. Hence by various processes it is converted into malleable or wrought iron and steel. It is possible to produce malleable iron directly from the ore without this process of smelting in the blast furnace. This direct, as distinguished from the indirect, process of first making pig iron has always possessed particular attraction for inventors and experimenters. Many have struggled with the problem, but failed to reach commercial success. The basis of all these efforts is the facility with which iron oxides are reduced at moderate temperatures when in contact with carbon in some form.

Blast Furnaces.—Practically all the iron produced in the leading manufacturing countries, as has been stated, is obtained by the indirect process, the first operation being the smelting of the ore in a blast furnace. The manufacture of commercial iron consists chiefly in the reduction of its oxides, such as hematite, Fe_2O_3; magnetite, or loadstone, Fe_3O_4; and limonite, $Fe_2(OH)_6 Fe_2O_3$. Blast furnaces vary in size and shape; the size depending largely upon the kind of fuel to be used—a coke-fed furnace being larger than one in which soft coal is used. The furnace is a vertical shaft, cylindrical and in horizontal section, widening from the top downward to near the bottom, ranging in height according to local circumstances, from sixty to ninety feet, and from twelve to twenty feet in diameter at its widest part. The body is formed of wrought iron plates, riveted together, forming a shell, which is lined with the most refractory variety of fire brick. This body or stack is supported on a cast iron ring resting on columns. Below the furnace is contracted to form the hearth in which the molten metal and slag and cinder accumulates. At a given distance above the bottom are openings, through which water-jacketed pipes are introduced, called "Tuyeres." Through these air or "blast" is blown by blowing engines, the blast being conducted to the tuyeres from a pipe which encircles the lower part of the furnace, and from which branches lead to the tuyeres. The materials are charged at the top, which is closed by a bell lowered by a special appliance, whenever ore, fuel or flux are to be allowed to drop into the furnace. The top is closed in order to divert laterally the gases produced in a large pipe called the "down comer." The gas is utilized in heating hot blast stoves and in raising steam to supply blowing engines and elevators with power.

In modern blast furnaces, those parts which are exposed to the greatest heat are saved from rapid destruction by a system of water cooling, a number of appliances being used. The molten iron which accumulates at the bottom of the furnace is tapped off, while the cinder, which constitutes the earthy impurities of the ore, and the ash of the fuel with the flux added, is allowed to flow off continuously at a somewhat higher level. Being lighter it floats on the iron.

In the blast furnace there are two currents, traveling in opposite directions and constantly acting on each other—the ascending current of gas and the descending current of ore, fuel and flux. The effect of the highly heated blast (reading 1,000° Fahr. and upward, with modern hot blast stoves) is to produce carbonic acid at the level of the tuyeres where it comes in contact with descending incandescent fuel. This carbonic acid in ascending is reduced to carbonic oxide by the excess of carbon and becomes the active agent in reducing the oxide of iron to metallic iron. The latter in contact with highly heated carbon forms an alloy, melts and collects in the hearth, constituting "pig iron."

The ascending current of hot gas heats the descending column of solid materials, which come down as the lower parts of the column are melted and tapped off. The result is that from the white heat attained at the tuyeres and for some distance above them, the temperature gradually lessens until near the top it is moderate.

Since all iron ore contains varying quantities of impurities and accessory materials, notably silica, aluminum, magnesia and lime, and the fuel carries varying amounts of ash, their removal is affected simultaneously with the reduction of the ore by melting into a homogeneous mass the cinder. In order to produce a cinder whose composition is such that it forms at the proper temperature, it is necessary in the majority of cases to add limestone.

The ore, limestone and fuel are charged at the top of the furnace in alternate layers, the "stock," as it is called, being hoisted to the top of the furnace either in elevators or on inclined planes. The cinder is generally allowed to flow into boxes mounted on cars and is easily disposed of—casting it liquid or throwing it when cold on adjoining territory. It is used as road ballast, in the making of cement, in glass making and in the production of slag-wool.

Fuel consumption is one ton of coke to one ton of pig iron produced, i. e., between 1,000 and 1,500 tons per week for each coke furnace. In recent years the blast furnace has also been used for the manufacture of ferro-manganese, ferro-chromium, ferro-silicon and other alloys.

Transformation of Pig Iron Into Wrought Iron and Steel.—Pig iron, by various processes, is converted into wrought iron and steel. The pig or cast iron is hard and comparatively brittle and can be readily fused at a high temperature, and may be moulded into solid forms by casting, and in modern iron works forms an intermediate product in the manufacture of the other classes. According as the metal may be best adapted for founders' or forge masters' use it is distinguished as forge or foundry pig.

Cast iron, as the crudest, cheapest and most fusible, is used for the heavy portions of engineering work, such as bed plates for machines, cylinders, columns, cisterns, low-pressure boilers, water and gas pipes, rollers, girders and the like. A large quantity is consumed in the manufacture of "hollow wares," which includes pots, pans and other cooking vessels. For all kinds of ornamental objects, also, it is almost exclusively used, because here its property of being readily cast into molds gives it a great advantage on the score of cheapness.

(1). *Wrought or Malleable Iron.*—This is the nearest approach to the chemically pure metal that can be obtained on the large scale. Wrought iron has a clear gray color and a specific gravity of 7.7-7.8. It is softer than cast iron or steel, and extremely tenacious and may be drawn into the finest wire or hammered or rolled into sheets as thin as paper. When two pieces heated to redness are placed in contact and hammered they unite, practically forming one piece; this process is known as welding. When heated and suddenly cooled it retains its softness. The quality of the iron is greatly influenced by the presence of phosphorus and sulphur. Even .01 per cent. phosphorus renders the iron brittle when cold; it is then termed "cold-short," and an equally small amount of sulphur makes it brittle when hot, so that it will not weld into a close joint, but splits and crumbles and is said to be "hot," or "red-short." The presence of any foreign body, such as sulphur, phosphorus, carbon, silicon, copper, oxygen, etc., increases the difficulty of welding. To insure a good weld the surfaces must be clean and the metal at a white heat. Malleable iron is largely employed in manufacture of hardware, such as locks, hinges, bolts, nails, screws, keys, wire, etc., and the so-called tinplate, which is merely sheet iron dipped in melted tin. It is also much used for roofs and bridges of large size and is the mainstay of the railways and the electric telegraph and has almost displaced timber as a material for ships. Rolled armor plates for warships are now made of malleable iron from five to twenty-two inches thick. When iron is exposed to moist air it readily rusts, or oxidizes, so it is often coated with some substance to prevent this, such as tinning, galvanizing and painting.

(2). *Steel.*—Pig iron is the raw material from which steel is made. Steel possesses several valuable properties which do not belong to either cast or wrought iron, but it also partakes of some of the properties of both. It is harder, denser, and whiter in color, is more elastic, takes a higher polish and rusts less easily. It is of a finely crystaline structure, with a specific gravity of 7.6-7.8. Steel may be made in two ways: By increasing the carbon in wrought iron to between .6 and 1.5 per cent., either by adding carbon directly to it or by adding pig iron until the carbon is sufficiently increased. The second way is to remove the carbon from the pig iron.

Pig iron is treated in the Bessemer converter for the production of Bessemer steel; in the Siemens' furnace for Siemens' steel, and melted in a cupola for foundry purposes. The "Bessemer process," invented about 1855, is successfully and largely used in the making of steel. The first stage is effected through the Bessemer converter, made of wrought iron and lined with an infusible material. Into this converter from five to ten tons of molten pig iron are poured and a powerful blast of air is blown through the molten iron until the carbon and silicon is removed by oxidation, and then introducing into the melted iron a given quantity of spiegeleisen, containing a known percentage of carbon. The steel is then poured into molds and allowed to cool. These are the "steel billets" of commerce. Many of the converters are lined with dolomitic limestone, and a quantity of lime is added to the molten iron, and practically all the phosphorus is taken up by the lime and the lining of the converter. Bessemer's invention revolutionized the manufacture of steel. Now ten tons of crude cast iron may be converted into good steel in less than thirty minutes in a single converter. Such steel is extensively used in rails, bridges and boilers.

The Siemens' regenerative gas furnace is now much used for the making of steel. No other furnace can be compared with it in respect to economical consumption of fuel; almost any kind of fuel, however poor, may be used for the gas producers, which are connected by means of a pipe with the regenerators. The furnace consists of two parts: one of these contains the "regenerators," the other, which may be near or some distance away, contains the "gas-producers," or source of the heat. In the regenerative portion there is a melting hearth or bed. Immediately below this hearth there are two pairs of arched chambers filled with fire bricks placed sufficiently far apart to let air or gas pass between them, and at the same time expose a large surface to the heat from the gas-producers. One pair of these chambers communicates by separate flues with one end of the hearth, the other pair with the opposite end. The furnace being in operation, while the gas and air are being admitted to the hearth through the left pair of these chambers, the highly heated products of combustion pass through the open brick work of the corresponding pair on the right before reaching the chimney; thus what would pass up the chimney as waste heat in an ordinary furnace is absorbed by the bricks of the regenerators. After a given time—usually from thirty to sixty minutes—by means of suitable pipes and valves the current is reversed. Gas and air are now sent through the freshly heated pair of generators, while the "waste heat" in turn passes into the other pair, thus hot currents of gas and air in suitable proportions are always reaching the hearth, where combustion is effected at a very high temperature.

The pig iron produced in the blast furnace is carried in large ladle cars, in a molten condition, to the converters; there it is blown and the liquid steel cast in "ingot" molds. The blocks of steel, as soon as the outer crust is sufficiently cooled to allow their removal from the molds, are put into soaking pits. When their heat has been equalized they are carried to rolling mills where they are rolled direct into steel rails, plates, beams, etc. In the production of Bessemer steel, Pennsylvania is credited with over one-half of the output. This State also leads all the States in the production of open hearth "ingots," in crucible steel, in rolled iron and steel.

The modern blast furnace, with its immense blowing engines, its hotblast stoves, its rich ores and excellent coal to smelt them, has been a powerful factor in the present marvelous development of the world's iron and steel industries.

Chemistry of Iron.—Iron has for its symbol, Fe., from the Latin Ferrum. Its specific gravity is 7.3 to 7.8. Pure iron may be obtained by reducing peroxide by means of hydrogen gas and heat, when it is obtained in the form of a fine black powder, or by heating the protochloride in a glass tube through which a current of dry hydrogen is passed, the iron is deposited as a glistening mirror on the glass. Thus chemically pure iron is of very little general interest, and, practically speaking, may be said to be of no commercial value. But on the other hand very small traces of foreign elements exert a very marked influence on the metal, and it is these small, and in many cases unnoticed, differences of composition that render so many points in the chemistry and practical working of iron obscure and difficult to be understood. When it is considered that the investigation of such problems calls for researches involving the utmost refinements of analytical chemistry, it is not remarkable that contradictory statements and opinions still abound on many points of the chemistry of iron making.

The melting point of pure or even ordinary malleable iron has not been determined with certainty. According to some it lies between 1500° and 1600° centigrade, while others place it as high as 2100°. Pure iron is susceptible of being magnetized to a much higher degree than steel, but unlike the latter, it does not retain its magnetism when the exciting cause is removed.

The affinities of iron for most of the non-metallic elements are very powerful. The chief of the iron compounds are (a) Oxide of Iron. Iron forms definite compounds with the oxygen, viz: (1) the protoxide, FeO, which is the base of the green or ferrous salts of iron; (2) the sesquioxide or peroxide Fe_2O_3, which is the base of the red or ferric salts; (3) the black or magnetic oxide, Fe_3O_4, which is regarded by some chemists as a compound of the two preceding oxides, and (4) ferric acid, FeO_3. The protoxide cannot be obtained in an isolated form, but it forms the base of various ferrous salts and combines with water to form a hydrate, $Fe(OH)_2$. The most important protosalts of iron or ferrous salts are the carbonate, the sulphate, the phosphate and the silicate. Carbonate of iron, $FeCO_3$, exists naturally in various minerals and may be obtained artificially by precipitating a soluble protosalt of iron with carbonate of potash or soda, when the carbonate falls in white flakes. On exposure to the air it absorbs oxygen and gives off carbonic acid and is thus converted into the hydrated sesquioxide. Sulphate of Iron, $FeSO_4+7H_2O$, is obtained by the solution of iron or its sulphide in dilute sulphuric acid; in the former case there is an evolution of hydrogen and in the latter of hydrogen sulphide. The reactions are expressed by the following equations:

$$Fe+H_2SO_4=FeSO_4+H_2.$$
$$FeS+H_2SO_4=FeSO_4+H_2S.$$

By evaporation of the solution the salt is obtained in clear, bluish-green rhomboidal crystals, containing seven equivalents of water. This salt is commercially known as copperas or green vitriol. Phosphate of iron is obtained by precipitating a solution of protosalt of iron with phosphate of soda, when a white precipitate of phosphate of iron is thrown down. All these salts, especially the carbonate and sulphate, are extensively used in medicines. Silicate and phosphate of iron occur naturally in several minerals. The peroxide of iron, known as sesquioxide, red oxide, or ferric oxide, is used for polishing glass, jewelry, etc., and is also used as a pigment. Ferric acid has not been obtained in a free state, and is only known as a constituent of certain salts. Haloid Salts of Iron—the chlorides—viz.: a protochloride, $FeCl_2$, and a perchloride, Fe_2Cl_6. The tincture of the perchloride is perhaps more generally employed in medicine than any other preparation of this metal. (c) There are probably several sulphides or sulpurites of iron.

The ordinary sulphide is a protosulphide, FeS. It occurs in small quantities in meteoric iron. It may be obtained artificially by the direct union of the two elements at a high temperature. It is insoluble in water, but in moist air becomes rapidly oxidized into protosulphate of iron. With acids it develops sulphureted hydrogen. The bisulphide of iron, FeS_2, is the iron pyrites of mineralogists, and the Mundic of commerce. Under the latter name it is used extensively in the preparation of oil of vitriol. There are also other sulphides of less importance.

The chemical changes which take place in the preparation of iron are essentially reduction and oxidation, the reduction of the iron oxide to metallic iron, and the oxidation of the carbon to carbon-dioxide. The nearly complete combustion of the carbon in the crucible produces metallic iron, carbon-dioxide, and carbon-monoxide.

$$Fe_2O_3+C_2=2Fe+CO+CO_2.$$

The gases pass up through the strata of hot carbon and ore, where the carbon-dioxide is largely reduced to carbon-monoxide. The carbon-monoxide is combustible, uniting with oxygen to form carbon-dioxide. It is, therefore, a reducing agent. Since the oxygen from the tuyeres has been largely combined in the crucible, the carbon-monoxide must draw its oxygen from the ore. It is consequently active in reducing the iron to the metallic state. This may be expressed by the following equation:

$$Fe_2O_3+3CO=Fe_2+3CO_2.$$

Many things relating to the chemistry of iron are here omitted and will be found under other topics where they are necessarily mentioned.

Minerals Used as Ores of Iron.—In the United States the minerals smelted for iron are, in order of quantity used, hematite, limonite, magnetite and siderite. Goethite and turgite are commercially included with limonite under the name brown hematite and more or less ilmenite is melted with other ores. The residues from the roasting of pyrites are sometimes used as a source of iron, but not in this country. The mineral franklinite, after treatment for zinc, and certain manganiferous hematite and siderites, are smelted and yield "spiegeleisen," an alloy of iron and manganese, used as a source of carbon and manganese in the manufacture of steel.

The varieties of ore and the district in which they are found may be given as follows:

1. Red hematite, being all anhydrous hematite, although known by various names, such as red hematite, specular, micaceous, fossil, slate, iron ore, martite, blue hematite, etc. The red hematite class contributes about three-fourths of the total of iron ores produced. It is blackish red to brownish red in color, or a steel gray color, assuming a red tint in thin fragments and when it is scratched. Its symbol is Fe_2O_3, and it contains, when pure, 70 per cent. iron. It usually carries silica, manganese and some phosphorus as impurities. Minnesota is the largest producer of red hematite ores, Michigan follows very closely, while Alabama ranks third.

2.—Brown hematite includes the varieties of hydrated sesquioxide of iron, recognized as limonite, goethite, turgite, bog ores, pipe ores, etc. Brown hematites are distinguished by their brown or yellowish brown color. When pure it contains about 60 per cent. of iron and 14.4 per cent. water. It contributes about one-seventh of the total production. Virginia and West Virginia lead as brown hematite sources of supply, Alabama being second and Colorado third. The bog iron ore (described more fully in the following pages) is a variety of brown hematite, usually containing phosphorus, and occurs in marshy districts and recent formations.

3.—Magnetite includes the ores in which the iron occurs as magnetic oxide and including some martite, which is mined with the magnetite. Its symbol is Fe_3O_4, containing, when pure, 72.4 per cent. iron. It is a black mineral with metallic luster, strongly attracted by the magnet (no other black mineral is strongly attracted by the magnet) and occurring in all conditions from loose sand to compact, coarse or fine-grained masses. It is highly valued for its purity. It makes up about 10 per cent. of the iron ore mined in America, being obtained especially from the States of Pennsylvania, with the greatest amount, and New York and New Jersey indicating a close contest for second place, and Michigan coming in for fourth place. Smaller amounts are obtained elsewhere and it is present in many localities. In this country loadstones are obtained mainly from Magnet Cove, Ark. Whole mountains are made up of this mineral in Sweden and it is practically the only iron ore mined in that country.

4. *Carbonate, or Siderite.*—These are the ores which contain a considerable amount of carbonic acid. When found in a comparatively pure or crystallized state it is known as spathic or sparry ore, but when impure and earthy as clay, or clay-band ironstone, or black band. It is found in Ohio, Maryland, New York and in the coal regions of Pennsylvania, Virginia and Tennessee.

It is used as an ore of iron and when high in manganese it is used for the manufacture of spiegeleisen, but forms only a little over one per cent. of American iron ore. The ore mined from deposits in the U. S. is usually subjected merely to a rough hand-sorting to get rid of accompanying rock or of lean ore, so that the shipping ore is carried up to or above a specified minimum iron content. In the case of brown ores, washing must often be resorted to in order to take out the clay. During the past few years, however, particularly since the prejudice against the use of fine ore in the blast furnace has lost much of its patency, lean iron ores are crushed and concentrated to remove the accompanying gangue. This has been particularly the case with magnetites, recent inventions having improved machinery for separating by magnetism the particles of magnetite ore from the non-magnetic rock or gangue intermingled with them. All carbonate ores, and those ores of other classes, particularly magnetites, which carry sulphur, are "roasted," a simple heating process, the object of which, in the first class mentioned, is to expel the carbonic acid, while the latter is to attain a partial elimination of the sulphur. Incidentally, the roasting, particularly in the case of magnetites, tends to put the ore physically and chemically into a condition better suited for its subsequent reduction to metallic iron in the blast furnace. Roasting is now generally performed in the kilns, which, when they are located in the proximity of blast furnaces, are often heated with the waste gas from the latter.

Minerals Used for Production of Acids.—(a) Sulphur-pyrite, and, to a large extent, marcasite and pyrrhotite, are very extensively used in the manufacture of sulphuric acid. The sulphides are burned in furnaces with grates, and the gases are converted into sulphuric acid. The residues, in addition to iron, frequently contain copper, nickel or gold, and these are usually extracted later. The largest deposits working in the United States are in Massachusetts, New York and at several localities in Virginia; considerable deposits are also found in several other places. Pyrite is being formed today by the action of hydrogen sulphide of thermal springs upon soluble iron salts. It has been developed in many rocks by the action of water on iron salts in the presence of decomposing organic matter. It may be, also, of igneous origin. It is found in rocks of all ages, associated with other metallic sulphides and with oxides of iron. It readily oxidizes and decomposes, forming sulphate of iron and sulphuric acid, thus acting as a vigorous agent in the decomposition of rocks. The final results are usually limonite and sulphates of calcium, sodium, magnesium, etc. Few minerals are of such general and widespread occurrence.

(b) *For Arsenic.*—The mineral arsenopyrite is the chief source of arsenic of commerce and occasionally contains enough gold or cobalt to pay for extraction. It is found chiefly in crystalline rocks with other metallic sulphides and arsenides. Throughout the Rocky Mountains it is a common mineral; it is also found in New England.

(c) *For Chromium.*—Practically all the chromium compounds derive their chromium from the mineral chromite, very little of which is now mined in the United States. The most important compounds manufactured are potassium bichromate used in calico printing, oxidizing rubber, bleaching indigo and in manufacturing the chrome paints and matches; potassium chromate used in the manufacture of aniline colors, etc., and ferro-chromium, which added to steel, produces the tough alloy known as chrome steel.

(d) For Tungsten.—Tungsten and the tungstates are extracted from wolframite and scheelite. The world's product is not more than 600 to 700 tons, and is chiefly employed in the manufacture of crude tungsten for tungsten steel and sodium tungsten for rendering fabrics non-inflammable.

The Lake Superior Region.

The Lake Superior region is by far the most important single factor in the world's production of the most useful of all metals. This region includes the States of Minnesota, Wisconsin, Northern Michigan and the provinces of Canada bordering on Lake Superior.

The iron ores of the Lake Superior region all occur within or are associated with certain formations which have been called the iron-bearing formations. The cherty iron-bearing carbonates are the chief original sedimentary rocks of the iron-bearing formations. These are the rocks from which the other varieties of the iron-bearing formations and the iron ores have been mainly produced by various metamorphic and sedimentary processes. The iron-bearing carbonates vary from nearly pure siderite to dolomite. Between these different minerals gradation varieties exist. In the Mesabi district it has been held that the source of the iron can be traced to glauconite. But the work done by the United States Geological Survey seems to indicate that hydrous ferrous silicate and iron carbonate are the important sources of iron ore in that district. Analyses by Sleiger show that iron silicate is not glauconite, as it contains no alkali. In the Michipicolei district of Ontario, pyrite and marcasite occur within the original iron-bearing carbonate and with quartz in associated rocks. Pyritic quartz rocks also occur in the Vermillion district in great quantities. The iron sulphide to some extent has undoubtedly been a source of the ores. But it still remains true that the iron-bearing carbonates are the dominant original sedimentary rocks out of which the iron-bearing formations and ore bodies have been produced.

The Lake Superior ores are of higher grade than those from other parts of the United States and the actual amount of iron ore produced in the lake region is about four-fifths of the total of the United States. The total product from the Lake Superior region since shipment first began in 1850, to 1900, inclusive, was 171,-418,984 long tons, but it was not until 1860 that the shipments of Lake Superior ore annually exceeded 100,000 tons. Coke did not exert an appreciable influence upon manufactured pig iron in this country until after 1850. These dates show how late in the last century we began to utilize the raw materials that now have a world-wide reputation. There is apparently no limit to the supply of rich iron ores in the Lake Superior region and elsewhere in this country. The Vermillion and Mesabi ranges alone, in 1906, produced a total of 25,500,000 tons.

The iron ores of the Lake Superior region, although distant from most of the blast furnaces which use them, reach their destination at relatively low transportation cost, by reason of the long water haul on the Great Lakes, the railroads carrying the ores from the various ranges to their ore docks at the shipping ports, five of which are located on the shores of Lake Superior, and two on Lake Michigan.

A full discussion of the cherty iron-bearing carbonates, the ferrous silicates and the pyrite quartz rocks cannot be given here. It is believed, however, that the iron-bearing formations were largely derived from the more ancient basic volcanic rocks of the Lake Superior region. "Where these igneous rocks were adjacent to the seas they would be leached by the underground water and the iron transported to the adjacent seas. It is probable that to some extent this leaching process also went on below the waters of the sea. The iron was probably transported to the water mainly as carbonate, but to some extent as sulphate. The carbonate would there be thrown down by oxidation and hydration as limonite, and the sulphate in part as basic ferric sulphate. Much of the sulphate was probably directly precipitated as sulphide by the organic material. The limonite would be mingled with the organic matter which was undoubtedly present, as shown by the associated carbonaceous and graphitic slates and shales. When deeply buried the organic matter would reduce the iron sesquioxide to iron protoxide. By the simultaneous decomposition of the organic matter carbon dioxide would be produced, which would unite with much of the protoxide of iron, producing the pyritic carbonates. Where the iron was brought to the sea mainly as sulphate the direct reduction of this salt by organic matter would form iron sulphide with little or no carbonate. Simultaneously with the production of these substances, chert was formed, probably through the influence of organisms. Some of this silica would unite with a part of the protoxide, producing ferrous silicate. More or less mechanical sediment would also be laid down. Thus the original rocks—the cherty iron carbonates, the ferrous silicate rocks and the pyritic cherts—would be produced.

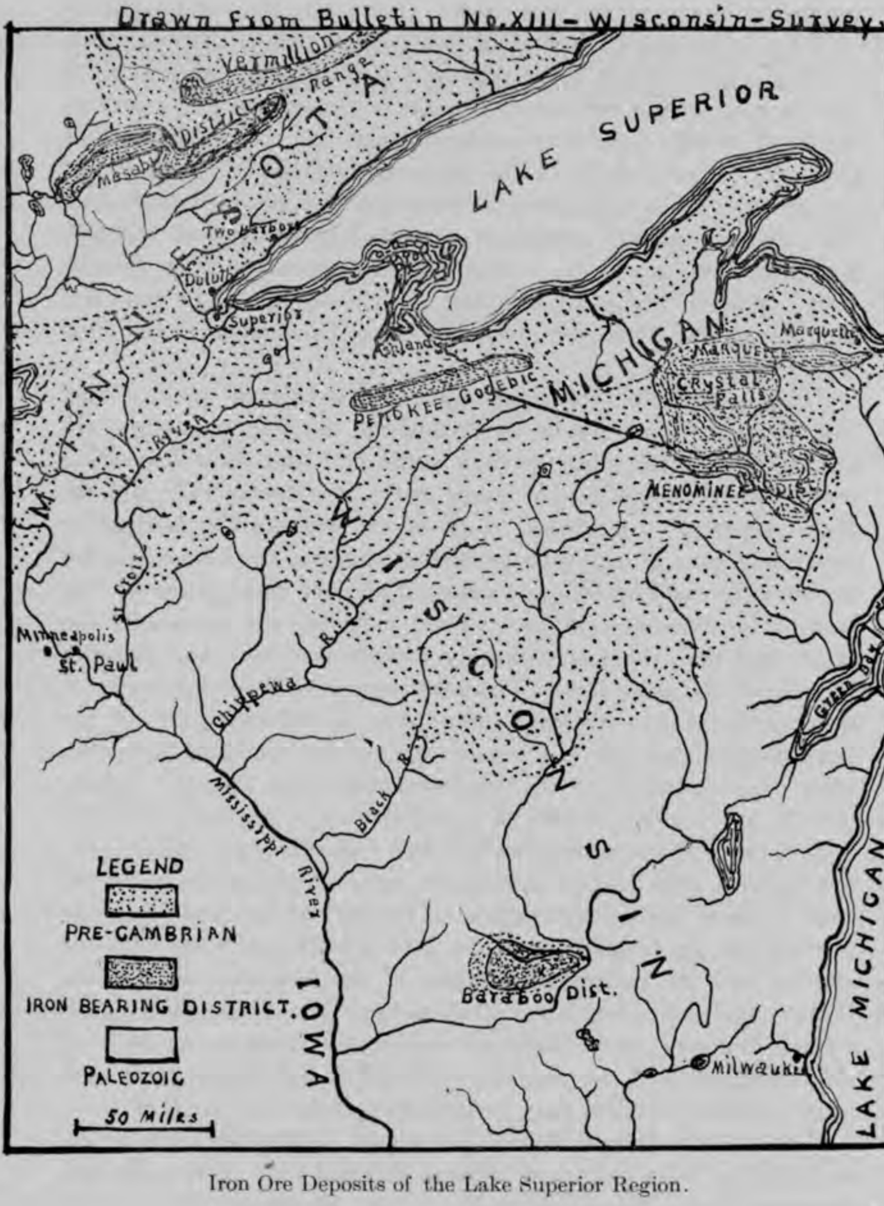
"It has chanced that at three different periods in the history of the Lake Superior region these processes of the development of the original rocks of the iron-bearing formations have occurred extensively. While this might at first be thought remarkable, there is no good reason for thus regarding it. At some time during each of the Archean, Lower Huronian, and the Upper Huronian periods the quiescent conditions of chemical and organic sedimentation have occurred, and since the iron-bearing volcanic rocks were each time available for the work of underground waters and sea-waters, naturally iron carbonate and the other original rocks have been produced. In each period the source of the material and the process of its formation were essentially the same.

"The alterations of the original rocks of the iron-bearing formation have been along two general lines, depending upon whether the iron-bearing carbonate or ferrous silicate or pyrite, when altered, was at the surface or at a considerable depth. Where the rocks were altered at or near the surface, so that oxygen-bearing waters were abundant, ferruginous slates, ferruginous cherts and ore bodies were produced. Where the iron-bearing carbonate was deeply buried when altered, and especially where altered in connection with igneous rocks so that the temperature was rather too high, the rocks which were produced were amphibolic and magnetic slates and schists. The formation of the ferruginous slates and ferruginous cherts from the iron-bearing carbonate is usually a process of liberation of carbon dioxide and of oxidation and hydration of the iron. Where oxidation takes place with little hydration, jaspilites may be formed. Where pyrite is also present the process is that of oxidation of both the sulphur and iron and partial hydration of the iron oxide. Ordinarily the rearrangement of the iron and chert emphasized the original sedimentary banding.

"During any of the above processes of alteration the iron oxides may be more or less concentrated. The concentration may result in bands of nearly pure iron oxide between the leaner portions of the rock. It may result in the concentration of the iron oxide in large masses under peculiar conditions and thus produce ore bodies. The ores are mainly somewhat hydrated hematite, but limonite and anhydrous hematite (either earth or specular) occur plentifully. Magnetite is also found, but is very subordinate in quantity. The great mass of the iron ore of the Great Lake Superior region is iron sesquioxide.

"It appears from the foregoing that the original rocks of the iron-bearing formations, notwithstanding the fact that they appear to be in three unconformable series and that their disposition must have been millions of years apart, are remarkably similar. Moreover, while the original rocks of the iron-bearing formations have undergone a very wide variety of changes, the alterations for the three formations followed substantially the same courses. The reasons for this are that the original materials are essentially the same, and that they were largely transformed to other varieties of rocks at the same time. The particular transformations are extremely variable in different districts or in different parts of the same district, but the end results are similar for each formation when the conditions of the metamorphism were similar. Consequently one who has worked for a brief time in the Lake Superior region, even if he cannot describe and name the individual varieties of each iron-bearing formation, soon learns to recognize the chief kinds of rocks characteristic of the formations, and especially to recognize the associations of the different kinds of rocks with one another and the general appearance of the formation as a whole. Hence, while the iron-bearing formations are lithologically extremely variable, their common origin and common methods of metamorphism and the peculiar relations of the different varieties to one another make it easy to recognize them."—Van Hise.

Mesabi.—The Mesabi district lies wholly in Northern Minnesota, northwest of Lake Superior, between 47° and 48°. It extends continuously from Pokegama Falls, on the Mississippi River, in a direction about N. 60°, east to Birch Lake, a distance of 100 miles. The general trend is roughly parallel with that of the Marquette-



Iron Ore Deposits of the Lake Superior Region.

Penokee-Gogebic and Vermillion district. West of the Mississippi the Mesabi formations undoubtedly continue, but they are so deeply buried with glacial deposits that they have not been traced.

The formations of the Mesabi series lie along the south slope of a ridge known as the Giant or Mesabi (Chippewa for Giant) Range. This ridge, while extending in the general direction named, has several gentle bends, and near the center of the district a relatively sharp bend known locally as "The Horn" carries the ridge and the iron-bearing formation about six miles to the south. The elevation of the range is seldom more than 400 feet above the level of the surrounding country. These higher elevations are found mainly in the central and eastern portion of the district, the elevations gradually decreasing to the west.

The Mesabi iron ores are for the most part soft, somewhat hydrated hematite, although soft limonite ores are present in subordinate quantities. Their texture varies from exceedingly fine-grained "flue dust" to a fairly coarse, hard and granular ore, breaking in parallelopiped blocks. In either case the ores need but little blasting to allow the steam shovel to take them from the bed. The fineness of many of the ores has prevented the use of large percentages of them in blast furnace charges. The iron content when dried, computed from cargo analysis, varies from 58.97 to 64.85 per cent., with an average of about 63.28 per cent. The phosphorus content varies from 0.025 to 0.080 per cent., with an average of about 0.042 per cent. The silica content varies from 2.50 to 9.20 per cent., with an average of about 3.38 per cent. The water content varies from 6.81 to 14.11 per cent. and averages about 10.78 per cent.

Few of the mines have reached the bottom of the deposit, but explorations show that in most of cases the ore extends to no great vertical depths. In many places the bottom of the rich part of the deposits are at a depth less than 200 feet, and but few deposits extend to a depth as great as 300 feet. It is clear that the Mesabi ore deposits are shallow as compared with those of some of the other iron-bearing districts of the Lake Superior region. This is due to the very gentle pitch of the deposits as compared with the steep pitches of the deposits in other districts. But the shallowness of the deposit is much more than compensated for by its great breadth and length. Minnesota contains more high grade ore than any other equivalent area in the Lake Superior region, and the Mesabi district as a whole has vastly more ore shown up than any other Lake Superior district.

The common method of mining in this district is to strip off the drift and load the ore directly from the deposit into the cars by the use of the steam shovel. The large open pits with trains running in and out and steam shovels loading from the banks to the train are characteristic sights in the district, but there are as many or more mines operated by underground work. The greatest stripping at Mesabi is the Shenango mine of the Oliver Company, where there is an average surface of about 108 feet.

For the season of 1906 the Mesabi Range made a total shipment of more than 23,600,000 tons of ore.

Origin of the Ore Deposits.—"They are mainly secondary concentrations in pitching troughs with impervious basements by downward moving waters, and subordinately oxidations in place. The process is the one outlined below. Iron from carbonate and silicate, taken into solution by the descending waters, was carried to the pitching troughs, and there met other waters bearing oxygen more directly from the surface, resulting in the precipitation of the ore. The solution of the silica was a simultaneous process and was favored by the large quantities of water concentrated in these troughs. The ores are very porous, and show decided indication of slump. This seems to be conclusive evidence that the silica has been dissolved more rapidly than the iron oxide was put in its place.

"The meteoric waters, entering the pervious iron-bearing formation at the higher northern ground, followed the troughs transverse to the range down the general slope, and mainly issued on the low ground before passing below the impervious slate. The higher geological horizons, the horizons near the overlying slates—were not in general transformed to ore deposits. When the ore deposits do approach the slate they are usually found to grow lean and thin. These were the places where the waters were ascending and issuing, and such waters were deficient in oxygen, and hence the circulations were not favorable for the development of large ore deposits of good quality.

"The waters were confined below the impervious strata, probably mainly slates, at different horizons, although principally in horizons some little distance above the bottom of the formation. In some cases, as shown above, the presence of slaty layers has not prevented the concentration of ores upon an impervious basement lower down, since between the outcrops of two sets of relatively impervious strata there is a broad area where meteoric waters may enter. However, in most cases there is a considerable thickness of apparently barren iron formation material below the iron ore deposits. In the Penokee-Gogebic district all the ore deposits, with the exception of the Iron Belt and the Atlantic, are at the bottom of the Ironwood formation and rest upon the Palms formation, and one might anticipate that the same condition of affairs would obtain in the Mesabi district, and that the ores would rest upon the Pokegama formation. The apparent absence of large ore deposits at the bottom horizon in the iron-bearing formations in the Mesabi district is probably explained in most cases by the fact that the part of the iron-bearing formation below the impervious layer, whether this layer be slate or impervious chert, was not sufficiently thick to furnish material out of which such ore bodies could develop. In some cases, however, it may be ascertained that the lower part of the formation was originally of a different and somewhat less favorable character than the rocks rich in iron carbonate and ferrous silicate out of which the ore deposits developed."—Van Hise in "Treatise on Metamorphism."

Penokee-Gogebic District.—This is a narrow belt south of Lake Superior. The eastern and most profitable third of the district is in Michigan; the western and less profitable two-thirds of the district are in Wisconsin. The important towns of this region are Hurley, Ironwood and Bessemer. The iron ores of the district are soft, red and somewhat hydrated hematite, with a very subordinate amount of hard steel-blue hematite. The iron content from cargo analysis varies from 53.45 to 65.42 per cent. and averages about 61.32 per cent. The phosphorus varies from .127 to .138 per cent.

"In the Gogebic district we have the concentration of the ores somewhat fully worked out. The descending waters on the higher elevations worked to the east or west along the dikes to the north-south intersecting drainage. During this journey the ores were collected and deposited. Below the valleys the waters were ascending and escaping. Of course in pre-glacial time, when the main part of the ore deposition was done, many of the drainage lines were much deeper than at the present, for the valleys are filled, in some cases, to the depth of many feet.

"There is no reason to suppose that the ore deposit of the Penokee-Gogebic district may not extend to as great a depth as in other districts of the Lake Superior region."—Van Hise.

Menominee District.—This district lies wholly in Michigan and extends from the Menominee River in a southeastern direction. The area that has been mapped is about 20 miles long and on the average of six miles wide. The Huronian belt has not been mapped farther east because it is capped by the Cambrian sandstone. It has not been mapped west of the river because of the overlying Pleistocene. The important towns of the district are Iron Mountain, Quinnesec, Norway, Vulcan and Waucedah.

The iron ores of the district are principally grey, finely banded hematite, and to a subordinate extent dense, flinty black hematite. The iron content from cargo analysis varies from 40.64 to 64.4 and averages about 56.6 per cent. The phosphorus varies from .009 to .738 per cent. and averages about .083 per cent. The silica varies from 2.07 to 39.10 per cent., with an average of about 7.57 per cent. The water averages about 7 per cent. The total production since 1877, when mining first began, to 1907, was more than 39,500,000 long tons. Recently good finds have been made and all exploration shows encouraging results, and large contracts with diamond drill companies have been made for the coming year.

It is not generally known that a tradition exists among the Menominee Indians (who were the only inhabitants of this range prior to the discovery of iron ore), that if any member of the tribe should disclose to a white man the existence of a mineral deposit his speedy death was sure to follow. This superstition may have been influential in the lateness of the mines' discovery and of their subsequent operations—on this range; for by bringing specimens (which could readily be obtained) to the trading posts they would have incited earlier investigation. Be that as it may, it is incomprehensible why the existence of ore deposits in such vast quantity should have remained unknown for so many years.

Another embarrassment, and one of more substantial import, was the impression that iron ores of quality and quantity could exist only in the Marquette range. The geological formations of other districts, where indications of ore were prevalent but not corresponding exactly with those of the Marquette district, seemed to preclude the possibility of the existence of paying ore. This impression was general and was so effective as to influence the most active and noted explorers. The edict had gone forth: "There was no good ore outside of the Marquette country," and, blinded with this phantasm, explorers strolled aimlessly over locations from which millions of dollars' worth of ore have since been extracted and millions more are yet to come.

These iron ranges have shown a striking example of rapid development. This is especially true of the lower Menominee range and the Iron River, Crystal Falls, Gogebic and Minnesota districts; ore has been disclosed over a territory, the value of which a short time previous, if it had any, was based solely upon the pine timber standing thereon.

The location of this district, remote from water and rail transportation, the reported severity of its climate, as also the reported bareness of its soil, all tended to divert immigrants. Sawlogs and sawmills were the only products shipped from the Menominee and its tributaries.

The first exploring party to enter the territory embracing the lower Menominee range, was headed by N. P. Hulst of Milwaukee. As a representative of the Milwaukee Iron Company he began exploring in the summer of 1872. The exploration was discontinued in the fall of that year. In the spring of 1873 exploration was again begun and carried on with success. In the spring and summer of 1874, 55 tons of iron ore was hauled to Menominee on sleds and wagons and smelted in the furnace at that point, with a mixture of hard ore from Jackson and Winthrop. The last furnace charge consisted entirely of the Menominee range ore, thus establishing its tractability. Robert Jackson, superintendent of the furnace, spoke in the highest terms of the quality of the ore. This was practically the first test of standard ore from the Menominee range, and it was the incentive to rapid and successful exploration along the entire formation.

The total product for the year 1906 was almost 3,000,000 tons, with a force of about 3,000 employes. The product is keeping up to, if not exceeding, former years, with the number of employes somewhat reduced, because of the application of improved machinery, underground haulage and improved methods of mining. The quality of the ore produced is not so good as in former years, yet all finds a ready market and no complaints are heard from the operating corporations. The scale of wages is as high, if not higher, than ever before on this range. This standard of pay, in the face of reduced value of ore, is maintained only by the use of improved machinery and by skillful management in the raising and shipping of the product.

It is estimated that the ore is now delivered on cars at some of the mines at a cost of 60 per cent. less than in former years. When ore was worth from $8 to $12 per ton the operator could afford to be somewhat indifferent as to the cost of production, but with a price of $4 at the end of the market, it behooves the management to exercise the utmost economy and skill in the operation of the mine.

Notwithstanding that the existence of ore in shipping quantity was fully demonstrated in 1874, and notwithstanding the heavy demand for lumbering supplies (which at that time were hauled on wagons from Menominee), it was not until 1877 that the Menominee River Railroad was completed in Quinnesec. In 1880 the road was extended to Iron Mountain and thence to Iron River, Crystal Falls and the Gogebic range. The delay in the construction of the road as far as Quinnesec arose from a matter of doubt on the part of capitalists as to whether this range would sustain a railroad costing $475,000. The road paid for its construction in its first year; and this little stretch of railroad from Iron Mountain to Escanaba since it began operations, has paid for many hundreds of miles of track on the western prairie. We have now three railroads penetrating the range: the Chicago & Northwestern; Chicago, Milwaukee & St. Paul, and the Wisconsin & Michigan. All are doing an ore-carrying business. This, with other traffic incidental to the operation of our mines and the development of a comparatively new country, provides ample business for both passenger and freight traffic.

Marquette District.—This is a comparatively small east-west belt. It lies wholly in the State of Michigan and gets its name from the city of Marquette. The more important towns are Marquette, Ishpeming, Negaunee, Champion and Republic.

The iron ores of the Marquette district are mainly soft, red hematite. Hard specular hematites are also important. Magnetite and limonite are subordinate. The iron content from cargo analysis averages about 63 per cent. The phosphorus averages about 0.083. The silica content varies from 1.30 to 38.27 per cent. and averages about 4.8 per cent. The water content varies from 9.45 to 15.29, with an average of about 5.49 per cent. The total production of the district from 1854, the first year of shipment, to 1906, inclusive, was about 77,500,000 long tons.

Nearly all writers on the geology of the Marquette and Menominee district have maintained the general equivalency of the iron-bearing series in the two districts. The opinion is based on the unconformability of the clastic series in each district above a series of gneisses and crystalline schist and upon the lithological similarity that exists between certain members in both series. The sequence of the two districts appears to be similar, but the rocks of the one region have not been traced into the other, so that it cannot be said that this similarity proves the formations in the two districts to have been found contemporaneously.

It has long been known that many rocks are possessed of decidedly magnetic properties, due to the presence of varying quantities of magnetic iron ore. By mining engineers and prospectors this has been turned to a practical use in aiding in the location of iron mines when the ore is of a magnetic kind. In the iron ranges of the south shore of Lake Superior the magnetite is rarely concentrated in large bodies and its known occurrence as such is restricted to a small part of the western Marquette district, where in one producing mine it now forms practically the whole product and in another a variable but usually important part of the whole. It is well understood that disturbances of the magnetic needle, however great, do not mean workable deposits of magnetite, but such disturbances may lead to the discoveries of rich ores other than magnetite.

Workable iron ores have been found at many places from east of Negaunee to Michigamme and Spurr, on the northwest, and to Republic on the southwest. In this respect the Marquette district differs from the Mesabi and Penokee districts, which have long stretches of iron-bearing formation, which, as yet, have not been fruitful. In general the portions of the ore deposits which reach the surface are located on the middle or upper parts of the slopes, although in some instances the ore deposits are entirely below low-lying areas, but in these cases the impervious basement material makes a surrounding amphitheater.

Vermillion Range District.—This iron-bearing district occupies a broad belt in Minnesota. The area extends from Vermillion Lake on the west to the international boundary on the east, in the vicinity of Gunflint Lake and Lake Saganaga. The belt is about eighty miles long and varies in width from 4 to 10 miles. The chief towns of the district are Tower, Soudan and Ely.

The iron ores of the Vermillion district are hard blue and red hematites. The ore is partly massive and partly brecciated. The iron content from cargo analysis varies from 60.47 to 67.37 per cent., with an average of about 63.7 per cent. The phosphorus varies from 0.040 to 0.131 per cent. and averages about 0.057 per cent. The silica varies from 2.55 to 7.67 per cent. and averages about 4.78 per cent. The water content averages about 5.50 per cent. The total production of the district since 1884, the first year of shipment, has been about 25,000,000 long tons.

"The large ore deposits of this district are located below crests or slopes. From the study which has been given this region, it may be concluded that the ore deposits of the Vermillion district were produced from original cherty iron carbonates. The iron-bearing carbonate was partly oxidized in situ, thus producing some of the iron oxide. Another and larger portion of the iron carbonate was contributed by descending waters, and iron oxide was precipitated in the troughs by oxygen-bearing solutions. The analogy between the ore deposits of the Vermillion district and the great ore deposits of the Marquette district is very close. The pitch of the ore deposits is parallel to the range, the same as in the Menominee, Marquette and Penokee-Gogebic districts." The shipments from the Vermillion range for 1906 were 1,800,000 tons.

Crystal Falls District.—This includes the Metropolitan, Commonwealth, Florence and Iron River areas. The greater part of the district is in Michigan and the remainder in Wisconsin. The chief towns are Crystal Falls, Florence, Commonwealth, Mansfield, Amasa and Iron River. This district was so named from the town of Crystal Falls, the county seat of Iron County. The iron-bearing area along Paint River, near the town of Crystal Falls, was first called in literature the Paint River district. As soon as the town was begun, about 1880, the name of the town was applied to the district. The area situated on the Upper Peninsula of Michigan serves as a connecting link between the two great iron ore producing districts: the Marquette and Menominee. The Crystal Falls district is of itself of considerable economic importance, as will be seen, though not deserving to be ranked with either of the two above-mentioned iron regions.

The total production of ore from 1882, the first year of shipment, to the present time, is about 14,500,000 tons. The ores are chiefly a soft red hematite, although in some places it is hydrated and graded as brown limonite. The iron content from the cargo analysis varies from 54 to 63 per cent., with an average of about 59 per cent. The phosphorus ranges from 0.049 to 0.7 per cent., with an average of about 0.40 per cent. The silica ranges from 4 to 9 per cent., with an average of 5.5 per cent. The water varies from 3 to 9 per cent., with an average of 7.5 per cent.

The Crystal Falls district is not sharply defined, but consists of a continuous belt of more than thirty miles in length, varying in width from two to five miles, lying wholly within the drainage basin of the Michigamme River and its principal upper tributary, the Fence River, and is continuous with the Marquette district on the northeast and the Menominee district on the southeast. It is, however, remarkable for the vast accumulation of volcanic rocks, which, while by no means absent from the adjoining district, do not there play so important a part.

"There volcanic rocks have associated with the rocks of sedimentary origin, as is shown by their well bedded condition and the rounding of the fragments. The Subaqueous rocks are, however, composed of little altered volcanic material, and evidently point to oscillation of the crust during the time of volcanic activity --such oscillation as has long been known as common in volcanic regions. Following the volcanoes and overruling them, probably unconformably comes a series of sedimentary rocks believed to belong to the upper Huronian. These comprise chlorite, ferruginous and carbonaceous slate, associated with quartzites, gray-wackes and small amounts of carbonate beds. It is this slate series that, with the exception of the Mansfield Mine, the ore deposits of the Crystal Falls district are found. Although a great deal of exploring has been done for iron ore in the Mansfield slates, only one large body of ore has thus been discovered, on which is the Mansfield Mine."

The iron ores at Commonwealth, Florence and vicinity were the first to be discovered in this district. At Iron River and vicinity ore has been taken from various mines for a number of years.

The Baraboo District.—This district has recently come into prominence on account of the discovery of iron ore. The district lies near the center of the southern half of Wisconsin. The length, east and west, is approximately 28 miles, and the width varies from two miles at the east end to 10 or 12 miles in the middle and at the west end. It covers an area of about 225 miles.

While the presence of iron in the Baraboo district was not definitely known until very recently, Prof. T. C. Chamberlain, in 1882, recognized the possibility of the occurrence of iron in the area of the quartzite ranges, as shown in the following statement: "In the Baraboo region of Sauk County large bunches of brilliant specular iron in veins of white quartz are often met with, but no indication of the existence of ore in quantity in the Huronian of this region has been observed. It is a matter of great interest that while we have in the Penokee and Menominee Huronian the same kinds and succession of rocks as in the iron district of Marquette, in the Baraboo country, and to the northeast from there we find a great development of the porphyry so characteristic of the Huronian iron district of Missouri. It is wholly within the possibilities that iron ores may yet be discovered in the Baraboo Huronian."

Iron ore was first discovered in the district in April, 1900. Exploration, however, began as early as 1887 by the Douglass Iron

Mining Company. The Baraboo iron ore is mainly red hematite, with a small amount of hydrated hematite. This district is adding largely to the production of the State.—(See Wisconsin Survey-Bulletin No. XIII.)

Canada.—In the Lake Superior region of Canada the iron-bearing rocks are known to have great development. In these rocks, at various places, are extensive belts of iron-bearing formations. These iron-bearing series are a direct extension of the series which have been productive on the United States side up to the present time; however, comparatively little exploration has been made and only a few mines opened in the ore region of Canada. The Michipicoten District is at present the chief ore producer. Sufficient development has not been made to insure that this district will be a great producer in the future.

The iron-bearing formation and the associated rocks have not been separately mapped, but when this is done it will undoubtedly be very helpful to the development of the merchantable iron ore districts of the Canadian region.

"While it may be possible that on account of glacial erosion the product of high grade ore in Canada may be less than in the districts of similar size and geological position on the United States side of the boundary, it cannot be doubted that in the future important quantities of ore will be explored in the Canadian Lake Superior region. Doubtless also this exploration would have been begun many years ago were it not for the duty which ores mined in Canada must pay when entering the United States."—Van Hise, 21st An. Rept., U. S. G. S.

Outlook for 1907 in the Lake Superior Ores.—A large amount of development has been done recently in the Lake Superior region and enormous amounts of iron ore lie exposed ready for the steam shovel. New companies are entering the ore field with vigor and are making explorations with a view of developing new ore lands. A sale of Mesabi lands just closed with the Buffalo & Susquehanna interests shows how anxious consumers are for iron. It is of a tract just north of the old Mesabi chief mine and consists of the lean and mixed character of that deposit. It contains, so far as now exposed, about 2,500,000 tons of ore, mostly of an ore that must be washed to become merchantable and carries on an average too much phosphorus to permit its use in the Bessemer process. It is a State lease, and in addition to the State 25-cent royalty, there is a second 25 cents a ton with a minimum of 100,000 tons, and a cash bonus of $70,000 for the lease. This bonus is equal to

3 cents per ton cash on all ore so far discovered, including ore that runs far too low to be available in its present form.

The advance in the base price of Lake Superior ores has been from 50 to 75 cents per ton, but the real advance has been greater owing to the lowering of the guaranteed iron content. The following are the base guarantees for 1907, as compared with the past season:

	Old Ranges.		*Mesabi*	
Bessemer Ores.	*1906.*	*1907.*	*1906.*	*1907.*
Iron per cent., natural......	56.70	55.00	56.70	55.00
Moisture	10.00	10.00	10.00	10.00
Iron per cent., 212°.........	63.00	61.12	63.00	61.12
Phosphorus...................	0.045	0.045	0.045	0.045
Base price	$4.25	$5.00	$4.00	$4.75
Non-Bessemers.				
Iron per cent., natural......	52 80	51.50	52.80	51.50
Moisture	12.00	12.00	12.00	12.00
Iron per cent., 212°........	60 00	58.52	60.00	12.00
Base price	$3.70	$4.20	$3.50	$4.00

Bessemer ore here is understood as ore carrying 55.60 per cent. iron and not over 0.045 per cent. phosphorus. Under these conditions the actual increase in price to furnacemen is 90 to 95 cents per ton for Bessemer ores, and 60 to 65 cents for non-Bessemers.

In considering the possibility of a material increase in ore tonnage from the Lake Superior region for the year 1907 several facts must be kept in mind. In the first place there will be no increase except from Mesabi. Old ranges are being worked to limit now, and of the class of ores, if a gain might be made, but little will be used. On the Mesabi are three railroads: The Duluth & Iron Range is at its limit at 8,000,000 to 9,000,000 tons for the season. The Duluth, Mesabi & Northern, which moved 11,000,000 tons in 1906 is prepared to forward 13,000,000 tons for 1907. The Great Northern, with over 6,000,000 in 1906, may reach 8,000,000 tons for 1907. The shipments of iron ore from the Mesabi and Vermillion ranges as given for the three railroads for 1905 and 1906 were as follows: For 1905, 21,711,409 long tons; in 1906, 25,484,546 long tons, an increase of 3,773,137 tons. These roads for 1907 can possibly put out an increase of 3,500,000 to 4,000,000 tons over 1906. As to vessel capacity there is no question. But new mining may be limited by the capacity of steam shovel shops and by the labor market.

The fear of an ore shortage existing in mid-summer created an early demand for iron ore for 1907 delivery, and consumers began to besiege shippers to make sales. These were held off until early in November, when almost the entire output for 1907 delivery was disposed of in a single week. The amount sold each customer depended upon his needs in previous years, and his standing as a customer had a good deal to do with the allotment. It was found even that the supply of iron ore that could be insured would not go around and some sales were subsequently made at a premium, despite the fact that the regular advance has been to the highest level since the Mesabi range was discovered.

In previous years difficulty with labor unions, combinations of vessel owners to affect the rates of transportation, the urgent demand for coal shipping and the heavy movement of grain has seriously affected the amount of tonnage in the ore trade. But it has never before been that the dangers of a shortage of iron ore has arisen almost entirely from the inability of the Lake Superior region to produce the amounts of ore the consumers have demanded. This has arisen from two sources. One of them is the fact that more furnaces have been placed in operation, demanding supplies from the Lake Superior region; most of the furnaces have been active more continuously than ever in their history, and the sales of Lake Superior ore have been scattered over a wider area. The other condition which is most striking is that the high grade ores are rapidly becoming more scarce, while the guaranteed iron content is less than it has ever been, demanding that the ore shippers must increase their output to produce the same amount of iron. With the production of pig iron constantly showing great advance it is not surprising that the Lake Superior region should have difficulty in meeting the needs of consumers. The car shortage did not hinder the ore shippers for the reason that the railroads, seeing they were so dependent for new equipment on the continued activity of the steel trade, set everything else aside and moved the ore as rapidly as it came down the lakes.

Although no material increase from the entire region will likely be made for 1907, it is expected from the Minnesota districts alone to send out 29,000,000 tons of ore, and all other areas where developments have been made will be worked to the limit.

Iron Mountain.

This is the name of a famous deposit of iron ore in St. Francois County, Missouri, forty miles southwest of St. Genevieve, on the Mississippi, and connected with St. Louis by railroad. The deposit is of rich and pure ore. It is magnetic and in some places acts strongly on the needle. The main body of ore was several feet in thickness and an immense amount of ore has been taken from this region, but the deposit did not prove as great as was expected from early investigation. A great deal of this ore was used in some of the Indiana furnaces.

At a recent meeting in St. Louis the stockholders of the Iron Mountain Company voted to dissolve the corporation for the reason that it "has not been actively engaged in business operation for a long time past, and has no indebtedness; and the aggregate value of the assets has been reduced by depreciation in the value of its real estate, to a small percentage of its capital stock of $3,600,000." The court has since granted the petition to dissolve and a committee has been appointed to wind up the company's affairs.

The Iron Mountain Company organized about forty years ago. The iron ore deposits of Iron Mountain and Pilot Knob, eighty miles southwest of St. Louis, were the basis. They were believed to be sufficient to make St. Louis the rival of Pittsburg and to supply the iron industry of the United States for an indefinite time. They were sufficient to secure the building of the St. Louis and Iron Mountain Railroad, which has since become part of the chief line from St. Louis to the southwest; the construction of a blast furnace at Carondelet, a suburb of St. Louis, and the establishment of large iron works.

The Iron Mountain, however, proved to be only a surface deposit which was gradually worked out. Exploration failed to show anything of value in depth, and finally the mine was abandoned. The mining town of Iron Mountain dwindled down to a small village. For years the output of the ore was insignificant, and for some ten years past it has been nothing.

The company was honestly managed and the stockholders received a very large per cent. on the par value of their shares in dividends.

The Iron Mountain tract of 12,000 acres is to be sold and the greater part of it except the part occupied by two granite quarries is to be turned into a stock farm.

BIRMINGHAM.

The iron mines of the Birmingham district are prominent in the industry of the United States. Mining is changing from its period of open cut to underground working, and although the cost of production may have slightly increased, it has not been materially affected, as the yield has been enlarged by improved methods and machinery and substantial growth is assured.

The ore occurs in the Clinton formation of the Red Mountain, a range of hills. Two ridges extend south-east, north-west, and border a valley, the eroded crest of an anticline. On the valley sides of these flanking ridges are found the beds which have been explored by the erosions that removed the crest. Mining is confined largely to the eastern outcrop, which is worked extensively for 150 miles. Near Birmingham the outcrop has been stripped and work carried on underground for 15 miles.

The ore deposits are uniform as viewed along the outcrop, but as the workings are shallow, seldom exceeding 1.000 to 1.800 feet, change in regularity cannot be determined. The strata range in thickness from 2 to 20 feet, often aggregating 35 feet. Shale partings break up the continuity of the beds, for example a 20-foot strata may in the course of a mile, divide into two or more distinct parts, on account of the shale partings, varying in thickness from the fraction of an inch to a foot or more.

There are two kinds of ore in the district, aside from that of the Siluro-cambrian beds occupying the center of the Red Mountain. These ores, though hard and soft hematites, are intimately associated with each other in the same stratum and were formerly of the same composition. The leaching of the surface water is responsible for the change in lime content. The percentage of iron in the two ores is close to 37 and 48 per cent., while that of lime is 1.6 and 1.5, respectively. They may be designated as high and low silica, or self and non-fluxing ores, the variation of lime is more marked than that of silica. The hard ore is used more than the soft and has an average composition of:

	Per cent.
SiO_2	13.4
Fe	37.4
CaO	16.2
Al_2O_3	3.18
P	0.37
S—	0.07
CO_2	12.24
H_2O	0.5

In many mines the lower limit of soft ores has been passed. Beside the "hard" and "soft" ores, there is another known as fossil ore which has the same characteristics as the non-fossiliferous and may be hard or soft according to leaching action. This is composed of fossils, usually quite small, which give a granular appearance. All ores of the Clinton formations are distinctly red.

Plate XVI.

Dip-Slope Mines in Suburb of Birmingham, Alabama.

Mine and Tipple at Readers, near Birmingham, Alabama.

The Potter mines, with an area of 1,800 acres, fourteen miles south of Birmingham, in Jefferson County, are considered among the most desirable in the Red Mountain district. These ores carry sufficient lime to be practically self-fluxing and are lower in silica than those nearer Birmingham. They run about 31 per cent. in iron and from 14 to 16 per cent. lime.

Plate XVII.

Iron-Ore Layer at Readers, near Birmingham, Ala. Nine Feet of Fossil Iron Ore.

Production.—In the Southern territory, and in Alabama in particular, work was greatly curtailed during the last part of 1906. Several furnaces were shut down for repairs and others were able to work only about half-time because of scarcity of raw material supplies caused by the railroad car shortage being so intense, consequently most of the Alabama iron companies were behind more or less in their deliveries, but sales for 1907 were made right along and all iron wished before April was termed practically "spot" iron. Spot iron is quoted at $23 per ton, No. 2 foundry and soft. The markets in Chicago were somewhat delayed on account of an advance in Southern pig iron freight rates—Birmingham to Chicago and adjoining points—from $3.90 to $4.85, effective February 1, 1907. On quick delivery No. 2 iron brings $21@23, Birmingham, or $24.65@26.65, Chicago, the range being wide on account of diversity of millers' needs and the scarcity of the supply.

Much of the Alabama iron is used for the manufacture of sugar-making machinery for the Southern States and also Cuba and Mexico. In the Birmingham district the ore is mostly smelted in furnaces only a few miles from the mines. Special railroad cars haul the ore to the furnaces. These cars carry 30 to 50 tons each. During the past summer there was great activity in mine development and in new equipment, which will in the future give a much increased production of ore at reduced cost.

INDIANA.

Indiana is pre-eminently an agricultural State, but in recent years it has rapidly passed into the front ranks as a manufacturing State. Many of the largest and most modern factories and mills have been founded within its boundaries and other great manufacturing concerns have works under way of construction. The finding of natural gas and oil, the abundance of coal, the inexhaustible supply of limestone, good cement shales, excellent fireclays, together with the splendid transportation facilities, have all added to the building up of great enterprises, which have brought into the State millions of dollars to be invested in economic interests that are paying handsome dividends on the money spent.

The supply of raw materials within the State is unlimited; new developments are being made along many lines and old interests are being revived, which were formerly held in check through lack of means of transportation and inexperienced management.

To say that Indiana was at one time a chief iron-producing State might appear to be misleading, but when we go back to the years of 1830-1870 and find a dozen blast furnaces in operation and producing a fairly good tonnage of iron, we cannot fail to see that Indiana was a large producer of iron. Some of the furnaces used exclusively Indiana ores, others worked these ores mixed with foreign ores, others used only such iron ores as were shipped to them from deposits like "Iron Mountain," Missouri. The furnaces were located as follows: St. Joseph Iron Works, at Mishawaka, at the extreme northern edge of the State; one at Logansport; the "Old Virginia," or "Cincinnati," Furnace, in western Monroe County; the Richland Furnace, in Greene County; the Irontown Furnace, in Martin County; the Brazil, the Lafayette, or Masten, on Otter Creek, south of Brazil; the Planet or Star, northeast of

Harmony, and the two Western Iron Company furnaces at Knightsville, make up the list for Clay County; the Indiana Blast Furnace on Brouillett's Creek, near Clinton, in Vermillion County, and the Vigo Blast Furnace at Terre Haute, the last one to go out of blast. All of these furnaces have long since ceased operation and only little remains to mark the location of the big iron industries of the State which went into decline, yet leaving a more or less interesting history.

Eastern furnaces with lower railroad rates and better facilities for handling ore, and the opening of the great ore deposits of the Superior region and other districts has kept Indiana from returning to the manufacture of iron. But in the last few years interest has again revived in the ore deposits of the State, and the construction at Gary, Indiana, of what will eventually be the largest system of blast furnaces and iron mills in the United States makes it an assured fact that Indiana is again to become one of the chief iron-producing States of the Union, although most of the raw material may come from the Lake Superior region, but nevertheless the iron ore deposits of Indiana are well worthy of consideration and will undoubtedly prove a paying investment to those who carry out their development.

There are in the State several varieties of iron ore which may be classified as follows:

1. The Geological Formations.—The limestone, sandstone and shales, which contain from one to fifteen per cent. of iron and are of value in this connection only in that they may be shown to be the source of certain ore deposits.

2. Hematite.—The true hematites are comparatively rare. The red ochre variety is somewhat common, but usually quite impure from clay. The most abundant variety is a clay ironstone, a compact reddish material and highly siliceous. This class, however, more truly belongs with the limonite or brown hematite variety. Radiated and kidney-shaped masses are also found which approach the true red hematite variety very closely. Formerly the true hematites probably formed a much greater part of Indiana deposits, but it has been changed by the action of atmosphere, water, organic matter, etc., into limonite and siderite.

3. Limonite.—(a) Brown clay ironstone variety found in compact banded layers and nodular masses impure from clay. By drilling and other investigation it is found that these limonites are derived from carbonates which have been highly oxidized. (b) Bog ore of recent formation, loosely aggregated ore from marshy

ground, deposited chiefly from the surrounding soils; it is often found intermixed with and replacing twigs, etc. This variety may be found in a greater or less degree in almost any part of the State.

One usual result of the decomposition of any iron-bearing mineral is limonite. The decomposition by water, carbon dioxide and organic acids produces soluble iron salts, which are carried to some valley by the streams, and by oxidation the relatively insoluble limonite forms as a scum on the water and then sinks to the bottom as bog ore. In time, by pressure, heat, etc., these deposits are compacted. Notable examples of this decomposition and deposition are to be found in many of the streams of Martin County (see Report on Martin County).

4. Carbonates.—We have stated that limonite may be formed by the high oxidation of carbonates and it is also true that limonite, by the action of decaying vegetation, may be changed to carbonate. Thus iron ore is accumulated. In the presence of excess of organic matter it retains the form of ferrous carbonate. In the coal measures iron carbonate is largely found as a stony material, impure from sand, clay, etc., and may be massive, concretionary, banded or in the form of clay ironstone. When found massive, there is also frequently found associated with it more or less bituminous and earthy matter to which the term "black band" is applied; this bituminous matter may be somewhat equally diffused through masses of ore, giving it an almost black appearance. The concretionary form is very common and is composed of fairly compacted centers of carbonate ore, coated with thin layers of brown iron oxide.

5. Kidney Ore.—This includes all the ores in concretionary form and the name is derived from the peculiar kidney shapes of the concretions. In strata where two or more substances are found, it appears that there is an attraction of like for like, and the more soluble particles diffused through the more fixed segregate themselves into nodular masses. The concretion begins to grow about some nucleus, often some shell or other organism. In connection with sandstone the iron concretions are oxide of iron; in clay strata they are of carbonate, usually with a thin coating of oxide. These nodules are sometimes solid and others are hollow. They vary in size from that of a pea to more than a ton in weight.

6. Limestone Ore.—These are the ores which occur upon, or very near, the top of a limestone stratum and are regarded as replacements of limestone by ferruginous solutions, derived from overlying sediments. These ores are in some cases found occupying

a broader field than the limestone, but if they occur near the stratigraphic position of the limestone the term is still applied. The presence of limestone has an important influence on the precipitation of ferrous carbonate, and where both iron and calcium carbonates are present the former has in many cases replaced the latter. The iron content of the overlying formations has been carried down and deposited upon the limestone, which is afterward dissolved and carried away. The limestone ores carry a small percentage of lime.

7. Magnetite.—Magnetic ore is found in Indiana only in some of the black sands and in very small amounts. By dragging a magnet through these sands the particles of ore are gathered up.

8. Sandstone Ore.—This is a highly siliceous ore and is somewhat abundant. It is formed in part by replacement of the sandstone, but chiefly as a filling in the porous sandstone. It is richest on the outcrops, showing the downward and lateral movement of the iron waters.

While none of the Indiana deposits would be considered extensive as compared with the great ore-producing districts, yet the deposits aggregate a fair tonnage. The larger deposits which can be more easily worked would probably yield 15,000,000 tons of ore, and the smaller inaccessible deposits which would be easily worked out by the owners or the inhabitants if furnaces were in a reasonable distance, would bring the total up to at least 25,000,000 tons. In many cases the smaller deposits contain the best grade of iron; this would fully compensate for the extra cost in mining. Further developments and information from the use of the core drill may materially increase the above estimate.

The Methods of Prospecting in Indiana Fields.—The determination of the practical value of a mineral area in advance of actual mining is a matter of the greatest importance. Since large amounts of capital must be expended in the purchase of lands, building of railroads, installation of mechanical equipment, driving workings, etc., before a mineral property can be put on a working or paying basis, it is apparent that a great deal of prospecting by the most efficient means should prepare the way for actual developments.

The methods of prospecting in the Indiana fields as here described have not only been carried out in the iron ore fields of Greene and Martin counties, but also extensively in the coal fields of Southern Indiana and in the limestone and cement shale areas.

As a preliminary step in the development of the ore lands of Greene and Martin counties, the land was carefuly gone over and the ore outcrops and surface indications fully mapped. Then by the use of picks, shovels, drills and other hand tools and dynamite, vertical faces were cut on the outcrops extending from the surface down through the entire body of ore into the underlying formations. The length of these faces varied from five to 100 feet. In some cases where formations were broken and irregular some drift mining was done in order to determine more fully the dip and extent of the deposit. In some places in Martin County hundreds of tons of ore were removed from the face of the outcrop so that the information desired might be obtained. At points where surface indications seemed favorable and also back on the hill slopes some distance from the outcrop, where the hills do not rise to a great height above the deposits, shafts or pits from 6 to 10 feet in diameter were driven down to the line of the deposits or to greater depth, as were required to determine extent and thickness.

The cost of working a mineral area is determined to a large extent by the character of the formation and is affected by every variation in the pitch of the seam and the condition of the strata immediately overlying and underlying the mineral.

The methods described above are, however, of value only when ore outcrops are to be found or where the overlying formations are comparatively of little thickness. But when the deposits are far beneath the surface or when the hills rise to much elevation above the outcrops or line of deposits, the most economic and satisfactory prospecting is by drilling, as the cost of putting down a single shaft would be more than that required for many feet of drill holes.

There are thus five methods of prospecting to be considered. Each of these has certain advantages over the other, according to conditions. But for the average area the order of value would be as follows:

1. Mapping and Surface Outcrop Work, as Described Above.—The accurate delimitation of the iron-bearing or coal-bearing formations or any other formation containing valuable mineral product is of inestimable value to investigators. In many fields innumerable shafts and bores have been made at great distances outside of the possible mineral formations, thus wasting large sums of money. Although the result from mapping and preliminary work cannot be relied upon to definitely point out the places where the prospector will find iron deposits, they have enabled in a broad way to delimit the various formations and warrant the statement that iron deposits may occur in certain areas and that prospectors will not find iron deposit in certain others. This method proved to

be an excellent plan in the Indiana fields and could hardly have been dispensed with.

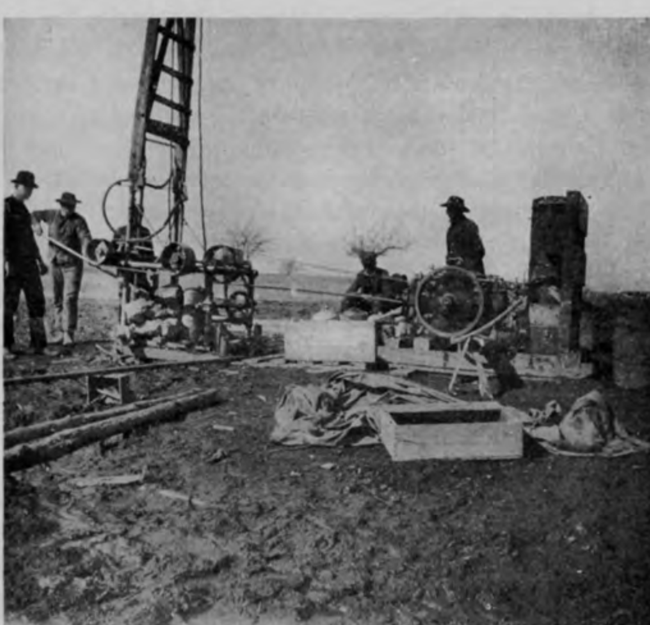
2. Sinking of Shafts and Pits or Drifting on the Deposits.—This method is necessarily slow and of great cost and has not been used in the ore field prospecting except as mentioned above.

3. Drilling With the Churn Drill.—This method is cheap and rapid and the samples from holes thus drilled consist of chopped-up particles representing the content of the hole, the various strata of which are necessarily more or less intermingled, so that the condition of the mineral as to purity and the character of the overlying and underlying strata are mere guess work. This method was little used in ore prospecting, but several holes have been put down with the churn drill within the bounds of the ore field in prospecting for oil and gas and the records made of formations through which the drill passed have been of assistance in working out the geology and practical value of the ore deposit.

4. Core Drilling With Chilled Shot or Saw-Toothed Bits.—This is an improvement over the latter method, but leaves much to be desired in the matter of drilling speed and condition of the core. There are no devices by which the cores are extracted carefully, nor is there the required pressure and smoothness to prevent the core from being broken up by vibration. Recently, however, a drill has been placed upon the markets in which a double tube core barrel is used. The bit is a cylindrical shell of selected steel, with a series of chisel edges, melted or forged in one end. The other end is threaded for attaching the core barrel. In operation the cutter and barrel are rotated and at the same time forced downwards. This cutter will rapidly and economically cut the majority of rocks. But there are some rocks so hard that the cutter will not bore them at an economical rate. In such cases the "chilled shot" method is used. Chilled shot, which is simply molten iron or steel "atomized," and suddenly cooled, will scratch glass. In drilling, the chilled shot is between the bit and rock and under the rotation and pressure of the drill rods the rock surface is milled or crushed away.

The chilled shot drills did not give satisfactory results in the ore fields chiefly because of lack of sufficient power (gasoline engines being used) and the soft and broken formation of the district. For drilling in solid strata as in the limestone fields of southern Indiana the chilled shot drill works at a good rate and gives a very satisfactory core. But in soft shales, coal and soft iron ores, the shot are lost in the material, the cores are worn and broken by the

Plate XVIII.



Chilled Shot Core Drilling in the Martin County Ore Field.

Rear View of Chilled Shot Core Drilling Outfit.

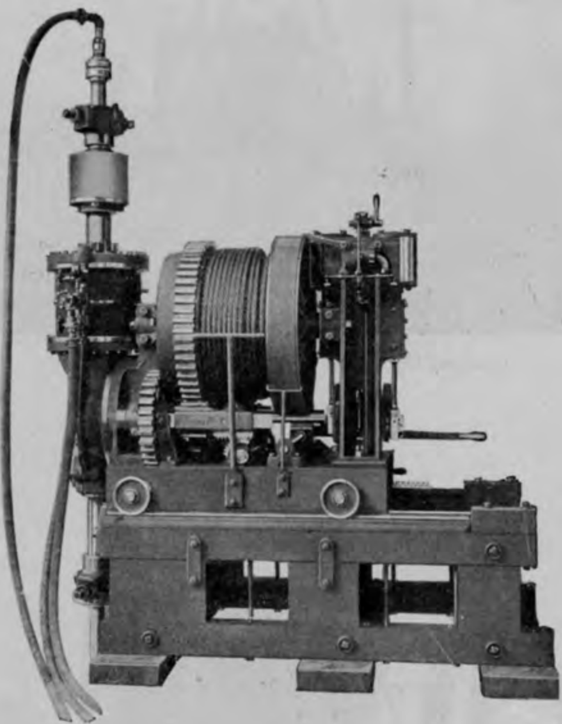
churning vibrations. The consumption of shot varies from ten to fifty pounds per hundred feet bored, according to the material. The slow speed, the jar and vibration of the drill and the slushing of the water in soft shales often cause "stuck drills." Holes of great depth cannot be successfully drilled with the ordinary style of chilled shot drill, but with the improved drill depths from 1,500 feet to 3,100 feet have been bored. The prices for drilling with the improved drill vary according to geological conditions from 30 cents to $2.00 per foot.

5. Drilling With the Diamond Core Drill; Using the Double-Tube Core Barrel.—Among progressive mining men the diamond core drill has replaced the methods of sinking shafts and drifting and the equipment of a modern mining concern is not considered complete without one or more diamond drills. Drills have been sent to the most out-of-the-way corners of the world, where they have acted as advance agents for the opening up of important mineral districts. In the South African gold field these drills have proved to be of inestimable value in verifying the persistence of mineral veins at great depths. Numerous holes have been successfully bored to a depth of a mile or over, including one near Johannesburg, recently completed at a depth of 6,340 feet from the surface.

The diamond drill consists of a line of hollow rods screwed together in five or ten-foot sections, rotated by an engine through a shaft and gearing and fed downward by hydraulic pressure regulated by finely graduated values. At the lower end of the rods is placed a double tube or "core-barrel," at the end of which is placed a bit, in which pieces of "black diamond," or carbon, are set, and which, as the rods are rotated under pressure, cuts a circular hole in the rocks, leaving a centerpiece of core undisturbed. At intervals, usually after drilling ten feet, the rods are withdrawn by means of hoisting mechanism, consisting of a derrick, or tripod, carrying a sheave wheel and a rope which is wound upon the drum forming a part of the drilling machine. The rods bring with them the core, which is caught and held by self-locking "core lifter." The core is then removed, the rods again lowered and the process repeated until the mineral body sought is found, or the desired depth reached.

Usually the cores are two inches in diameter, a dimension fixed upon after extensive experience. The cores extracted, even in friable formations, are practically complete, showing only a minute loss from abrasion and are a perfect index of the formations existing at the point drilled. The cores are placed in boxes made to carry from one to four sections and from three to ten feet in length, thus forming a permanent record. Vertical sections of the ore may be taken for analysis as required, the remaining portions being preserved.

In addition to the reliability of the records which they secure, diamond drills are also much more rapid than any other coring drill, owing to the small diameter of the hole bored, and the readiness with which the diamond bit penetrates all strata.



Diamond Core Drill.

Several thousand feet of drilling have been done with the diamond drill in the areas of Greene and Martin Counties, and extensive use has been made of these drills in the coal fields of Warrick, Pike and Gibson Counties. In Martin County a two-inch core was removed at a cost of about $2.50 per foot. In Greene County the core was 15-16 inch in diameter and the cost per foot to the company would be somewhat less, as the company owned the drilling outfit and put down many holes. In the latter county

Plate XIX.

Diamond Core Drill in Operation, Martin County.

Removing the Mineral Core from Double Tube Core Barrel.

a few holes were drilled at an angle to determine the thickness of dipping formations. In fact, the diamond drill may be set to penetrate the strata in any direction desired, while the "chilled shot process" and similar methods are useless except on perpendicular holes. In Martin County considerable trouble was experienced in keeping a supply of water on account of the scarcity of water and the crevices in the sandstone through which drilling was done. The water is forced through the rods to keep the diamonds cool and to wash away the cuttings from the bit. Thus, in holes where the crevices and broken formations occurred, it was necessary to ream the hole and case it. Nevertheless the average number of feet drilled per day was fair and the greatest depth drilled in one day was a little more than forty feet. The average per day would be somewhat low on account of shallow borings and frequent moves.

The cost of diamond drilling varies within wide limits, depending upon local conditions as to labor, fuel, water, superintendence, availability of supplies, living expenses, etc. The "Engineering and Mining Journal" has the following to say on the subject of costs:

"A recent compliation of statistics with reference to the cost of diamond drilling, goes to show how variable is the cost of such work and how utterly impossible it is to fix anything more than general rules from which an approximate figure of cost can be deduced. Out of 20 holes drilled through jasper, marble and iron slate, and varying in depth from 110 to 1,100 feet, the average cost was $3.14 per foot. Of this cost 39 per cent. went for labor, 22 per cent. for carbon and the remainder for fuel, repairs, supplies, etc. Another series of 16 holes, varying in depth from 94 to 380 feet, with an average of 314 feet, showed an average cost of $2.70 per foot. Of this amount 38 per cent. went for labor and 13 per cent. for carbons. The cost of drilling in soft schist rock was as low as $1.00 per foot, of which labor formed 66 per cent. and diamonds 30 per cent. The cost of drilling in hard syenite rock was twice that of drilling in tough diorite; the cost of the diamonds in drilling the syenite rock approximated 63 per cent. and the labor 38 per cent.; the carbon cost 30 per cent. and the labor 66 per cent. of the total. The speed of drilling varied from 6 to 25 feet per day, and the holes had a mean diameter of 1¾ inches."

The method of core-drilling indicates to the prospector the exact depth of the ore body from the surface and the thickness and character of the vein when found, as well as the nature of the material penetrated before reaching the vein. It is thus possible to estimate very closely the cost of the work of development, while the core of the mineral gives accurate samples for analysis. Of about equal importance, if the ore body is absent the drill indicates the fact, thus saving the cost of an exploratory shaft. Since the core may be preserved in boxes, each piece in its proper position, we have a record that is one of the best arguments that may be used to induce capitalists to invest in mineral properties.

THE KANKAKEE AND LAKE REGION.

This region is comprised of the counties of Lake, Porter, Laporte, St. Joseph, Elkhart, Lagrange, Steuben, Dekalb, Noble, Kosciusko, Marshall, Starke, Whitley, Northern Wabash, Fulton, Pulaski and the northern part of Newton and Jasper. This area includes more than 250 lakes, varying in size from less than a fourth of a square mile in area to a little over five and one-half square miles, and varying in depth from a few feet to 125 feet. The rivers and streams wind through marshes, with a slight current and without definite banks. The Kankakee marshes comprise the most extensive body of swamp land in Indiana. The original area of this marsh land in the seven counties drained by this stream was almost a half-million acres. The Calumet River is also noted for its low banks and the sluggish action of the water. Much has been done by the use of artificial ditches to drain these marsh lands, yet there are thousands of acres that for four or five months of the year are covered with from one to five feet of water and during the remainder of the year this area is little better than an immense bog.

In the margin of many of the lakes and in the marshes are found considerable quantities of limonite or bog iron ore, and peat formed by the partial decomposition of vegetation beneath the surface of the water. Although this ore is apparently abundant in many places and would yield a superior iron, yet the expense of removing the overlying material increases the cost of the ore so that it cannot be furnished in competition at present with the rich ores of the Lake Superior region. An excellent fuel, where great heat is required, has been produced by mixing about equal proportions of coal and peat, and when some such plan has been devised for converting the peat with which the ore is associated into a fuel that can be successfully used in iron manufacture, each may add to the value of the other and bring these marshes into more favorable notice.

Origin and Deposition.—The bog ore is usually found at the bottom of the peat bogs, often as a "hardpan" of iron ore, sometimes one or two feet thick. It is also found in masses scattered through the lower materials of the marshes; masses of several tons weight have been found in a few places. It is never crystallized, but grades from the loose, porous bog ore and earthy ochre of brown to yellow color to more compact varieties. Bog ore, or limonite, is a variety of brown hematite, usually quite impure from sand, clay, phosphorus, etc. It is often found intermixed with or replacing leaves or twigs. It collects in low places even where there is no decided bog. The manner in which this iron ore accumulates is very interesting and in a geological point of view very important.

A sedimentary deposit of bog iron is finally concentrated by precipitation of the mineral in a marsh or lagoon. But the earlier stages of the work of segregation are by underground waters, and if their part of the work were considered the ores would be classed as metamorphic. The iron precipitated is usually carried under ground as carbonates, but when oxygen is abundant oxidation takes place, the carbon dioxide is liberated, the ferric oxide unites with water, and limonite is then thrown down.

Iron Works.—In 1834 we have the beginning of the iron industry of Northern Indiana. A man by the name of A. M. Hurd came to the place where the city of Mishawaka now stands, and laid out a town about five by six blocks, which he called "St. Joseph Iron Works," and which was later incorporated under the present name. Hurd constructed a small wing dam at the head of the rapids on the St. Joseph River and dug a ditch for the purpose of carrying the water to a place where it could be utilized to furnish power. There he built a small smelting furnace and a mill. The necessary machinery, which consisted mainly of a large cast iron cylinder blower, was hauled through the woods from Detroit by oxen. The country to the south was heavily timbered and a number of practical furnace men and charcoal burners were attracted to the place from the furnace districts of Ohio. The ore used was the "bog ore," which was found in considerable quantities in several nearby localities. The farmers delivered the ore and charcoal to the furnace and were paid on the basis of one-fourth cash and three-fourths in goods from the company's store.

The only outlet for the products of the furnace was in the manufacture of iron castings, which were needed by the early settlers of the surrounding country, and as there were no such wares made in the west at any point, the various articles, kettles for household use, kettles for maple sugar making and larger ones for turning the ashes left after clearing the land by burning the timber into pot and pearl ashes, called pot-ash kettles; later stoves were made, and previous to the coming of railroads in this direction the merchant and home-makers for probably a hundred miles around came here for their wares. With the coming of the railroad—the present Lake Shore and Michigan Southern—all was changed, much of the iron work for this and other railroads was made and a period of prosperity followed. The business, after passing from the possession of Mr. Hurd, was owned by J. H. Orr, J. E. Hollister and John Niles. About 1858 the smelting of ore was discontinued, chiefly because of the high cost of charcoal.

About 1847 a second furnace was started, owned principally by Boston parties. It was not successful and in a few years the enterprise was abandoned. At an early date a forge was built for the manufacture of wrought iron directly from the native ore, and the product was hammered out by heavy tilt hammers, as this was before the time of rolling mills. With the introduction of rolled iron the business was abandoned.

The city of Mishawaka now has a population of about twelve thousand and its existence is probably due to the deposits of ore in the marshes of that vicinity.

In 1845 Messrs. French and Beers erected a Catalin forge in Rochester, on the Elkhart River, in the northeast (NORTHWEST) corner of Noble County. About the time the forge was completed, and before it was put in operation, the original proprietors sold to W. F. Lee of Mishawaka, A. D. Webster of Rochester, New York, and D. M. Beers of Newtown, Conn., who put the forge in blast, employing about sixty men in digging and hauling ore, burning and hauling charcoal and working the forge. About four hundred bushels of charcoal were burned in making one ton of bar iron from three tons of ore. The product was ten tons of bar iron per week, which was sold at $100 per ton. Ore diggers, colliers and common laborers were paid fifty cents per day and boarded, while "bloomers" and "hammersmen" received two dollars per day and board. The tract of land on Ore Prairie from which the ore was dug was then owned by Hon. Henry L. Ellsworth, of Lafayette, Ind., who received a royalty of twelve and a half cents per ton for all ore taken out. The firm continued in business until the spring of 1850, when they sold to Wood and Bromley of Lagrange, who carried it on a few years and abandoned the enterprise.

About the year 1850 a forge was started at Lima, Lagrange

County. The ore used was found along Pigeon River, west of Lima. This ore was worked into bar iron, which made a very good article and demanded a fair price. The ore being difficult of access, and charcoal increasing in price, the forge was abandoned about the time the Lake Shore and Michigan Southern Railroad placed this part of the country in quick and cheap communication with the iron manufacturers of Cleveland and Pittsburg.

New Iron and Steel Works.—The union of cheap coal and iron ore has attracted to the shores of Lake Michigan what will eventually be the largest and most complete iron and steel manufacturing plant in the world. The tract of land purchased by the United States Steel Corporation for the new industrial city of Gary, Ind., at Indiana Harbor, measures 2,793 acres and cost $1,926,065. On this is being erected not only the largest iron and steel plant, but also a city dependent upon it. The engineering skill, the designing and building of such a plant, will be an accomplishment that will rank with the great public works of the world.

The immediate erection and completion of a great rail-mill, with sufficient blast furnace and steel work capacity to provide for its requirements, and the installation of other finishing units as required, with their raw material accessories, is the scheme that has been adopted for the development of the plant of the Indiana Steel Company, a subsidiary company of the United States Steel Corporation. The rail-mill is to have a capacity of seventy-five thousand tons a month, or nine hundred thousand tons a year. The four blast furnaces are to have a daily output of 1,800 tons, and the twenty-eight open-hearth furnaces 3,000 tons. As the rail-mill will require nearly three thousand tons of steel per day, there will be no surplus and the pig output is also adjusted and provides for about 40 per cent. admixture of scrap. The blast furnaces under construction are in the center of the ultimate group of sixteen; and the two open-hearth units are similarly located in the group of six open-hearth plants, which will ultimately contain eighty-four furnaces. The stove and furnace stacks will be ninety feet high and will have a diameter of twenty-one feet and six inches. From these dimensions it is apparent that they have been designed with a view to the use of a fairly heavy percentage of fine ores. Gas-driven blowing engines will furnish air to the stacks. Gas engines for utilizing blast furnace gases are being introduced in old mills and are to be used on a large scale in the new plant. According to the "Iron Age" there are now under construction, and ordered by the Steel Corporation, gas engines aggregating a total of 102,000 horse-power, of which 44,000 horse-power will be in blowing engines, and 58,000 horse-power for the other purposes, chiefly for the generation of electric power. Only a few of these engines will be supplied with producer gas for special purposes; the rest, furnishing a total of 100,000 horse-power, will be operated with the gases from the blast furnaces, which would otherwise go to waste, with the exception of that portion which would be utilized in the hot blast stoves and under boilers.

There has been but very little done in the northern part of the State to determine the extent of the iron ore deposits. It would be impossible to place an estimate on the amount of ore that might be found during the progress of careful development. As stated above large quantities of ore have been found in the edges of the lakes and marshes. Many wells that have been put down in this area have passed through ore, while others do not show but a trace even in analysis of the water. In Dekalb County a vein of water found at a depth of eight to ten feet is colored, due largely to seepage from peat beds, and is slightly chalybeate, and at a depth of about forty feet from the surface there is a vein of water strongly chalybeate. At La Crosse most of the wells penetrate more or less iron ore and the water when analyzed shows iron. The ditches that have been made for the drainage of the Kankakee region have, in several places, cut through considerable beds of the ore. In cutting a ditch through the Wm. Henke farm, south of the Kankakee, a carload of bog ore was taken out and utilized in a blast furnace and is said to have shown an iron content of about 65 per cent.

The chief known deposits are in the Calumet region, especially in the vicinity of Furnessville, where masses of ore weighing hundreds of pounds have been unearthed. Along the Kankakee, extending back in places several miles, and along the river to its source in the marshes near South Bend, where much of the ore for the furnace at Mishawaka was found. In Ore Prairie, in Noble County, and along Pigeon Creek, in Lagrange County, is found the greatest abundance of ore in the eastern part of the region.

This region, outside of the manufacturing district, is chiefly an agricultural district, but in order to drain and reclaim the thousands of acres of marsh land, the main channels of the streams must be straigtened and deepened and the digging of a large number of lateral ditches through the swamps to the improved channels will be required.

These ditches will largely determine as to the amount of ore, and the coming of new blast furnaces, the scarcity of fuel, and the use of low-grade ores may lead to the development of these bog ore deposits.

SCOTT, CLARK AND FLOYD COUNTIES.

In the base of the knob shales immediately overlying the New Albany black shale are found several bands of kidney ore and iron stone, which can be found over a large area in the above-named counties. The ore outcrops in almost every ravine cut through the shales. The knob shale, when exposed, is readily weathered out and the iron ore washes down and accumulates along the valleys and streams. The ore, wherever found, is of the same general character and contains about 28 per cent metallic iron. As many as six to ten bands of the ore may be found in a vertical space of about twenty feet. The lower band is usually on a level with the drainage of the country. The bands will average from two to six inches in thickness and are separated from each other by from two to four feet of shale.

The iron ore deposits of Scott County are confined to Finley and Vienna Townships, and are seen at the head waters of Pigeon Roost Creek and along Kimberland Creek. The stratified iron stone with the kidney ore makes up several bands from 2 to 10 inches in thickness. Along Pigeon Roost and Big Ox Creeks and other streams of the iron-bearing shale is considerable pebbly iron-stone conglomerate gravel, which has been used on many of the improved roads.

In Clark County the principal bands of iron ore are found in the vicinity of Henryville. At one time a Mr. Stewart, who lived at Henryville and was the owner of large tracts of land containing this iron stone, offered to take a contract, at \$1.75 to \$2.00 per gross ton, to deliver on the cars at Henryville, from 100 to 200 tons of this iron ore per day, for a period of five or ten years. His offer, however, was not accepted.

About 1840, James Works, an ironmaster from Pennsylvania, examined the ores of this area and especially those found near Henryville, Clark County. He pronounced it good ore and made preparations to erect a furnace, but the project was finally abandoned. A little more than thirty years ago interest in these ores was again revived and several analyses were made. The chief value then supposed to be in these ores was mainly due to the amount of maganese shown by the analysis and it was thought if properly smelted would yield a highly manganiferous pig iron, if not a true spiegeleisen. Since the ore accumulated in the ravine it would be easy of access, and by the various railways passing through this area the ore would have a ready means of shipment to the blast furnaces then in operation in the State, unless new furnaces were built expressly to melt this ore, the question of cheap fuel being of chief importance in the selection of the locality.

The character and importance of this iron will be shown in the following analysis and sections. It is stated that in making the analysis the kidney ore was mostly used and the coating of red oxide was removed and the analysis made of the enclosed blue carbonate.

Analysis:

SAMPLE SCOTT COUNTY ORE.

Combined water	15.00
Silicic acid	14.00
Protoxide of iron	38.56
Sesquioxide of iron	3.01
Oxide of manganese	4.50
Carbonate of lime	2.02
Carbonate of manganese	.85
Sulphur	.05
Phosphoric acid	.50
Carbonic acid and loss	21.51
Total per cent of iron, 32.20.	

SAMPLE FROM NORTH OF HENRYVILLE.

Moisture dried at 212°	0.500
Insoluble silicates	16.400
Carbonate of iron	49.400
Peroxide of iron	2.171
Manganese	2.500
Alumina	1.500
Carbonate of magnesia	14.000
Carbonate of lime	10.000
Sulphuric acid	0.686
Phosphoric acid	0.779
Loss and undetermined	1.744

Iron content of ten bands of ore, near Henryville. Bands numbered from top to bottom:

	Per cent.		*Per cent.*
Band No. 1	26.41	Band No. 6	29.74
Band No. 2	26.66	Band No. 7	29.23
Band No. 3	30.51	Band No. 8	27.17
Band No. 4	28.20	Band No. 9	28.00
Band No. 5	29.12	Band No. 10	28.48

Sections.—A vertical section on Pigeon Creek:

1.	Ash colored and ocherous clay	5 ft. 00 in.
2.	Shale containing 5 in. band of iron stone	5 ft. 00 in.
3.	Three to four feet shale with kidney ore	4 ft. 00 in.
4.	Band of iron stone	6 to 8 in.
5.	Shale 2 to 4 ft., with band of iron stone	8 to 10 in.
6.	Shale 3 to 5 ft., with band of iron stone	8 to 10 in.

Section outcrop one-half mile north of Lexington:

1.	Clay soil	3 to 12 ft.
2.	Black slate	4 to 7 ft.
3.	Oxide of iron	6 in.
4.	A light gray fossiliferous limestone	4 ft.
5.	Darker, fossiliferous limestone	8 ft.
6.	White limestone with fossils	6 ft.

Section three and one-half miles northwest of Henryville:

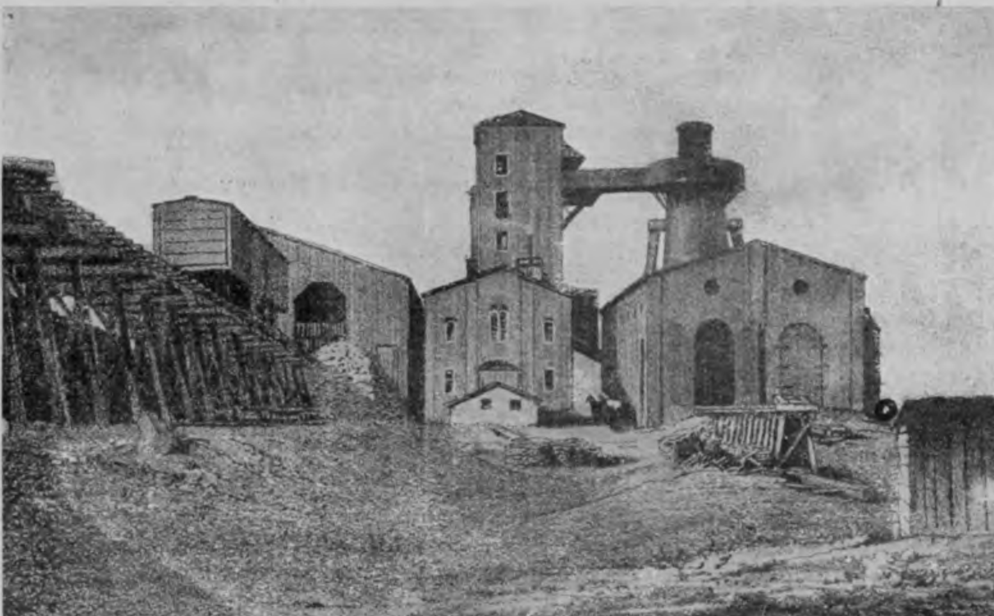
1.	Greenish blue shale	2 ft.	0 in.
2.	Band iron ore with kidney ore	0 ft.	5 in.
3.	Greenish blue shale	4 ft.	0 in.
4.	Band iron ore	0 ft.	5 in.
5.	Greenish blue shale	4 ft.	6 in.
6.	Band iron ore	0 ft.	6 in.
7.	Greenish blue shale	3 ft.	0 in.
8.	Band iron ore with kidney ore	0 ft.	8 in.
9.	Greenish shale	2 ft.	0 in.
10.	Band iron ore	0 ft.	8 in.
11.	Greenish shale	1 ft.	6 in.
12.	Band ore	0 ft.	5 in.
13.	Shales	3 ft.	0 in.
14.	Ferruginous limestone	2 ft.	6 in.
15.	New Albany black shale	6 ft.	0 in.
		31 ft.	6 in.

VIGO AND VERMILLION COUNTIES.

On the west side of the Wabash River in the bluish-gray shales are bands of clay iron stone and kidney ore concretions. Along the hillsides and in the ravine these pieces of ore are found in considerable quantities. They were formerly found in sufficient quantities to justify their being gathered up and carted to the Vigo Blast Furnace at Terre Haute, to be mixed with the Missouri ores and smelted. This furnace was the last one of the old group of Indiana furnaces to go out of blast; it ceased operation about 1895.

The old Indiana Furnace in Vermillion County, when in blast, obtained its supply of iron ore from these shales. It experienced no difficulty in finding an abundant supply of ore, though it was in blast for a number of years and consumed daily from thirty to forty tons of ore. The outer wall of the stack was built of sandstone and about forty feet high and nine feet across the boshes.

Plate XX.



VIGO BLAST FURNACE.
Terre Haute, Ind.

The daily make of metal was about nine tons. The furnace used charcoal for fuel and on account of the growing scarcity of timber for charcoal and the distance from railroad facilities the furnace went out of blast in 1859.

An attempt was once made to use the coal in this section in the furnace and "a number of kettles were cast from the iron produced, but the metal proved brittle, probably from the presence of sulphur," and no further use of the coal was made for smelting purposes.

The principal places where the ore is found in the greatest abundance are in the vicinity of Tecumseh, or Durkey's Ferry, on the west side of the river, about six miles north of Terre Haute and along the line of the new branch of the Southern Indiana Railroad and extending up into Vermillion County along Brouillet's Creek and from the mouth of Little Vermillion, at various places along the Wabash to the mouth of the Big Vermillion, but the more abundant deposits lie just beyond the Illinois line.

At Durkey's Ferry, in some of the ironstone nodules, fine specimens of fossil ferns have been found. On Little Vermillion compact brown ironstone is found containing fish remains, and at Hanging Rock many iron ore concretions are found containing fossil plants.

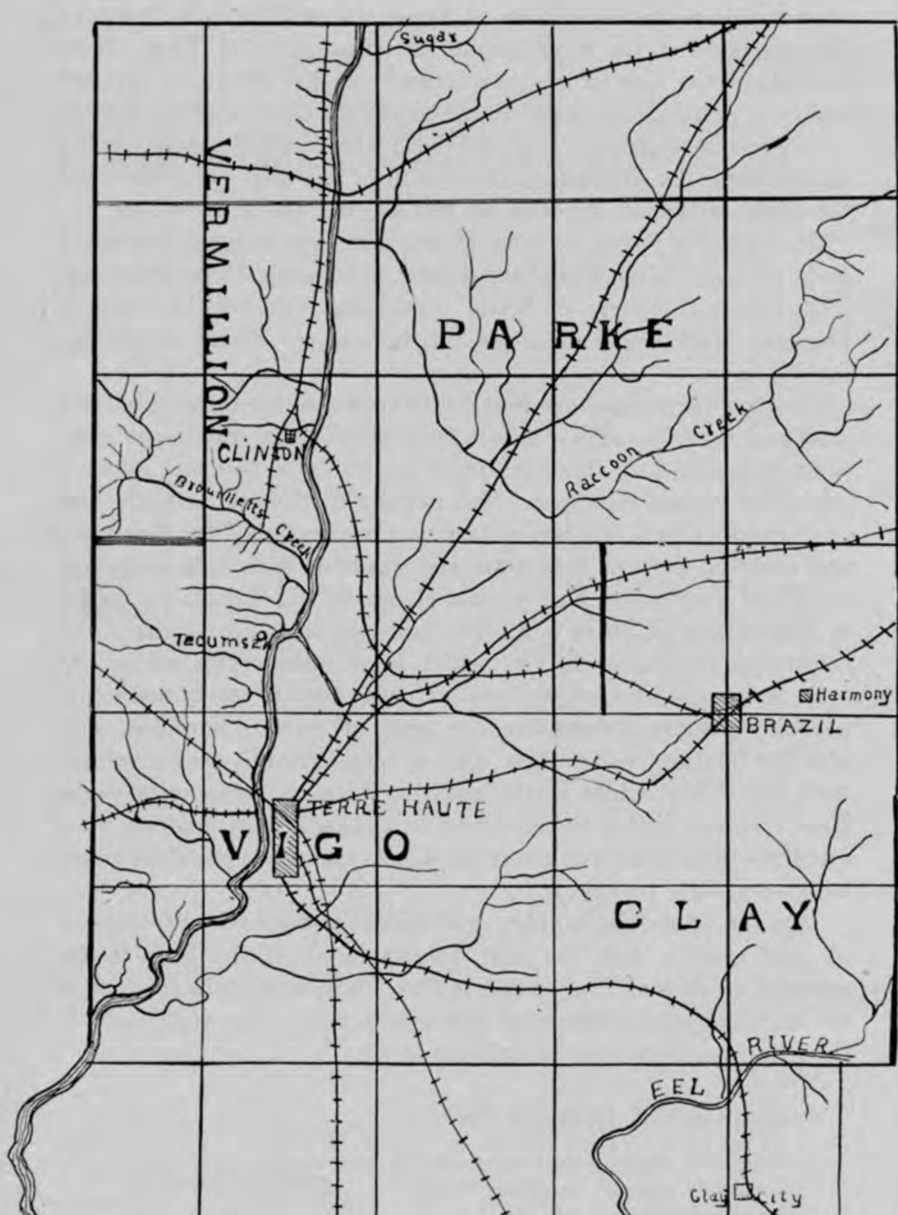
The iron ore nodules are found scattered through the coal bearing shales of these counties. About four miles below Eugene is a deposit of limonite in thickness from one to three feet and containing about 35 per cent iron. The deposit is of small extent. Also on Norton's Creek is a bed of bog iron ore probably two feet thick and covering three or four acres and available with light stripping.

"Upon Browntown branch, and along the Big Vermillion, as far as Moore Branch, there is a heavy band of quite pure light brown calcareous carbonate of iron, which is of considerable value. At some points the lime largely predominates, but the whole bed would probably average twenty-five per cent. of iron. Limestone, suitable for fluxing, renders this, also, a very valuable ore for mixing with the richer oxides in the smelting furnace. The seam varies from eighteen inches to three feet in thickness and deserves more attention than it has yet received. Large quantities could be mined with very little trouble.

"On the whole, the country is abundantly supplied with iron ore of good quality and the near neighborhood of the beds to the seams of block coal," according to Cox, "will soon make this one of the most important centers of iron production in the west."—E. T. Cox, Geological Survey of Indiana, 1869.

Section south of Durkey's Ferry:

Gray clay shale, with iron ore bands and concretionary masses containing fossils..............	20 ft.
Soapstone shale with fossils....................	2 ft.
Black shale	2 ft.
Coal at river bed..............................	3 to 5 ft.



Area from which a half dozen old furnaces obtained part of their ore supply.

Section near the site of the Indiana Furnace upon Coal Creek, a tributary to Brouillet's Creek:

Greenish sand shale, with iron ore bands and kidney iron ore	20 ft.
Drab clay shales	5 to 20 ft.
Shaly coal	1 to 3 ft.
Coal	2 to 4 ft.
Fire clay	6 ft.
Sand shales	10 to 12 ft.
Limestone	1 to 2 ft.

Section near Newport on Little Vermillion:

Clay shales with iron-stone	3 to 5 ft.
Clay shales	6 to 5 ft.
Coal	8 to 20 ft.
Fire clay	4 to 6 ft.
Shales	25 to 40 ft.
Iron-stone and nodules in shale	3 to 5 ft.

Section on river bank near Eugene:

Surface and fire clay	2 ft.
Black shale	2 ft.
Fossiliferous iron-stone and shale	2 ft.
Black shale	6 in.
Slaty shale with cannel coal	1 ft.
Coal	1 ft.
Sandstone	1 ft.
Fire clay grading to sand shale	7 ft.

Section upon Browntown Branch:

Black calcareous ore	1 to 2 ft.
Black shale	4 to 5 ft.
Fire clay	1 ft.
Shaly sandstone	6 to 8 ft.
Compact sandstone	9 to 10 ft.
Shaly sandstone	1 to 2 ft.
Iron ore band	2 in.
Sand shale	10 ft.
Shaly iron ore with fossils	18 in.
Shaly sandstone with some ore	40 ft.

The iron ores would give an average analysis of about 33 per cent. But as will be seen from the above description and the sections given these ores are not now of economic importance, yet they are of geological importance and of special interest to fossil seekers.

PARKE AND FOUNTAIN COUNTIES.

The iron ores of these counties, although not of sufficient abundance to supply blast furnaces, have been carefully investigated several times. It is much the same as that found in the counties described above. Where the creeks and branches cut through the shales at the base of the coal measures several bands of low-grade iron ore are exposed to view and the beds of the streams are in places almost covered with pieces of ore that have been washed down from the shales. The principal places where these iron ores are found are along Coal Creek and in the bluffs facing the Wabash River.

Concerning the ores of Parke County, Prof. Cox says, in his Geological Report: "The banded and kidney ores are abundant throughout the county, and they are estimated to yield about 30-33 per cent. metallic iron. Very good-natured clay ores are also found at different creeks of this and other counties and may be classified in the following manner:

1. The impure carbonate of iron, including clay ironstones, in flattened spheroidal masses and in bands, more or less continuous, associated with argillaceous shales.
2. Brown sesquioxides or limonites.
3. Silicious oxides.

The ores indicate sufficient richness to justify smelting, whenever facilities can be had for cheap and ready transportation. Especially do they show that the country has the desirable ore for admixture with those of Lake Superior and Missouri."

Section on Sand Creek, Parke County:

Surface	10 ft.
Sandstone and shale	8 ft.
Fossiliferous limestone	3 ft.
Ivory shale	1 ft.
Coal	3 ft.
Shale with bands, iron ore	25 ft.
Coal	4 ft.
Fire clay	3 ft.
Sandstone	5 ft.
Sand shales with several bands iron ore	20 ft.
Coal	6 in.
Soft, reddish sandstone down below bed of creek	15 ft.

Section on river bluff, southwest corner of Fountain County, beginning 30 feet from surface:

Coal	1 ft.	6 in.
Fire clay	3 ft.	6 in.
Shale with iron ore	8 ft.	0 in.
Iron ore concretion	0 ft.	6 in.
Black shale	2 ft.	0 in.
Shaly coal	1 ft.	6 in.
Sandy fire clay	2 ft.	6 in.
Shale with iron ore concretions	10 ft.	0 in.
Band iron ore	0 ft.	4 in.
Black shale	1 ft.	8 in.
Coal	1 ft.	8 in.
Fire clay	6 ft.	0 in.
Shale with ore	2 ft.	0 in.
Fossiliferous limestone	4 ft.	10 in.
Shaly coal	4 ft.	0 in.
Fire clay	4 ft.	0 in.
Soft white sandstone	2 ft.	0 in.
Siliceous iron ore	0 ft.	10 in.
Sandstone	6 ft.	0 in.

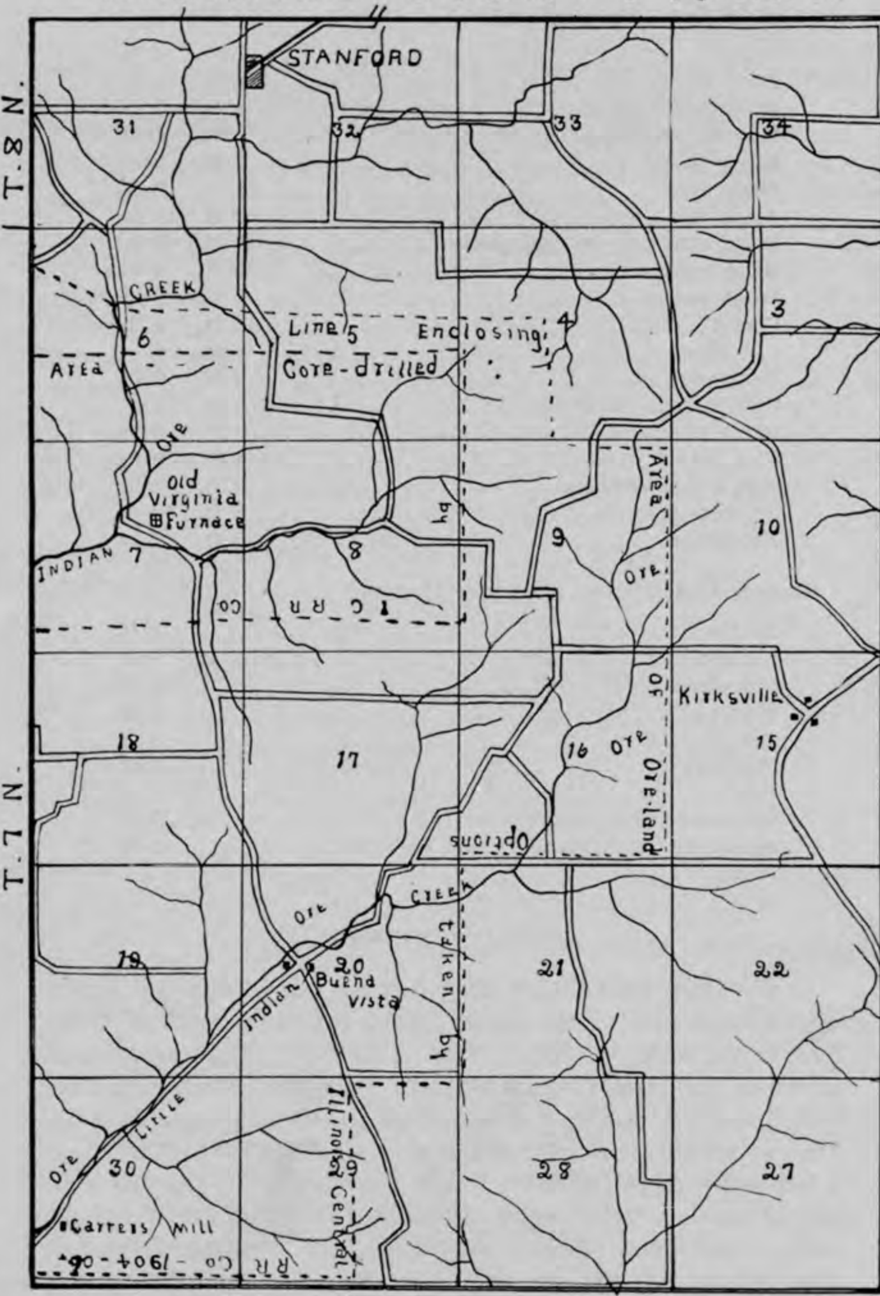
Section Coal Creek, Fountain County:

Surface	5 ft.
Shale with iron concretions	6 ft.
Limestone	2 ft.
Shale	8 ft.
Coal	1 ft.
Fire clay	3 ft.
Coal	1 ft.
Shale with iron concretions	2 ft.
Sandstone	12 ft.

MONROE COUNTY.

In the years 1839-1840 a blast furnace was constructed in the southwestern part of the county, about two miles south of Stanford, in the N. E. ¼, Sec. 7, Twp. 7, R. 2. W. This furnace was known as the "Old Virginia Furnace," also the "Cincinnati Furnace," and was managed by an inexperienced man from Virginia. The ore for this furnace was found in small deposits of ore from a few inches to two or three feet in thickness. The deposits were also of small lateral extent and consisted chiefly of ironstone concretions and highly silicious banded ore. The location of the furnace and the deposits are marked on the map. One of these was about one-half mile northeast of the furnace and the other about

MONROE COUNTY AREA.



three miles east. Small quantities were taken from several points along Indian Creek. The greater part of the ore, however, for this furnace was brought from the edge of Greene County, in the vicinity of the little town of Cincinnati. The ore was taken from the hillsides and streams by the farmers and hauled to the furnace. Charcoal was used as fuel and the preparation of this gave employment to a number of men. An abundant supply of limestone for flux was found in the surrounding hills about fifty feet above the elevation of the furnace.

The furnace would be in blast for a few weeks and then shut down for some time for repairs and to await a supply of ore.

The best per day production was three tons pig iron, the average yield for the time running being about one and a half tons per day. The iron was sold at Louisville for twenty dollars per ton. On account of inexperienced men and difficulty in getting the ore and fuel, the furnace failed to repay the promoters and was only in operation a few years.

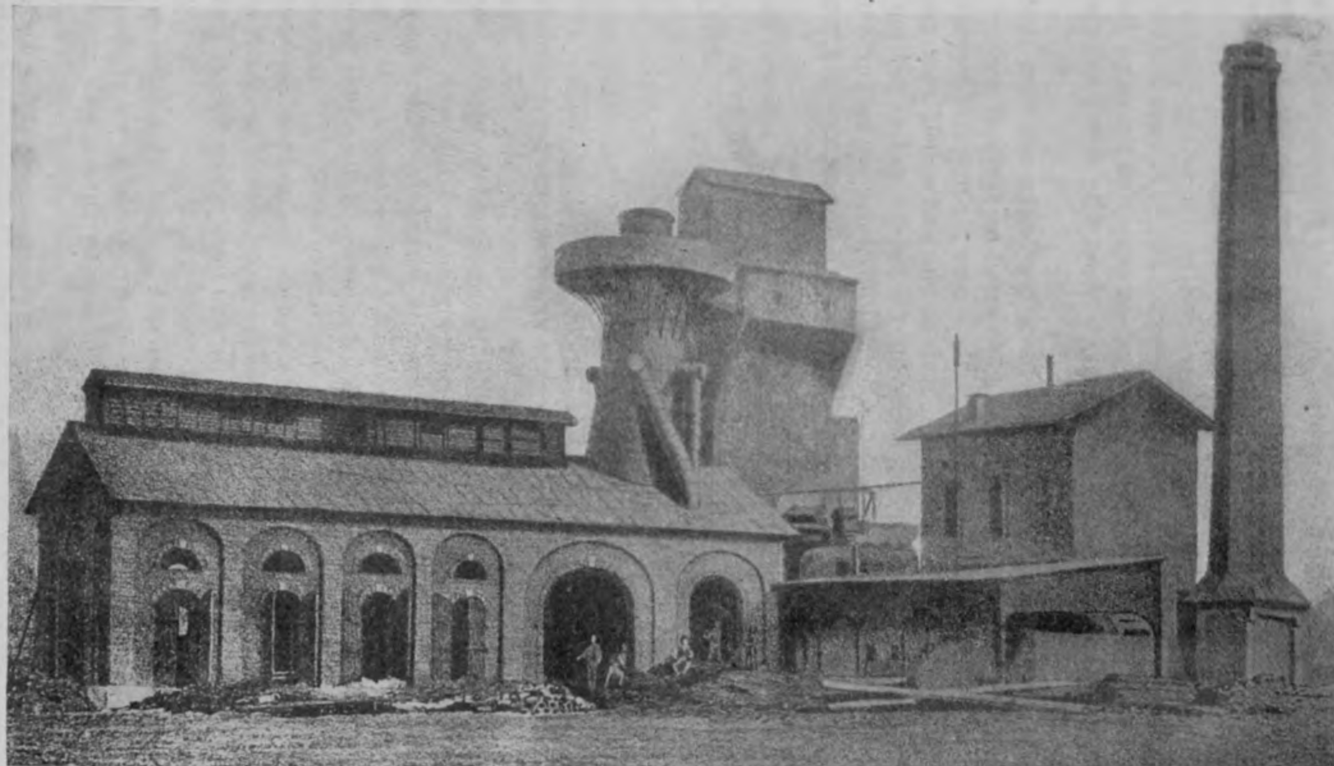
These deposits of ore in Monroe County are not of sufficient extent to be considered of any commercial and economic value.

CLAY COUNTY.

The introduction of the Brazil block coal for smelting iron led to the establishment of furnaces, rolling mills and foundries. The pioneer of these enterprises was the blast furnace in Brazil. This was erected and put in operation in 1867. The stockholders were Indianapolis and Brazil men; the capital was $150,000. The furnace was put in operation and run with profit for a short time, when it shut down with perhaps no other motive than for the larger stockholders to gobble up the smaller. During the period of its idleness the iron market became dull and the price of pig iron declined as a result of reduction in tariff. The furnace fell into the hands of Messrs. Garlic and Collins and was operated later by the Central Iron and Steel Company, which bought it in 1882 for about $20,000. The capacity was twenty-four tons of iron per day.

The original success led to the establishment of other furnaces: in Knightsville a double furnace was constructed at a cost of about $200,000, in 1867-68; the Masten Furnace on Otter Creek, north of Brazil, using chiefly native ore; the "Star" or "Planet" furnace, east of Harmony, using native ore and using fifty or sixty teams to haul the ore to the furnace. These furnaces were built

Plate XXI.



Brazil Furnace at Brazil, Clay County, Indiana.

on the theory that the location of all such works should be in the vicinity of the fuel, it being more practical to ship most of the ore. These furnaces have all long since gone down.

The five blast furnaces in Clay County made pig iron with raw block coal. "They all run upon the hot blast principle, and the blast is heated in gas ovens by the waste gas brought from the top of the stack. The total working capital employed at these furnaces was about $600,000. Combined they consumed daily:

300 tons "Block" coal.

150 tons ore—chiefly from Lake Superior and Iron Mountain.

50 tons of limestone for flux.

"The daily make of iron was about 110 tons, worth on an average, at the furnaces, forty dollars per ton, including all grades. The total value of each day's run of iron is, therefore, four thousand four hundred dollars, or about one and a half million dollars per annum, after allowing for mishaps and loss from accidents. The number of men employed at these furnaces, not including coal miners, was about two hundred.

"All the furnace companies own collieries and give employment to a great many more men who were engaged in mining 'block' coal for the furnaces, also for the market."

Although the iron ores found in this region were used to some extent it was found that the native ore was more expensive in proportion to the quality of iron it contains than the ore from either Lake Superior or Missouri. When the home ores were being used it was hauled in by the farmers and when the furnace capacity was increased so that the furnace owners called for 200 tons of ore per day the farmers were alarmed and were afraid to attempt to furnish the required amount.

Section of bore near Knightsville:

Surface clay	7 ft.	6 in.
Sandy clay	7 ft.	0 in.
Hard pan	1 ft.	0 in.
Brown sandstone	5 ft.	2 in.
Fire clay	1 ft.	2 in.
Blue shale	2 ft.	2 in.
Iron ore	0 ft.	3 in.
Blue shale	2 ft.	2 in.
Iron ore	0 ft.	1 in.
Blue shale	0 ft.	7 in.
Shale with sandstone	6 ft.	6 in.
	35 ft.	4 in.

Plate XXII.

LAFAYETTE FURNACE, Clay Co.

B.F. Master Supt.

Section three and one-half miles southeast of Brazil, Section 10, Township 12, Range 6 W.:

Surface	11 ft.	0 in.
Hardpan	10 ft.	6 in.
Gray slate	4 ft.	0 in.
Shale with ore concretions	3 ft.	0 in.
Black slate	1 ft.	6 in.
Coal	3 ft.	6 in.
	33 ft.	6 in.

Section four miles west of Brazil, near Staunton:

Shale with iron concretions	20 ft.	0 in.
Coal	1 ft.	8 in.
Sandstone	20 ft.	0 in.
Shale	4 ft.	0 in.
Coal	2 ft.	6 in.
Shale	46 ft.	0 in.
Coal	2 ft.	6 in.
	96 ft.	8 in.

ORANGE COUNTY.

The topographical features of this county are varied. The southern and western part is very hilly. In many of these hills, at the base of the conglomerate sandstone and above the "whetstone" grit, is found considerable deposits of silicious iron ore. In some localities it is comparatively free from silica. There are numerous deposits from two to four feet in thickness on the outcrop, but of small length and lateral extent. This county is on the eastern edge of the chief ore area, and its ore deposits in themselves are of little economic value, but if furnaces should be built for smelting the ores of adjoining counties, the ores of Orange County could be utilized and would largely increase the tonnage of Indiana ores. No analysis of these ores was made expressly for this report, but when the blast furnace at Shoals, Martin County, was in operation tests were made of the ore found in section 8, township 1 north, range 2 west, and showed an iron content of 35 per cent. to 50 per cent., according to material taken; the selected specimens giving the higher percentage.

LAWRENCE COUNTY.

This county also is on the eastern edge of the iron area of the State. The western part is also similar in its physical features to the part of Orange county described. The southwestern part, south of the river to the county line, consists chiefly of the the same formations to be found in the iron district of Martin County. The area containing workable deposits of iron is very limited, although there are a few deposits that may prove of value. The part of the county south of the river showing indications of iron was worked over in a limited way, but no excavations or facings were made at the outcrops to determine the extent and thickness of the deposits. The largest deposit known is in section 21, township 4, range 2 W, and is a deposit of brown ore underlying the bed of porcelain clay which was formerly worked. The ore was also smelted in the Shoals blast furnace with very good results, the smelting requiring but little fuel and flux and made an excellent quality of pig iron. The ore varies in thickness from a few inches to over four feet. Other deposits, or rather a continuation of the above mentioned deposit, since thin connecting outcrops can bé traced along the hillsides, are to be found farther to the north and east, and in many places there is no white clay above the ore.

The section given below and the description of the clay and ore deposits are taken from Geological Report of Indiana by E. T. Cox, 1874. This quotation will be of interest and importance in the consideration of these ores. The section was made at the clay mine when it was well opened for work.

Section of the Porcelain clay mine:

Soil and subsoil	3 ft.
Coal measure conglomerate	100 ft.
Porcelain clay-replacing limestone	6 ft.
Iron ore	4 ft.
Marly and siliceous shale	4 ft.
Chester sandstone	50 ft.
Archimedes limestone	17 ft.
Marly shale	10 ft.
Chester sandstone	40 ft.
Limestone	6 ft.
Coal	1 to 3 in.
St. Louis limestone, to low water mark in White River	150 ft.

"It will be seen from the above section that the clay lies immediately beneath the Millstone grit or pebbly conglomerate of the coal measures and here occupies the place of a bed of Archimedes limestone which is seen in situ about two miles southeast of the mine. The overlying sandstone is very ferruginous and the base, where exposed to the weather, has decomposd and covered the clay in places to a depth of eight or ten feet with ferruginous sand and pebbles. There is a constant oozing of water from this sandstone which has, no doubt, played an important part in the chemistry of the clay and hematite deposit, for, though similar in its chemical composition to kaolin, this clay differs physically and owes its origin to an entirely distinct set of causes and effects. While the former is derived from the decomposition of the feldspar of feldspathic rocks, such as granite, porphyry, etc., the porcelain clay of Lawrence County has resulted from the decomposition, by chemical waters, of a bed of limestone and the mutual interchange of molecules in the solution, brought about by chemical precipitation and affinity. Where cavities existed in the limestone at the base of the strata, there the chalyebeate waters found the oxygen to change the carbonate into sesquioxide of iron, which finally filled up the cavity. In places, you can trace the passage of the ferruginous water along irregular joints in the clay bed, by the iron-stained path which it has left, to the brown hematite ore which lies in a mass at the bottom. The largest beds of hydrated sesquioxide of iron, both in Europe and America, are found at the base of the Millstone grit and filling up cavities in the cavernous sub-carboniferous limestone."

Recent developments from core drilling and field explorations show that the formations throughout this area are not continuous in uniform thickness, but are much broken—formations found in one place may be entirely missing only a short distance away. The section and description given by Mr. Cox would therefore appear to be much in error, since his section covers a lateral distance of more than two miles; and the origin of the clay and ore deposits would probably be due to other sources than those described.

Mr. Cox gives several analyses of samples of the ore from the clay bank deposits. Since no analyses were made of this or for this report I give below the average analysis taken from the tables by Mr. Cox. The samples taken for these analyses were, undoubtedly, made from selected specimens, as it will be seen that the percentage of metallic iron is much higher than other Indiana ores have shown:

Hygroscopic water	2.32
Combined water	8.50
Insoluble silicates	3.50
Sesquioxide of iron	79.50
Sesquioxide of manganese	2.00
Alumina	2.00
Magnesia carbonate	.426
Lime carbonate	.555
Phosphoric acid	.139
Sulphur	trace

It would be impossible to place an estimate upon the tonnage of merchantable ore in the above named deposits, until further developments have been made, both by excavations and core drilling. But there is in all probability enough ore in these deposits to justify careful and serious investigation.

There is another deposit in the southern part of section 31, and the northern part of section 6, T. 3, N., R. 2 W., with ore similar to that described. This deposit has not been faced, but there are two sides exposed and it probably contains about 37,000 tons. It could be mined with very little difficulty.

North of the river in section 28, Twp. 5 N., Range 2 W., are other deposits of red iron ore. The principal developments made here were a number of years ago by the "Southern Indiana Iron Companies," and deposits are reported varying in thickness from two to four feet, and covering a considerable area. About the time the old furnace ceased operation, the "Shoals Iron Company" were arranging to build a tramway from the mine to White River, thence making use of water transportation to their furnace at Shoals. Analyses of ores from these deposits show the following average composition:

Moisture and combined water	13.00
Insoluble silicates	0.90
Ferric oxide	84.89
Alumina	trace
Manganese	none
Phosphoric acid	.145
Carbonate of lime	1.00
Metallic iron	58.00

Analysis from E. R. Cox, 1873-1874.

GREENE COUNTY.

Greene County, ranking second in the State as to extent and value of its iron ore deposits, is situated as follows in reference to the other counties of the same ore area: On the north it is bounded by Clay and Owen; on the east by Monroe and Lawrence; on the south by Martin, Daviess and Knox counties, and on the west by Sullivan County.

The West Fork of White River, which runs in a southwestern course through the county, dividing it into two almost equal parts, is the principal stream of water. The main tributaries of White River in the county are: Eel River, Lotta's Creek, and Black Creek on the west side; and Richland Creek, Doan's Creek and First Creek on the east side. The southeastern portion of the county is drained by Indian Creek, which empties into the East Fork of White River.

The topography of the part of the county to the east of the river is more rugged than that to the west. Hills rise from 100 feet to 300 feet in height; whereas to the west of the river, with the exception of a ridge running from Eel River, on the north to White River on the south, in Fair Play Township, and passing a short distance to the west of Worthington, the county is generally level, or slightly undulating, a considerable part of it being prairie. This western portion is the great coal producing area of the county, and it is also the chief agricultural district. The valuable resources of the eastern part are more limited. Thin bedded coals are found; the limestones and sandstones are of little economic importance except for local use. There are extensive beds of shale, which may prove of value for the making of cement and other products of shale. Most of the fire clays are rendered worthless by the large percentage of iron which they contain. The chief interest at the present time is in the iron ore deposits of this part of the county.

Developments.—From 1840-1860, the iron ore deposits of the county were worked in a limited way and utilized in two blast furnaces built expressly for smelting these ores. Previous to the autumn of 1869, the time of completion of the Indianapolis & Vincennes Railroad, this county was without a direct practicable means of communication with the distant centers of trade. Consequently up to that time there was no incentive or inducement offered to its citizens to attempt any development of its resources, and for the same reason any works that were put in operation soon came to a standstill. Geologists and prospectors had but little to guide in their investigations beyond the obscure natural outcrops of the strata, and a few imperfect openings of coal and iron mines—the former of which were only worked to supply the limited wants of the immediate neighborhood.

Various attempts have been made to revive an interest in the iron ores of the county, but it was not until 1902 that any real prospecting began. In that year the promoters of the Indianapolis Southern Railroad secured options on several thousand acres and securing the services of an expert mineralogist and geologist, began prospecting for ore. The surface outcrops were investigated and excavations and cuts were made. Many prospect holes were put down with the core-drill, and although the company will give out no information, they claim to have found deposits of rich ore and pyrites apparently of great extent.

While there are considerable deposits of workable iron ore in Greene County, the actual extent of the deposits has at times been greatly exaggerated. In some cases large deposits of red shale have been classed as rich deposits of ore. Anyone familiar with the geology of the region will not expect to find large and continuous deposits. Nevertheless the ores that are found show a fairly high percentage of iron as compared with other Indiana ores, and since some of the outcrops show a thickness of several feet, it is to be hoped that the core drill records will show the existence of other deposits and depth to the outcropping bodies of sufficient importance to justify greater developments at an early date.

The Richland Furnace.—The Richland furnace was built by Andrew Downey and went into blast about 1841. It was located in section 25, T. 7 N., R 4 W., near where Ore Branch empties into Richland Creek.

The furnace stack was about 45 feet high and nine feet across the boshes. Charcoal was used as fuel and about nine tons of pig iron were produced daily. Some of the iron was made into hollow wares, stoves, machinery, etc., but most of the pig iron was marketed at Louisville. The iron had to be hauled to Mitchell and be shipped to Louisville, or else hauled all the way in wagons, the latter being more economical. Although the iron sold for $26 per ton, about $20 was used in the transportation. Hence the cause assigned for the blowing out of the old furnace was the want of a suitable and economical means of getting the pig iron to market. It went out of blast in 1858 or 1859.

The other furnace using the Greene County ores was the old Virginia furnace located in the western edge of Monroe County, and is described under that county. The pig iron from this furnace was also hauled to Louisville. The furnace was poorly constructed and "the only wonder is that it made pig iron at all." There are to be found as relics in the homes of some of the citizens a few bars of the pig iron made from these ores. In appearance it was a very good quality of iron.

The following from the report of Prof. E. T. Cox, 1869, on the iron ores of Greene County, is here copied for comparison of analysis, location of deposits, value and uses of the ore and the origin of the deposits:

"It is at the junction of the conglomerate with the sub-carboniferous limestone that we find the great repository of limonite ores in this county, and, in fact, it forms the common horizon of this variety of iron in most of the western states. The ore lies in pockets of various dimensions, and owes its origin in most cases, to a metamorphism of the surrounding rocks, produced by the permeating of mineral waters that are strongly charged with protoxide of iron.

"On Ore Branch, section 22, town. 7, range 4 west, on Mr. Heaton's land, the base of the conglomerate has been completely changed by this process into a siliceous ore that is rich in iron to the depth of ten or twelve feet. Similar ores are seen on sections 21 and 28 of the same township and range; also in the greatest abundance at Mr. Law's place, on sections 4 and 9, township 7, range 6, where it can not be less than twenty-five or thirty feet in thickness, and great blocks lie scattered over the side of the ridge; it is in abundance also, on section 12, of the same township and range, and in the neighborhood of Owensboro in the southeast part of the county.

"The principal ore used at the Richland blast furnace, near Bloomfield, from Ore Branch of Plummer's Creek, forms a bench on each side of the ravine, and appears to lie between the massive ore and the subcarboniferous limestone which shows itself in the bottom near by. An excavation was made during my stay in the county, to show the thickness of the ore bed, which went to the depth of six feet, at which point the work was stopped without reaching the bottom of the deposit.

"Capt. M. H. Shryer, of Bloomfield, who frequently saw this bed of ore at the time it was being worked for the blast furnace, assures me that the deposit is fully nine feet in thickness. It lies in kidney-shaped masses in a matrix of ferruginous clay, and contains less silica than the massive ore. Characteristic samples of this kidney ore and of the massive siliceous block ore from the Richland furnace ore banks, were analyzed, and the following results were obtained:

'Kidney Ore' (limonite), specific gravity 2.583.

Loss by ignition, water and organic matter, mostly water	11.50
Insoluble silicates	17.00
Sesquioxide of iron, with some protoxide and a trace of manganese	56.00
Alumina	2.00
Carbonate of lime	10.00
Magnesia	3.50
	100.00

Giving 39.20 per cent. of iron.

This ore contains a large amount of lime, and will make an excellent quality of metal, and when roasted the percentage of metal will be increased to 45.42 per cent. Specimens of pig iron made from this ore were found at the furnace and have every appearance of being the best quality of mill iron.

"An analysis of the siliceous 'block ore' gave the following result:

Specific gravity, 2.585-2.694.

Loss by ignition, water	7.50
Insoluble silicates	34.00
Sesquioxide of iron	54.73
Alumina	2.50
Manganese	1.14
Lime	.12
Magnesia	.03
	100.02

Giving 38.31 per cent. of iron.

It was tested for sulphur and phosphorous, but found no trace. Two hundred grains of this siliceous ore, mixed with 50 grains of limestone, were fused in a Hessian crucible, and a button of iron was obtained that weighed 76 grains, equal to 38 per cent.; very nearly the same result as obtained by the humid analysis. The button indicated a very good quality of iron, slightly malleable, and gave a semi-crystalline fracture. The roasted ore would yield fully 40 per cent. of iron in the blast furnace, and on account of the manganese which it contains it is admirably adapted for the manufacture of steel, either by the Bessemer process or in the puddling furnace. Iron made from these ores alone will possess cold-short properties, but by mixing them in the proper proportions, with the red-short specular and magnetic ores from Missouri and Lake Superior, a neutral iron may be made."

The Ore Map.—The ore map accompanying this report shows the area over which the most careful investigation was made. It is not to be understood from the map that the entire area under the ore markings is covered by workable ore deposits. The area includes the chief deposits, which in most cases are noted on the map by special markings, and it also includes the area over which more or less iron ore is scattered, showing the possibility of a deposit near by. The map then is more of a guide to lead to the finding of deposits than a real index of known deposits. The existence of deposits outside of the area mapped may have been found in the core-drilling. A few small deposits are known farther west and south along the river, and the surface in many places shows very good indications of iron and developments may show the presence of some workable deposits. The area mapped covers the chief iron bearing localities.

The Ore Deposits.

In Greene County the known workable deposits of iron ore are to be found chiefly along Ore Branch, Richland Creek, Plummer's Creek and in the vicinity of Cincinnati. Some of these deposits will be described and the analysis appended.

Richland Furnace Ore Bank No. 1.—This deposit lies along the slope of the ridge just south of the old furnace location, on Ore Branch. The deposit is of kidney ore intermixed with much clay and broken sandstone. The total thickness is 20-25 feet, but the ore would aggregate but a few feet. This would now hardly be considered workable, although considerable ore from the bank was used in the Richland furnace. The samples analyzed show an average iron content of 37.65 per cent. This of course does not include any of the impurities imbedded with the ore. In the table of analysis the sample marks are No. 6 and No. 11. The complete analyses are given in the table, and they would be a fair average for most of the kidney ores of the county.

Furnace Bank No. 2.—Located in the southwest 1/4, section 25, township 7 north, range 5 west, about 40 rods southwest of old furnace site. It is 65 feet above drainage. Elevation 565 feet. At the creek level is the outcrop of a thin bed of coal.

This iron ore is very siliceous. It is in a massive deposit but is very porous. The excavation, which did not reach the bottom, shows five feet of ore; it is probably six feet or more in thickness on the outcrop. The first drilling was made near the edge of the deposit, then two more were put down, one about 15 rods to the southwest, the third about the same distance to the southeast, and the fourth was near the first and was drilled at an angle, i. e. the drill was set perpendicular to the slope of the hill. The order of succession of these borings would indicate that the deposit was of small dimensions and as it thinned out back in the ridge it raised with the slope of the ridge. The deposit probably does not have a backward extent of more than 50 feet of workable ore. This deposit would yield about 8,000 tons of ore. It shows an iron content of 40.36 per cent. In the table of analysis the sample marks are No. 7 and No. 12.

No. 3, Cincinnati Ore.—In the vicinity of the little town of Cincinnati, in the eastern part of the county, the ground in many places is profusely covered over with fragments of ore, even on the tops and slopes of the highest ridges. About two and a half miles northeast of the town is a U. S. G. S. B. M., marked 853 feet. The mark is on a steel plate imbedded in a large piece of sandstone at the top of the ridge. Ore is found at this level, but there are no workable deposits.

On the east side of Cincinnati the ore outcrops in the shale along the sides of the ridge, and these outcrops follow around the ridge to the south of the town and more or less ore is found fringing the hills to the west and also to the north. The elevation of the town is a little lower than the surrounding hills. The elevation marked on a telephone pole by the store at the turn of the road is 825 feet. Another U. S. B. M. at an elevation of 880 feet is marked on a steel post about half a mile south of Cincinnati at a fork in the roads.

On the Starling Hudson farm in the southwest 1/4 of section 28, south of Cincinnati, is to be found considerable ore intermixed with the shale. This deposit of concretionary ore covers about forty acres. It is to be found in a thickness of more than ten feet in some places, but in no compactness that would be considered a workable ore. It is, however, very interesting geologically. At an elevation of 775 feet a thin bed of very fossiliferous limestone outcrops. Above this the ore is a constituent of the shales and sandstone; below the ledge of limestone the ore is concretionary and contains fossils or fragments of fossils, which have been replaced from the limestone fossils.

Deposit No. 4.—On Anthony Williams' land, northeast 1/4 southeast 1/4, section 21, township 7 north, range 4 west, is a deposit with an average thickness of five feet and has an exposed frontage of 250 feet. This is a brown, highly siliceous ore, which owes its origin to the filling of the sandstone with iron from mineral charged waters. Three drill holes were put down on the low ridge above the deposit.

U. S. B. M., 853 feet, two and a half miles northeast of Cincinnati. Marking the top of the highest ridges. Weathered fragments of ore are found at this level.

Fossiliferous limestone outcrop and concretionary ore described under deposit No. 3.

Concretionary ore intermixed with shale.

Another view of same deposit. Starling Hudson Farm, southwest of Cincinnati.

Across the road is another deposit of red hematite, which is in compact nodular masses imbedded in the clay. The excavation shows over five feet of this ore.

On the Miller farm, southwest of Williams's, ore similar to the above is also found.

In the table of analyses sample No. 1 was taken from the siliceous ore, and sample No. 3 was from the red hematite deposit, but does not include the clay, and sample marked No. 10 is from another outcrop of the siliceous deposit on the southeastern point of the hill about forty rods from the first deposit.

Deposit No. 5.—Southwest 1/4 of section 22, just east of the above deposits, is another opening from which ore was taken in the early days of the iron industry. It is a contination of the deposit of red ore, but probably contains less clay. The hills do not rise to great height above these ores, and both deposits would require on the average about fifteen feet of stripping. Samples Nos. 4 and 9 show the iron content.

Deposit No. 6.—On the John Bryan land, west side of section 9, township 7 north, range 4 west, is a deposit of red siliceous ore exposed on the south side of the ridge facing Richland Creek.

The deposit is about 40 feet above drainage and at an elevation of 600 feet. The maximum thickness is about 15 feet, and it has a frontage of more than 500 feet, but the backward extent is small, as the ridge is narrow and but little trace of ore is to be found on the opposite side. The tonnage would probably amount to about 25,000 tons. A vertical section of the ridge would be as follows:

Sandstone and clay with glacial material	15 ft.
Sandstone	25 ft.
Iron ore	15 ft.
Sandstone	35 ft.
Limestone down to creek	10 ft.

The analyses show an iron content of 42.01 per cent. The sample mark is No. 5.

Deposit No. 7.—Adius B. Hayes's land, section 16, township 7 north, range 4 west. Along the sides of the ravines are large accumulations of kidney ore, some pieces weighing hundreds of pounds. These shales are full of these ores. In the stream below the shales is a ledge of siliceous ore due to the filling of the sandstone with iron. Only a short distance back in the ledge the iron content is to be found. These deposits might be worked out along

Plate XXV.

Deposit No. 6 on the John Bryan Land.

Ore outcrops in abandoned roadway southeast of Bloomfield. John W. Craven land; 40 rods from B. & B. branch of Monon Railroad.

with the larger deposits. Sample No. 8, selected specimens from a number of concretions from this deposit.

Deposit No. 8.—In the southeast ¼ of section 4 and the northeast ¼ of section 9, south of Solsberry, are found large blocks of siliceous iron ore, also some outcropping ledges. This ore has been greatly overestimated. It was recently estimated by a prospector as containing 500,000 tons of workable ore. The ore is due to the filling and replacing of the sandstone and it is doubtful if this line of deposit will prove to be of any practical value.

Analyses.—The samples taken for analyses in Greene County were necessarily of higher iron content than the deposits would run in mining. Many of the excavations were not made through the entire thickness of the ore, and in other places the samples were taken from the leached outcropping faces. The analyses are given in the table and are numbered to correspond to the numbers given under the deposits.

ANALYSIS—GREENE COUNTY—IRON ORES.

Material Dried at 135° C.

Mark.	SiO_2	Fe.	Al_2O_3	CaO	P	S	Mn.
1	25.74	43.48	3.94	0.20	.198	.07	.102
2		51.51					
3	10.14	48.73	10.59	1.30	.702	.04	0.519
4	8.15	51.35	9.18	.60	.759	.80	0.279
5	16.87	42.01	5.68	.25	.455	.07	0.079
6	4.60	36.61	6.10	2.80	.479	.27	0.615
7		42.52					
8		49.81					
9		54.00					
10		40.95					
11	17.00	39.20	2.00				
12		38.21	2.50	.12			

MARTIN COUNTY.

By J. W. Beede and C. W. Shannon.

The work of exploiting the Martin County iron ore field was accomplished during the fall of 1905, and the winter and spring of 1906, for the Chicago, Indianapolis & Evansville Railroad Company, who desired to know the resources of the county and to determine as to the feasibility and advisability of opening up ore mines in that section. Much work was done in locating the outcrops of ore deposits, cutting of vertical faces and driving entries into the deposits, and in diamond core drilling to determine the extent of the ore in the hills.

Plate XXVI.

Deposit No. 7. Accumulation of kidney ore along sides of ravine.

Deposit No. 7. Ledge of replaced sandstone with kidney ore overlying.

This company deserves great credit for generously placing all the information, gained at an expense of thousands of dollars, at our disposal without compensation or reservation. We desire to express our gratitude to them for this generous act.

Location and Geology.—Martin County comprises an oblong strip of territory in the southwestern part of the State. Its maximum length from north to south is 28 miles and the greatest width is 13 miles. It is bounded on the north by Greene, on the east by Lawrence and Orange, on the south by Dubois, and on the west by Daviess County.

The surface rocks of the county are of three separate geological epochs, viz.: the Coal Measures and Mansfield sandstone of the Carboniferous and the Huron limestones and sandstones of the Lower Carboniferous periods. The Mansfield sandstone covers at least two-thirds of the county, the Coal Measures proper being found only in the southeastern corner and in irregular isolated patches on the tops of the higher hills and ridges of the central portion. The Huron group is chiefly in the eastern third; it is, however, exposed along the streams north of the center and along White River to a point west of Shoals.

The scenery is rugged and picturesque and cannot be excelled in the State. The surface is a thoroughly dissected plateau. The hills rise from one hundred and fifty to three hundred feet or more in height, and in many cases have almost precipitous sides.

The East Fork of White River meanders in a southwestern course through the county and with its main tributaries, Boggs and Indian Creeks, on the north, and Beaver Creek and Lost River on the south, constitutes the drainage system of the county, with the exception of the extreme northern end, which is drained by Furse Creek into the West Fork of White River. The East Fork and its tributaries have been the chief agents in producing the striking topographical features. The work of the streams in this area was never arrested by the invasion of an ice sheet, therefore the county has all the characteristic ruggedness of unglaciated regions. South and east of the river the county is more rugged than that portion to the north of the river, since the Mansfield sandstone is more massive and probably thicker.

The mineral resources of the county consist of coal, iron, limestone and sandstone and shale. The coal is thin-bedded, but is of a fairly good grade, but on account of the difficulty of mining it is of little importance except for local use. The limestone and sandstone are not of sufficient value as building stone to expect any extensive use to be made of them for that purpose. There are extensive beds of shale, but they have not been developed.

The Iron Ores.—The iron ore area of Martin County ranks first in the State. In the shales of the coal measures and near the base of the sandstone overlying the Huron limestone are found considrable deposits of iron ore. The occurrence of iron in the coal measures is in many respects like that of coal. Like coal it is found in seams varying in thickness from the fraction of an inch to forty or fifty feet or even more. Like coal the thicker seams are apt to be less pure from the presence of clay, etc. The veins of greatest richness are seldom more than three or four feet in thickness. The ore deposits are also similar to coal in that they are often repeated in the same section and that they are usually underlain by more or less clay or shale.

All the classes of ore mentioned in the introduction on the Indiana ore fields are found in this county in a greater or less degree. The first classes in the order of their abundance are carbonates, hematites, limestone and sandstone ore. The kidney or concretionary ore is very plentiful, but it belongs chiefly to the carbonate

Plate XXVII.

Looking north from the Pinnacle, Shoals, Ind. Showing the White River Valley and the iron-bearing hills in the background.

class, the inner part being carbonate, with the thin outer coating of iron oxide.

Prospecting.—As stated above the greater part of the developments that have been made in the Martin County ore field were recently made for the Chicago, Indianapolis & Evansville Railroad.

The ore map accompanying this report shows the area over which the most careful investigation was made. It is not to be understood from the map that the entire area under the ore markings is covered by workable ore deposits. The area includes the chief deposits which in most cases are noted on the map by special markings, and it also includes the area over which more or less iron ore is scattered, showing the possibility of a deposit nearby. The map then is more of a guide to lead to the finding of deposits than a real index of known deposits. The existence of deposits outside of the area mapped is known, i. e., deposits of considerable importance to the south of Lost River, and also to the west and north of White River. In this latter locality, however, no extensive deposits are known, but the surface in many places shows very good indications of iron and developments may show the presence of some workable deposits. The area mapped is the heart of the ore field, but the time at our disposal did not permit the mapping of the other localities. The iron scattered along the streams and hillsides may be traced almost continuously from the outcrop of one deposit to that of another, and while this is of great assistance in finding workable lenses it cannot be relied upon entirely, since in some cases where iron is profusely scattered over the ground, even at the level of the line of deposits, no deposits are found. The origin of the ore and the manner of its deposition have a great deal to do with the uniformity and continuity of the deposits.

Core Drilling.—Several drill holes were put down to depths varying from 50 feet to more than 200 feet. These holes were drilled back on the ridges at various distances from the ore outcrops, in some cases penetrating the ore deposits and in other cases showing the absence of ore. From the records of the drill holes and the information gained by facing the outcrops and driving entries we were enabled to approximately estimate the ore tonnage of the several deposits. Samples for analysis were taken from the cores and then the remainder of the core in the part of the hole where the mineral occurred was securely boxed in core boxes made to carry from one to four sections from four to ten feet in length. In each box was placed a description as shown below, so that if samples for analysis were again taken they could be properly located, or in order that persons interested might compare the "log," or diagram, of the boring with the core and determine the character of the strata and the regularity of the formations as they occurred in the various localities. The logs of the borings also accompany this report, and from them it will be seen that the formations are very irregular and broken and that which was found in one hole might be missing altogether in a boring only a little distance away. On this account it was impossible to correlate the logs of the borings over any large area.

Blank to be filled and placed in core drill boxes with each of the sections of ore or other core to be saved:

SAMPLE OF CORES.

Taken at depth of ....feet on ....1906.
From land of ....
In ....
Of Section ...., Town ...., Range..........
County of ....State of Indiana.
Prospect Hole ...., drilled by ....
Shipped ...., 1906.
...., Supt.

Elevations.—The elevations of the openings and prospect holes were determined by a corps of engineers, employed especially to do that work. As a starting point in the determination of these elevations the U. S. Coast and Geodetic Survey bench mark at Shoals was the base. From the bench marks of these engineers the minor elevations in various parts of the field were made by barometer readings.

When the elevation of the base or top of an outcrop was known and also the surface elevation at the point where drillings were made the dip of the strata could readily be estimated and the probable depth to which the boring must be made could also be ascertained.

Many of these elevations and bench marks are so marked that they may may be used in the future for years. Hence the list of the more important points is given below. These points are located in such a way that they can be easily found and will be of value to persons doing geological research or to mineral investigators or persons wishing to determine the elevation of surrounding points for other purposes.

LIST OF ELEVATIONS AND BENCH MARKS IN MARTIN COUNTY, INDIANA.

Government B. M. on window sill of court house, Shoals, Ind., 523 feet.

Southeast corner river bridge. Ele. 482.71.

Iron step corner of old News office. Ele. 504.40.

In Halbert township, north and east of Shoals: Shirley Ore Opening. Ele. 623.51, 107 feet southwest of peg on gum tree; B. M. 624.81, nail in root of same tree.

Top of ridge on east Clifton line. Ele. 732.05. Cherry tree 15 feet southeast of peg; B. M. 731.61, nail in root of same tree.

Iron bridge at Melvins-Shoals-Willow Valley Pike; B. M. 482.13, southwest corner bridge.

No. 15. Ele. 728.58, on oak tree 35 feet northeast of hole; B. M. 729.05, nail in root of same tree.

Ritter Spring. Ele. 673.46, cross on stone, ele. marked on fence.

Base of Mundey Opening No. 15. Ele. 650.56, marked on stone.

First bench from top of Mundey Hill. Ele. 686.45, marked on stump.

Top of Mundey Hill. Ele. 720.87, marked on stump 40 feet north; B. M. 718.04, nail in root of same stump.

Top of Thompson Hill. Ele. 721.99, marked on hickory tree 12 feet south; B. M. 721.47, nail in root of same tree.

Thompson Opening No. 14. Ele. 674.78, marked on Poplar tree 50 feet southwest opening; B. M. 681.56, nail in root of same tree.

Radcliffe Schoolhouse. Ele. 683.32, marked on southeast corner schoolhouse; B. M. 682.04, marked on stone southeast corner schoolhouse.

McKnight's barn. Ele. 731.21, marked on barn.

Tow's mail box. Ele. 693.08, marked on post.

In Columbia Township, south of Shoals:

Boring No. 1A. Ele. 773.02, marked on Persimmon tree 110 feet east; B. M. 774.05, nail in root of same tree.

Boring No. 1. Ele. 674.62, marked on stump 75 feet southwest; B. M. 673.41, nail in root of same stump.

Boring No. 2. Ele. 712.71, marked on oak tree 50 feet south of hole; B. M. 708.30, nail in root of same tree.

Boring No. 3. Ele. 723.38, marked on ash tree 75 feet northeast; B. M. 722.02, nail in root of same tree.

Boring No. 4. Ele. 612.09, marked on hickory tree 50 feet west; B. M. 587.94, oak tree 200 feet south of hole.

Boring No. 5. Ele. 592.68, marked on oak tree 50 feet southeast; B. M. 587.94, nail in root of same tree.

Base Horner Opening No. 6. Ele. 547.25, marked on post at opening; B. M. 587.94, oak tree 150 feet west of opening.

Boring No. 8. Ele. 662.74, marked on walnut tree 30 feet west.

Gammon Point, above opening No. 11. Ele. 682.34, marked on old stump 25 feet north; B. M. 682.89, nail in root of same stump.

Boring No. 6. Ele. 662.24, marked on old snag 170 feet northeast of point; B. M. 659.94, nail in root of same snag.

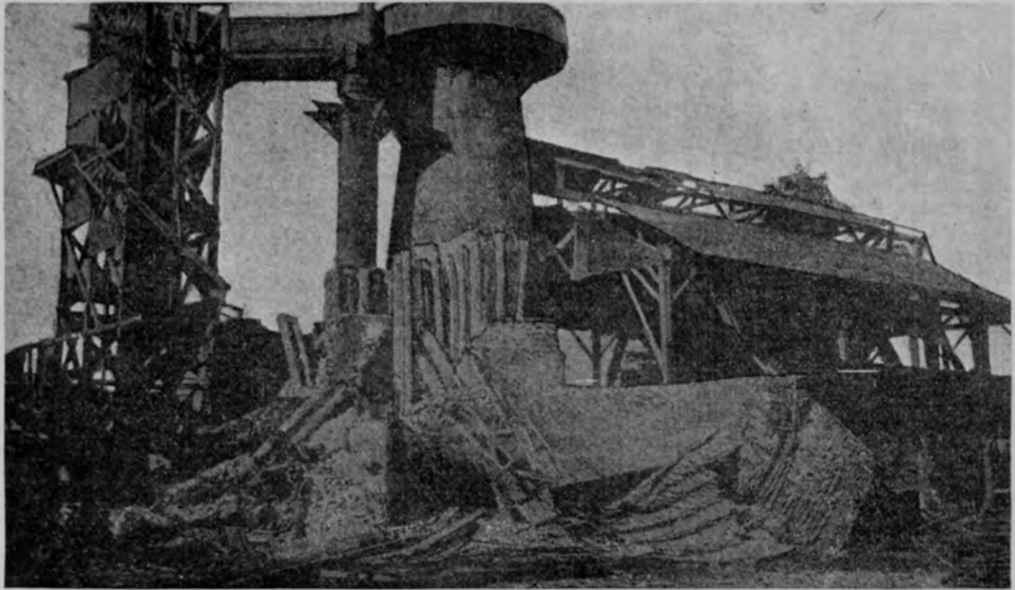
Albright Point. Ele. 664.97, marked on stump.

Boring No. 7. Ele. 600.90, marked on stump 12 feet west; B. M. 601.66, nail in root of same stump.

Martin County Blast Furnace.—About 1870 people became interested in the iron ores of the county and they employed Robert Dale Owen, geologist, to investigate and report on the iron ore deposits. This led to the organization of an ore mining and smelting company. It met with various difficulties, and during its existence was operated under a half dozen names, but during the most interesting and successful days it was known as the "Nelson Furnace Company." When working at its best, about 1873, several hundred men were employed, many of them among the hills mining the ore and others making coke. The furnace was located a little more than half a mile east of Shoals, and the thriving little town that sprang up around the furnace was incorporated under the name of Ironton, but when the furnace ceased operation the town rapidly declined and all that remains today, as can be seen from the B. & O. S. W. Railroad, are heaps of cinder about the location of the old furnace and on the opposite side houses empty and deserted. The product of this furnace was called "the American Scotch Pig," and with the "Hanging Rock" made at Ironton, Ohio, was regarded as the nearest American approach to the popular "Scotch Iron."

The furnace was operated under discouraging conditions. The railroad, then under the management of the old O. & M., was oppressive in the excessive freight rates charged. The result of the railroad's policy was failure of the iron company. The company found it necessary to reduce expenses and in so doing a $2,500 superintendent was discharged and replaced with a $50-a-month-man, who was inexperienced, and during the first week after he took charge he let the furnace chill and there was an accumulation of gases which caused an explosion which entirely destroyed the plant.

Plate XXVIII.



Martin County Blast Furnace after it ceased operation.

Some Missouri Iron Mountain ore was mixed with the siliceous native ore and by this process a neutral iron of excellent quality was produced. Not only was the iron put on the market in former years, but in recent years J. B. Loyd, secretary of the old iron company, shipped several carloads of the ore left lying about the old furnace, to the Globe Iron Company at Jackson, Ohio. Mr. Loyd has a letter which Mr. Crandall, president of the Ohio company, wrote to him concerning the Martin County ore. "The ore worked very satisfactorily. It melted easily and made the best class of high silicon iron and we are very much pleased with it all the way through. The ore seemed to vary in richness, but on the whole the yield was very fair." This letter indicates the desirability of the ore from a commercial point of view.

When the furnace ceased operation things were just in preparation for extensive mining in Martin and adjoining counties. New deposits had been opened, and more men engaged to take out the ore, but with the failure all the work declined and the interest was not again revived until within the last few years, during which time considerable money has been expended in investigation and development.

The following from the report of Prof. E. T. Cox, on the iron ores of Martin County, is here copied for comparison of analysis, location of deposits, value and uses of the ore, and the origin of deposits.

"Near the junction of the millstone grit, with the lower carboniferous limestone, there is more or less iron ore throughout the county. Generally, it is a siliceous hydrated oxide, which lies in pockets, or local beds, often of great extent; but there are some localities where an earthy carbonate of iron is found in seams that vary from a few inches to six feet in thickness, though, usually, where attaining the greatest thickness, it is mixed with more or less silex. No effort has been made to properly open either the iron ore beds, or seams of coal in Martin County; consequently, I found it difficult to pronounce, with any degree of certainty, on the true commercial value of the minerals, seen under so great a disadvantage. To pick into a seam of ore or coal, through the superincumbent earth and rock with a common geological hammer, seldom enables one to see the stratum, in so favorable a light, as where a clean vertical face is shown, by proper excavation.

"On Mr. Stevens' land, section 1, township 3, range 3, near the top of a hill, by the base of which runs the Ohio and Mississippi Railroad, there is a deposit of iron ore fully thirty feet thick and

Plate XXIX

Ruins of the Martin County Blast Furnace as it appears today.

Siliceous Iron-Ore outcrop along roadside in Sampson's Hollow, south of Shoals. This material has been used for road metal.

half an acre in area, which contains a large per cent. of metal, but is also quite siliceous, it has a reddish brown color and contains bands of a gray steel color. The ore lies in regular stratified blocks, as though the conglomerate sandstone had been metamorphosed, or changed by displacement, into an ore of iron.

"Chalybeate waters may have been chiefly instrumental in bringing about the conversion of the sandstone to ore, as springs of this water are quite common at the base of the millstone grit.

"Specimens of this ore were taken for analysis, and after crushing equal portions from three varieties, and then reducing them to an impalpable powder, a weighed portion of the mixed ores gave:

No. 1.

Insoluble silicates	27.00
Ferric oxide	66.40
Alumina	1.10
Phosphoric acid	trace
Sulphur	trace
Lime	trace

The yield of metal is equal to 44.48 per cent.

Similar deposits of siliceous ore are seen on sections 15 and 16, township 3, range 3.

Two varieties, which represent the larger portion of the ore bed, were taken for analysis, and gave the following:

No. 2, limonite; color, reddish brown; containing small cavities filled with decomposed ore and clay; running through the mass are streaks of steel gray ore, with glistening specks of quartz:

No. 2.

Moisture dried at 212° F.	1.24
Ignited to bright red heat, lost	6.56
Silica and silicic acid	28.60
Ferric oxide	54.45
Alumina	7.20
Phosphoric acid	trace
Sulphur	trace
Lime, magnesia and loss	1.95
	100.00

No. 3.

Color: Dark brown, mottled with pink.

Moisture. dried at 212° F.	1.00
Ignited to bright red heat, lost	8.00
Insoluble silicates	36.80
Ferric oxide	49.95
Alumina	2.12

The ferric oxide equals 34.96 per cent. of metal. The roasted ore will give about 38.41 per cent. of metal.

No. 4 contains too much silica to be worked with advantage in the blast furnace.

Nos. 1, 2 and 3, though containing a large amount of silica, are quite rich in iron and alumina and it is my opinion that they will work very well in the blast furnace, especially when mixed with a small proportion of hematite ore. The metal will be hard and well adapted for rails.

On sections 14 and 32, resting on the shale, forming the roof of the coal in Munson's Ridge, is a bed of siliceous iron ore two feet thick.

No. 5.

Moisture, dried at 212° F	4.00
Ignited to bright red heat, lost	9.11
Insoluble silica and silicic acid	32.35
Ferric oxide	53.00
Lime, magnesia, and loss	1.54
	100.00

The ferric oxide equals 37.10 per cent. of metal.

If roasted, this ore will yield over 41 per cent. of iron, but contains too much silica to be worked alone.

There is a four-inch layer of bituminous ironstone that is very rich in iron, as may be seen by the partial analysis here given:

No. 6.

Moisture, dried at 212° F	1.00
Ignited to bright red heat, lost	28.00
Insoluble silicates	7.00
Ferric oxide	60.50
Sulphur	trace
Phosphorus	trace

The ferric oxide is equal to 42.35 per cent. of iron.

If roasted, this ore will yield about 60 per cent. of metal. A portion of the 28.00 per cent. expelled by ignition is bitumen. In some respects it resembles the celebrated black-band ore-Mushetstone of Airdrie, Scotland.

In the bluish gray shales overlying the top coal in Sampson's Hill, there are a number of irregular bands of clay iron ore; a similar ore is seen in the shales which overlie the lower coal seam. At many places where the coal has been opened, and where exposed in washes, in the hillsides, a considerable quantity was also seen in the road leading to Baker's, south of Sampson's hill, and at Willow Valley, on the Ohio and Mississippi Railroad. The subjoined analysis shows it to be a good ore:

No. 7.

Moisture, dried at 212° F	1.15
Ignited to bright red heat, lost	24.05
Insoluble silicates	8.00
Ferric oxide, with some alumina	60.00
Phosphoric acid, undetermined.	
Sulphur, undetermined.	
Lime, magnesia and loss	6.80
	100.00

The ferric oxide is equal to 42 per cent. of metal, and this ore, after roasting, will yield 56 per cent.

On sections 9 and 10, township 4, range 3, lying about thirty feet above the lower carboniferous limestone, there is a bed of ironstone, which is, where I saw it exposed, four feet thick; samples from four parts of the bed were taken for analysis, and the result is here given:

No. 8. Lower stratum: greenish gray ore. About half a pound of the ore was crushed in an iron mortar, and the small quantity required for analysis was taken therefrom and reduced to an impalable powder in an agate mortar, by which means a good average was secured:

Moisture, dried at 212° F	1.40
Ignited to bright red heat, lost	22.80
Insoluble silicates	13.00
Ferric oxide (equal to 38.92 per cent. metal)	55.60
Carbonate of lime and magnesia	5.60
Sulphur	.90
Phosphoric acid, undetermined.	
	99.30

No. 9.—Lower portion of the middle member.

Moisture, dried at 212° F	3.00
Ignited to bright red, lost	10.50
Insoluble silicates	23.00
Ferric oxide (equal to 41.75 per cent. of metal)	59.65
Alumina	2.70
Phosphoric acid	trace
Lime, magnesia and loss	1.15

No. 10.—Upper portion of middle part.

Moisture, dried at 212° F.	3.00
Ignited to bright red heat, lost	8.00
Insoluble silicates	37.75
Ferric oxide (equal 33.63 per cent. metal)	48.05
Alumina	1.15
Phosphoric acid	trace
Lime, magnesia, and loss	2.05
	100.00

No. 11.—Upper stratum, four inches thick at the crop.

Moisture, dried at 212° F.	.30
Ignited to bright red heat, lost	28.50
Insoluble silicates	8.50
Ferric oxide (equal to 37.52 per cent. metal)	53.60
Phosphoric acid	trace
Sulphuric acid	trace
Lime, magnesia and loss	9.10
	100.00

"From the above analyses the average yield of iron from the ores of this bed will be about 37.95 per cent. and the average per cent. if silicates about 20.56. Though the silica is pretty large, still I am of the opinion that the ore may be worked in the blast furnace, alone, but mixed with the hematite ores of Missouri, will undoubtedly yield a metal of excellent quality.

"As already stated, the seams and deposits of iron ore are large and numerous, though, for the most part, siliceous; there are some stratified ores comparatively free from silica, and I am of the opinion that when thorough search has been made, by digging into the shales lying between the millstone grit and lower carboniferous limestone, that the six-foot seam, previously referred to as occurring on section 9, township 3, range 3, will be found, in many places, where it may prove to be of still better quality.

The average yield of iron, from the ores analyzed, is nearly 38 per cent., which is sufficient to be remunerative, as they can be had convenient to coal suited for smelting them, and may be mined at little expense. At all events, should it not be deemed advisable to smelt these ores by themselves; rich hematite ores that will make an admirable mixture may readily be had from Missouri, over the Ohio and Mississippi Railroad. Indeed, Shoals would prove an admirable location for a blast furnace, even though all the ore had to come from Missouri. It is situated on the East Fork of White River, is now the county seat and quite a flourishing manufacturing town, containing mills for cutting staves and headings, spoke, hub, and axe-handle factories, saw mills, planing mills and potteries."

The Iron Ore Deposits.

The iron ore deposits of Martin County lie in two main districts, one south of Shoals, the other to the northeast. It has been the general impression that the region to the south is the chief ore field of the county. Such would appear to be true in traveling over the county, since there are numerous outcrops and the fragments of the ore, or "floaters," are distributed over a wide area. The outcrops in the northeastern field are not so numerous, but are on the average much thicker and have greater persistency through the hills.

The chief deposits of each field will be taken up and briefly described. The order of numbering is that in which the samples for analysis were taken from the deposits at the first, and these numbers will be used throughout in referring to the deposits and the table of analysis.

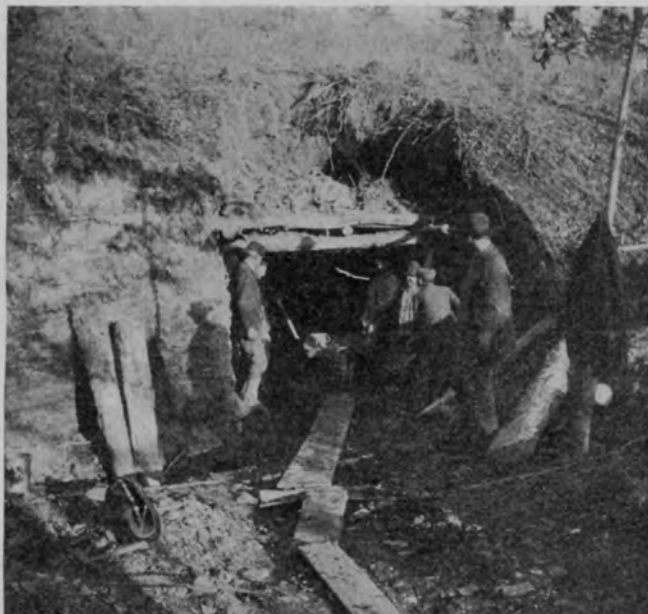
(a) The Southern Field.

The area south of Shoals contains many small ore bodies, located largely in the vicinity of "Coal Hollow." There are two lines of deposits, with an average difference in elevation of about 40 feet. The deposits are "local pockets," and are not continuous in workable thickness. The deposits will be spoken of as the upper and lower ore.

Opening No. 4.—Located on the J. A. Cook land, west side of S. W. ¼, S. E. ¼, section 6, township 2 N., range 3 W. Elevation 642 feet, about 90 feet above drainage. This deposit is on the point of a hill, with three sides exposed. It is a high grade carbonate ore oxidized on the surface. There is a thin covering of clay over this, however, and clay seems occasionally in it. This ore is from 4 to 6 feet thick and covers about 60,000 square feet and contains 15,000 tons. This will probably be best secured by scramming. It can be put on the cars at a low cost. Three samples from near the surface gave the following average analysis.

Water	10.50
Silicon	16.90
Metallic iron	39.63
Aluminum	4.70
Ferric oxide	56.62
Lime (CaO)	.85
Phosphorus	.65
Manganese	1.02

Plate XXX.

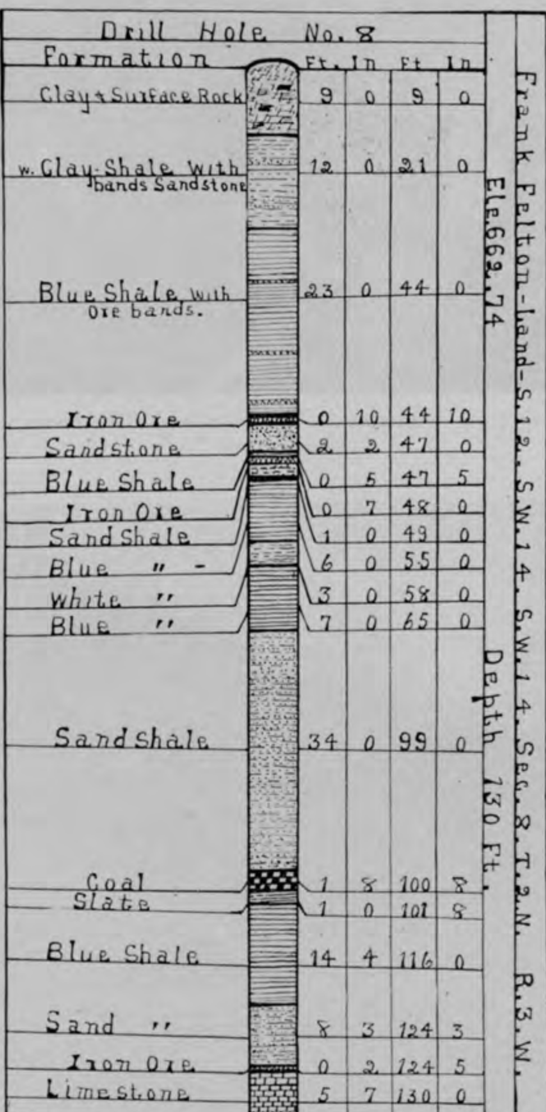


Opening No. 5, located on F. M. Felton land. Maximum thickness, six feet.

Opening No. 6. Opening ore outcrop in order to cut a vertical face.

About 50 feet below the above deposit is a thin deposit of the lower ore, and along the ridge for some distance to the east a highly siliceous ore two to three feet thick outcrops in several places.

Opening No. 5.—Located on F. M. Felton's land, center S. W. 1/4, S. W. 1/4, Sec. 8, T. 2, R. 3 W. Elevation 642 feet, 10 feet above drainage. The ore is brown on face, but is blue carbonate



within, some of it containing so much bituminous matter that it is almost black.

This ore bed has a frontage of 300 feet and a maximum thickness of 6 feet and in prospect hole No. 8, 320 feet southeast of the opening, the ore was shown to be 10 inches in thickness. Considering the backward extension at 200 feet gives this bed an average thickness of 4 feet of available ore, with a tonnage of 20,000 tons. The average analysis is as follows:

Water	9.20
Silicon	19.40
Metallic iron	36.95
Aluminum	5.84
Ferric oxide	51.51
Lime	3.46
Phosphorus	.52
Sulphur	.240
Manganese	.267

This ore may be easily mined and for loading in the cars would require a slight hoist. A workable vein of coal lies 15 feet above this ore.

Opening No. 6.—This deposit is located on the Sarah Horner land, southwest corner N. W. ¼, S. W. ¼, Sec. 17, T. 2 N., R. 3 W. The deposit is of the lower ore and lies about 40 feet above drainage. The elevation at the base of the ore is 547.25 feet. The main body of the ore lies directly on the limestone and has replaced and filled the limestone to a depth of about two feet. The ore has a maximum thickness of 12 feet, with an average workable thickness of six feet or more. The frontage is at least 500 feet and it extends backward into the hill 225 feet to prospect hole No. 5, where the drill penetrated two feet of it, mostly of the limestone variety. This hole, at the surface, has an elevation of 592.68 feet. More or less broken, siliceous and shaly ore was passed through, aggregating a thickness of from four to five feet, but on account of wide parting and the low grade of the ore it is not of workable value.

Along the outcrop of the lower deposit a vertical face was cut more than 75 feet in length and backward to the maximum thickness, and then from this vertical face an entry was driven for about 15 feet, showing the ore to be of the same general character throughout. It is of a reddish brown color and becomes somewhat mottled when exposed to the weather. The deposit would yield at least 56,000 tons of ore. Several analyses were made of this ore

Plate XXXI.

Deposit No. 6. Showing dip of deposit and entry driven backward from face.

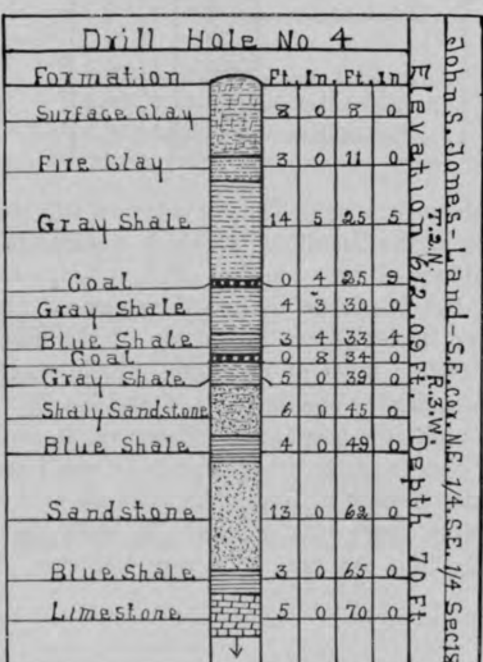
Deposit No. 6. Maximum thickness of 12 feet on vertical face.

and are given in the table. The average analysis of which is as follows:

Water	9.20
Silicon	20.85
Metallic iron	39.74
Aluminum	7.67
Ferric oxide	56.75
Lime (CaO)	6.81
Phosphorus (P)	.751
Sulphur	.081
Manganese	.880

The cost of removing this ore would be very low. At the maximum thickness there would be very little stripping. And farther back it has a sandstone roof from under which it could be mined. There is ample room for trackage below, and the ore can be dumped directly into cars from above.

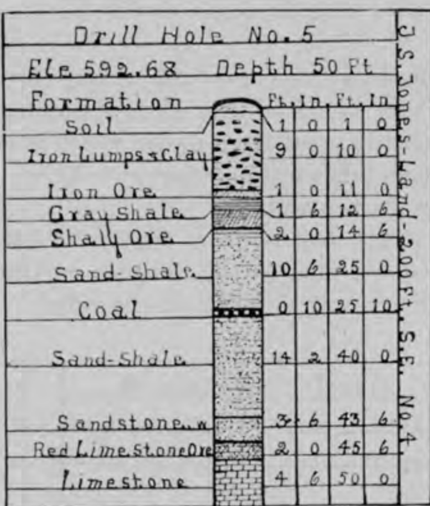
Drill hole No. 4, 200 feet north of No. 5, did not strike the ore, as was also the case in hole No. 2, 100 rods northwest of opening No. 6, and at the greatest elevation of the ridge.



Opening No. 7.—H. A. Stephens' land, N. E. ¼, N. E. ¼, N. E. ¼, Sec. 17, T. 2 N., R. 3 W. This is a small deposit in the upper ore, elevation 640.62 feet. The thickness at the face is four feet and has a frontage of 250 feet, but does not extend but a short distance into the hill. Drill hole No. 1, 225 feet to the northeast, shows only three or four thin bands of the ore as parting in two feet of shale.

The sample analyzed shows an iron content of 38.82.

Opening No. 8.—On the Sarah Horner land, northeast corner S. W. ¼, S. W. ¼, Sec. 17, T. 2, R. 3 W. Elevation 545 feet.



About 40 feet above drainage. The ore is brown and massive. There is a bed of ore in the limestone which it is difficult to estimate. There is an outcrop of over ten feet of it and it seems to have a good frontage, but has little backward extension. Boring No. 7 showed only two inches of ore in the top of the limestone. It is located in the 24-foot layer of limestone, which would be used as flux and which underlies openings No. 6 and No. 9. It is high in iron, but also high in phosphorus. However, it could be mixed with the sandy ores from the other deposit, in small quantities, and the entire amount present utilized. An estimate of 8,000 or 10,000 tons will probably cover this deposit. It, with the flux, can be dumped directly into the cars at a very low cost. The average analysis is:

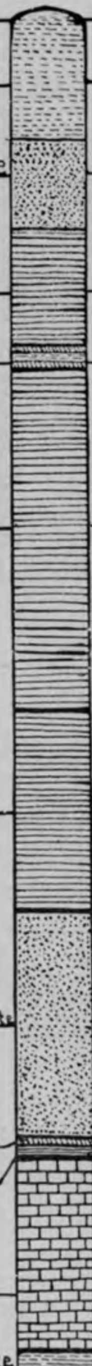
J.S. Jones-Land-NW.Cor. N.E.1/4. S.E.1/4. Sec.18. T.2.N. R.3.W.-

Drill Hole No. 2				
Ele. 712.71	Depth 210 Ft			
Formation	Ft	In	Ft	In
Surface Clay	3	0	3	0
Sandstone	18	0	21	0
Blue Shale	12	0	33	0
Coal	0	8	33	8
Clay Shale	3	4	37	0
Blue "	11	0	48	0
Sandstone	9	0	57	0
Blue Shale	8	0	65	0
Sandstone	5	0	70	
Blue Shale	22	0	92	0
Sandstone	1	0	93	

No. 2 - - - - Continued- - - - - -

Blue Shale	44	6	137	6
Shaly Coal	1	6	139	0
Fire Clay	6	0	145	0
Soft Shale	4	0	149	0
Ore with Shale	2	0	151	0
Blue "	1	7	152	7
Coal	0	8	153	3
Sand-Shale	26	9	180	0
Sandstone	21	0	201	0
Sand Shale	9	0	210	0

Drill Hole No: 1



Formation.	Ft.	In.	Ft.	In.
Surface Clay	13	0	13	0
Gray-Sandstone	8	0	21	0
Black Shale	13	0	34	0
Ore & Shale	2	0	36	0
Black Shale with-Ore-lumps	39	0	75	0
Black Shale	22	0	97	0
Sandstone, White	23	6	120	6
Hard-band-Ore	0	4	120	10
Black Shale	0	8	121	6
Limestone	24	6	146	0
Green Lime-Shale	5	0	151	0

C.W. Shannon.

Elevation 674.62 Ft.

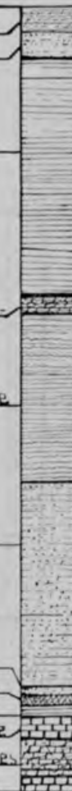
Depth 151 Ft.

H.A. Stephen - Farm - N.E. Cor. N.E. 1/4 N.E. 1/4. Sec. 18. T.2N. R.3W.

Drill Hole No. 3.					
Ele 723.38	Depth 200				
Formation		Ft.	In	Ft	In
Clay & Surface Rock		11	0	11	0
Soft Shale - Gray		5	0	16	0
Sand-Shale - with Ore bands		19	0	35	0
Blue Shale		16	0	51	0
Gray "		3	0	54	0
Blue "		11	0	65	0
Iron Ore		1	0	66	0
Blue Shale		18	10	84	10
Coal		1	6	86	4
Fire Clay		1	8	88	0
Sand Shale		7	0	95	0
China Clay-w-		1	0	96	0
Red Sandstone - with Ore bands		7	0	103	0

J.L. Gay - Land - N.E. Cor. N.E. 1/4. S.W. 1/4. Sec. 18. T. 2 N. R. 3. W.

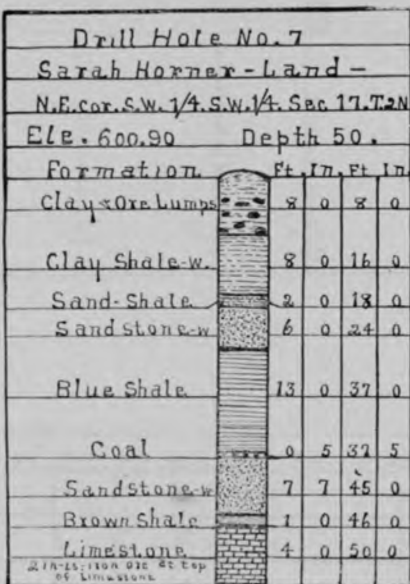
Red Shale		2	0	105	0
Sand "		2	0	107	0
Blue "		30	0	137	0
Conglomerate - Ls -		1	0	138	0
Soft Blue Shale		21	0	159	0
Blue Sand "		31	0	190	0
Sandstone		0	6	190	6
Limestone Ore		0	6	191	0
Blue Shale		0	7	191	7
White Limestone		2	0	193	7
Limestone with Crevices Partly Replaced with Iron		4	11	198	6
Blue Limestone		1	6	200	0



- No. 3 - - - Continued - - -

Water	6.50
Silicon	11.20
Metallic iron	51.52
Alumina	.80
Lime (CaO)	2.91
Phosphorus	1.00
Manganese	3.96

The origin of this ore is due in part to the filling of cavities in the limestone, but chiefly to replacement.



Opening No. 9.—Located on the Wm. Horner land, in N. W. 1/4, N. W. 1/4, Sec. 20, T. 2 N., R. 3 W. Elevation at base 560 feet; about 50 feet above drainage. The ore is brown on the outer part, but largely carbonate within. An entry was driven into the deposit for several feet. The ore body has a front thickness of seven feet, with an average thickness of over four feet of workable ore as far as investigated. The exact extent of the deposit into the hill was not determined by drilling, but 200 feet is a conservative estimate. Its lateral extent is at least 800 feet, and along this line several small openings were made, showing the ore to be of the same quality. The deposit contains 53,000 tons of ore easily accessible. About forty feet above this deposit is another with a maximum thickness of four feet, and this would greatly increase the tonnage at this place. The average analysis is as follows:

Water	8.50
Silica	22.47
Metallic iron	41.63
Aluminum	7.11
Ferric oxide	59.47
Lime	1.40
Sulphur	.754
Phosphorus	.822
Manganese	.192

Drill Hole No. 6

Formation	Ft.	In.	Ft.	In.
Soil	2	0	2	0
Yellow Clay	6	0	8	0
Soft Sandstone	2	0	10	0
w Shales "	6	0	16	0
Sandstone	11	0	27	0
Blue Shale	3	4	30	4
Iron Ore	0	8	31	0
Blue Shale	2	0	33	0
" " with Ore Lumps	13	0	46	0
Blue Sand Shale	16	0	62	0
Blue Shale	18	0	80	0
Coal	1	7	81	7
Blue Shale	1	5	83	0
Sand "	4	0	87	0
" " with bands Sandstone	11	0	98	0
Shaly Coal	0	9	98	9
Sand Shale with bands Sandstone	9	3	108	0
Sandstone	8	4	116	4
Shaly Limestone -with Ore-	0	8	117	0
Limestone	2	0	119	0

Ele. 663.24.

Depth 119 Ft.

J. W. Way-Land- N. W. Cor. S. E. 1/4. N. W. 1/4. Sec. 17. T. 2. N. R. 3. W-

Plate XXXII.

Cut through Deposit No. 6. Showing entire workable thickness of ore. Bottom of cut is limestone.

The iron content of these analyses and the average analysis should be increasing, because in both samples two feet of slaty, iron-bearing shale at the base was included, which reduces the iron content of the thickness given above and increases all the impurities accordingly.

Opening No. 10.—Located on the Phillip Gammon land, north side N. W. ¼, N. W. ¼, Sec. 17, T. 2 N., R. 3 W. Elevation 645 feet. This deposit was opened in the roadside just south and below the Gammon coal mine. The ore is banded and concretionary and is intermixed with clay. The deposit is about five feet in thickness and borders the edge of the hills for considerable distance. The tonnage would be hard to estimate, but a large amount of ore could be taken out at a small cost by hand mining.

Opening No. 11.—Phillip Gammon land, central S. E. ¼, S. W. ¼, Sec. 8, T. 2 N., R. 3 W. Elevation is 645 feet. This opening is 40 rods N. W. of No. 10, and is similar to it in every respect. No. 11 is 60 rods southeast of opening No. 5. Boring No. 8 is on a line between the two openings.

These openings lie just above drainage level.

Opening No. 12.—On the Stewart farm, S. E. ¼, S. E. ¼, Sec. 5, T. 2 N., R. 3 W. Elevation 625 feet; 10 feet above drainage. This deposit has a frontage of 400 feet and extends back from the face at least 250 feet and has a maximum thickness of 9 feet and contains 75,000 tons of ore. The ore is blue carbonate and is a massive conglomerate, containing concretions of very compact carbonate.

There are at least two accessory lenses within 200 yards of the above deposit, which will increase this tonnage considerably.

The average analysis of the main deposit is as follows:

Silica	23.52
Iron (Met.)	31.82
Aluminum	4.94
Ferric oxide	45.46
Lime	2.80
Phosphorus	.494
Sulphur	.476

This ore can be easily mined and put on cars at a small cost.

Opening No. 13.—On Johnson's land, S. W. ¼, N. E. ¼, Sec. 7, T. 2 N., R. 3 W. Elevation 635 feet and it is about 40 feet above drainage. The ore is brown on the surface, but blue within. The deposit has a front of upwards of 800 feet, with an average thickness of four feet or more. It apparently extends into the hill 200 feet or more and contains at least 35,000 tons. It has a sandstone roof. No recent facing was made at this deposit, hence the sample from the face for analysis was somewhat leached. The analysis shows 46.45 per cent. metallic iron, and back in the carbonate ore it will run about 40 per cent. It can be removed without difficulty.

Opening No. 17.—On the Felton land, 60 rods north of opening No. 5, and is in the same line of deposits. The quality of the ore is lower than No. 5, but the sample taken shows an iron content of 33.94 per cent. Shale partings break up the deposits.

Opening No. 18.—Davisson land, S. E. 1/4, Sec. 19, T. 2 N., R. 3 W. This opening shows a thickness of three feet of low grade siliceous ore, with clay and shale partings. Three or four openings were made along the side of the hill showing about the same thickness of ore. Sample of the ore taken without partings shows 36.36 per cent. iron.

Opening No. 19.—Adam Way land, east side N. E. 1/4, N. W. 1/4, Sec. 9, T. 2 N., R. 3 W. Elevation at base is 625 feet. This deposit at this opening is at drainage level, and is four feet in thickness. The ore is brown on the exposed surface, but within is a blue, conglomerate carbonate, similar to that of opening No. 12. These deposits show a good frontage and the ore will average about 30 per cent.

Opening No. 20.—Located 25 rods east of No. 19. The ore is more siliceous, but in other respects is similar and has about the same thickness.

On the opposite side of the road is another opening near the top of the ridge. The ore is brown and very siliceous.

No drilling was done in this area to determine the backward extent.

Northeastern Field.

Openings 1, 2 and 3.—This opening is thus numbered on account of the length of the face and the series of samples were taken at either end and near the center and over the entire thickness of the ore.

This deposit is located on the Pridemore land, S. W. 1/4, S. W. 1/4, Sec. 1, T. 3 N., R. 3 W. Elevation of base 620 feet, at the top 660 feet, and about 75 feet above drainage. The ore in general is brown, but contains massive blocks which are almost black, and with high metallic luster and of greater purity than the main mass. There are also bands and smaller masses of blue ore

Core drilling has not yet been done to show the exact extent of this deposit. The dimension determined from exposures are 200 by 1,000 feet and a maximum thickness on the face of 40 feet. These dimensions would give at least 330,000 tons.

This ore is now being shipped to Jackson, Ohio, for the manufacture of ferro silicon, and the reply comes back: "Keep sending it along; it is good stuff." The average analysis of the ore is:

Water	5.31
Silica	49.08
Metallic iron	32.35
Aluminum	1.43
Ferric oxide	46.21
Lime	0.00
Phosphorus	.33
Manganese	.51

This deposit is about 40 rods from the B. & O. S. W. Railroad, from which a track could be laid with little expense, and the ore placed upon the cars from an overhead dump at a very small cost, not to exceed 25 cents per ton.

Note.—The deposit of iron ore on the Pridemore land has recently been sold to the "Globe Furnace Company," at Jackson, Ohio. More than fifty cars of ore have been shipped from this deposit.

Opening No. 22.—Field's land; location same as above. This deposit lies just across a deep ravine east of Nos. 1, 2 and 3.

This has not been developed except by the sinking of a pit from the top of the ridge into the deposit and extending downward into it several feet. The elevation at the mouth of the deposit, near the top of the ore, is 635 feet. The ore is in every respect like that from the above deposit.

This deposit has a frontage of more than 1,000 feet and a backward extent of 450 feet and an average thickness of 20 feet, and a tonnage of 600,000 tons.

A short extension of tracking, from openings 1, 2 and 3, would reach this deposit and the ore be loaded in a similar way.

Opening No. 21.—In road north of Johnson's schoolhouse large boulders outcrop. No excavations were made to determine the extent, but the deposit here is probably an arm of No. 15 and Nos. 1, 2 and 3, and would be worthy of investigation.

Opening No. 23.—Located on the Dr. Shirly land, center of N. E. 1/4, S. W. 1/4, Sec. 20, T. 3 N., R. 3 E. Elevation 623.51 feet. On gentle slope, 20 feet above drainage.

Showing one end of the ore deposit on the Pridemore land. Maximum thickness 40 feet.

Ritter Spring. One of the springs of Chalybeate Water found near the base of the iron deposits.

It is a lens of ore near the surface; it is soft and contains considerable clay. The dimensions are 400 by 180 feet, with a maximum depth of workable ore 9 feet. It contains 25,000 tons, which can be stripped in large part and placed on cars for a few cents per ton. Analysis:

Silica	30.26
Iron	28.28
Alumina	8.60
Ferric oxide	40.40
Calcium oxide	3.10
Phosphorus	.879
Sulphur	.208
Manganese	.573

This ore is too poor to be available under existing conditions. Boring No. 9 will show the thickness of this ore and No. 10 will show that it does not extend back into the hills.

Opening No. 14.—On Thompson's land, 3½ S. W. ¼, N. W. ¼, Sec. 10, T. 3 N., R. 3 W. This deposit lies above the ore of No. 15 and is of small extent and low grade and would only be of value along with the underlying ore. Boring No. 13, 150 feet southwest of opening, penetrated 2 feet of this ore, which at that point was very siliceous and the percentage of iron very low.

Opening No. 15.—Located on Josiah Mundy land, southeast corner S. E. ¼, N. W. ¼, Sec. 10, T. 3 N., R. 3 W. This is only one of a number of openings made in this body of ore. The elevation of the ore at the base of the ore in this opening is 650.56 feet. It is almost at the drainage level. There are four drill holes and four exposures in the deposit. These are indicated on the map and shown on the sections. The chief opening shows a thickness of 12 feet; nine feet of massive blue carbonate capped with three feet of broken concretionary and banded ore. Farther to the north and east the ore outcrops in the bed of the stream with a visible thickness of five feet, and 120 rods to the west five feet of ore is exposed on the bank of the stream, and on the north side of the ridge near the Mundy Spring the ore was found outcropping, but without workable thickness.

Boring No. 11 is 125 feet northwest of the opening and showed 11 feet of ore, with the lower 6 feet massive and the upper five with shale partings as shown in the section.

From the section it will also be shown that about two feet and a half of ore was found a few feet below the main deposit.

Drill Hole No. 9

Formation	Ft.	In.	Ft.	In.
Soil -	2	6	2	6
Soft Red Ore	4	0	6	6
Sandstone	1	6	8	0
Soft Ore-Shale Partings	5	0	13	0
White Shale	13	0	26	0
Blue Shale	12	6	38	6
Ore Lumps	0	8	39	2
Soft Sandstone	11	2	50	4
Iron Ore	1	2	51	6
Blue Shale	10	6	62	0
Black Slate	1	0	63	0
Soft Shale - Gray	2	0	65	0
Sandshale -w-	16	0	81	0
- Blue Shale	10	0	91	0
Sandstone	20	0	111	0
Sandstone with Shale Partings	36	0	147	0
Sandstone	18	6	165	6
Limestone	4	6	170	0

C.W.S.

Ele. 623.51 — Depth 170 Ft.

Dr. Shirley - Land - N.E. 1/4 S.W. 1/4. Sec. 20. T.3.N. R.3.W.

Boring No. 12, 350 feet northwest of opening and 225 feet northwest of boring No. 11, shows 11 feet 6 inches of ore in the main deposit and nine feet of ore with shale parting and a conglomerate composed of lime, sand and ore. Eight feet of blue shale lies between this and the other deposit. The conglomerate shows 29.75 per cent. iron.

Boring No. 13, 100 rods southwest of holes Nos. 11 and 12, shows 6 feet and 6 inches of the massive ore, with an iron content of 36.05 per cent.

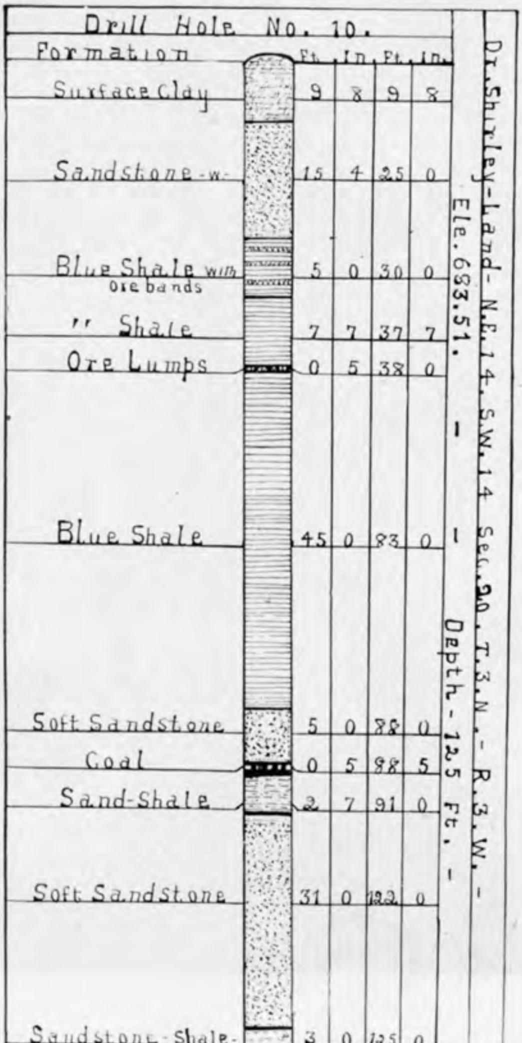


Plate XXXIV.

Drill Hole No. 11

Ele 686.45 Depth 75 Ft

Josiah Mundy-Land-N.W.1/4.S.E.1/4.Sec.10.T.3.N.R.3.W.

Formation	Ft.	In	Ft.	In
Sandy Soil	4	0	4	0
Yellow Clay	10	0	14	0
White Shale	5	0	19	0
Blue "	10	0	29	0
Iron Ore	1	4	30	4
Blue Shale	2	0	32	4
Iron Ore	0	8	33	0
Ore & Shale Partings	1	0	34	0
Iron Ore	6	0	40	0
Shale - Blue	0	4	40	4
Coal -	0	9	41	1
Clay Shale-w	8	0	49	1
Iron Ore	0	6	49	7
Ore-Shale Partings	2	5	52	0
Sandstone - w	2	0	54	0
" Brown	1	6	55	6
Soft " white	19	6	75	0

Drill Hole No. 12

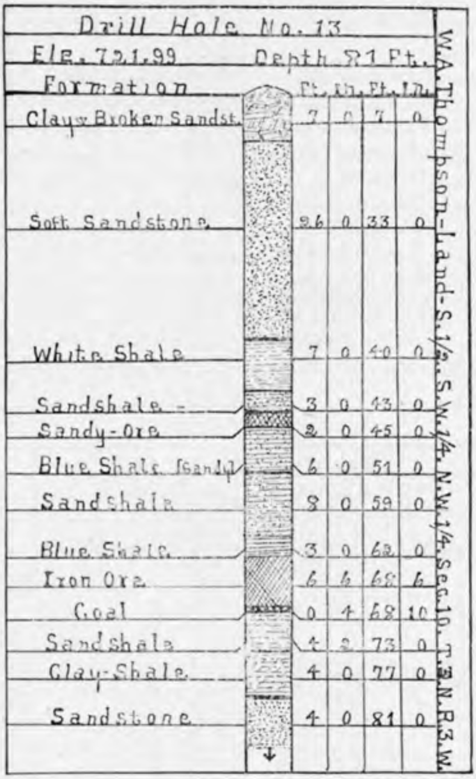
Josiah Mundy-Land- 225 Feet N.W.- No. 11-

Ele. 720.87 - - Depth 94 Ft. -

Formation	Ft.	In.	Ft.	In.
Soil	2	0	2	0
Yellow Clay	5	0	7	0
Soft Sandstone-Br.	34	0	41	0
Blue Shale	11	0	52	0
Blue Shale with Ore	2	6	54	6
Conglomerate - Lime Sand - Ore	6	6	61	0
Blue Shale	8	0	69	0
Iron Ore	4	0	73	0
Ore & Shale Partings	2	0	75	0
Iron Ore	5	6	80	6
Coal	0	4	80	10
Clay Shale	4	2	85	0
Sandy Shale	8	0	93	0
Sandstone	1	0	94	0

Boring No. 14, 700 feet north of boring No. 12, is on the edge of the deposit and shows only a slight trace of ore above a few inches of coal with shale partings.

The dimensions from the results of the opening and borings would be as follows: Frontage, 6,000 feet; extent into hill, 1,300

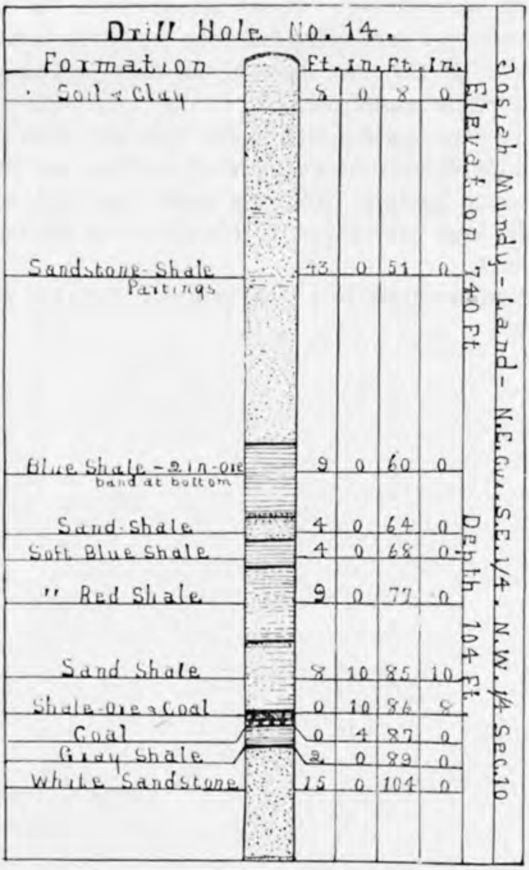


feet, and an average workable thickness of about 9 feet, giving it a tonnage of 4,500,000 tons. The drill left the field without boring a hole to the southeast of the main opening, which would probably have added about a third to the tonnage. The average analysis of this deposit is:

Silica	11.87
Metallic iron	34.79
Ferric oxide	49.30
Sulphur	.757
Lime (CaP)	4.65
Alumina	5.26
Phosphorus	.616
Manganese	.427

A layer of shaly coal, with an average thickness of four inches, is found to be continuous under this deposit.

Opening No. 16.—On McKnight's land, N. E. ¼, N. E. ¼, Sec. 17, T. 3 N., R. 3 W. This opening is one of several made in the ore along the sides of the ravine. The ore found in this locality is



concretionary and banded and has shale partings of greater thickness than the ore. The ore would aggregate a thickness of 5 or 6 feet. The ore removed from the shale shows 38.13 per cent. iron. It would be necessary to wash this ore to make it of value in the blast furnace.

This completes the list of the largest ore deposits that have been investigated in the Martin County field. The deposits described would yield a total of more than six million tons of workable ore and the smaller deposits when worked out would probably increase the tonnage about one-half. And the investigation of the yet unexplored area where the same conditions exist would at least double the tonnage of the present field.

Analyses.—The samples for analysis were taken from the faces of the deposits after the excavations had been made, and in the entries which were driven. In the places where the ore was thus exposed the samples were taken from the top of the bottom in a strip one inch wide. In this way the analyses show just what the deposits will run when mined out.

In former years samples sent in for tests were selected from the best part of the deposit, or were picked up from the surface where they had become leached. Analyses made from such specimens account for the high percentage of iron shown in the records of Indiana iron ores.

The analyses are given in a table in order that they may be readily compared.

RECORD OF ORE TESTS.

Number of Opening.	Name of Opening, Sample Mark and Number.	Water. H_2O.	Silica. SiO_2.	Iron Fe. (metallic)	Alumina Al_2O_3.	Ferric Ox. Fe_2O_3.	Lime. CaO.	Phosphorous P.	Sulphur. S.	Manganese Mn.
1, 2 and 3	Huron Bank. Sample No. 1	5.40	44.70	32.20	1.60	46.00		.33		.76
1, 2 and 3	Huron Bank. Sample No. 2	5.30	45.65	32.71	1.20	46.73		.33		.76
1, 2 and 3	Huron Bank. Sample No. 3	5.25	56.90	25.04	15.50	35.72		.22		.00
1, 2 and 3	Huron Bank. Sample No. 4			39.48		56.40				
	Total	15.95	147.25	129.43	4.30	184.85		.88		1.52
	Average	5.31	49.08	32.35	1.43	46.21		.29		.51
4	J. A. Cook Opening. Sample No. 1	10.50	16.90	45.54	4.70	65.07	.85	.65		1.02
4	J. A. Cook Opening. Sample No. 2			32.48		46.40				
4	J. A. Cook Opening. Sample No. 3			40.88		58.40				
	Total	10.50	16.90	118.90	4.70	169.87	.85	.65		1.02
	Average	10.50	16.90	39.63	4.70	56.62	.85	.65		1.02
5	Felton S. Bank. Sample No. 1	9.20	36.50	33.32	4.00	47.60		.54		1.28
5	Felton S. Bank. Sample No. 2		19.84	39.39	11.03	56.27	1.40	.60	.238	.378
5	Felton S. Bank. Sample No. 3		10.64	35.75	4.18	51.07	5.53	.484	.242	.281
	Total	9.20	66.98	108.96	19.21	154.94	6.93	1.624	.480	1.939
	Average	9.20	19.40	35.99	5.84	51.51	3.46	.52	.240	.667
6	Sarah Horner. Sample No. 1			55.44		79.20				
6	Sarah Horner. Sample No. 2	9.20	28.00	38.22	4.50	54.60	1.00	.57		1.53
6	Sarah Horner. Sample No. 3		23.14	36.86	13.00	52.65	4.63	1.03	.140	.438
6	Sarah Horner. Sample No. 4 (at seam)			40.65		58.07		.861		
6	Sarah Horner. Sample No. 4 (away from seam)			41.66		59.51		.919		
6	Boring. Sample No. 5 (12 feet 6in. to 14 feet 6 in.)		22.86	37.87	9.80	54.10	1.60	.882	.016	.666
6	Boring. Sample No. 5 (43 feet 6 in. to 45 feet 6 in.)		9.38	27.32	3.37	39.02	20.00	.244	.087	.846
	Total	9.20	83.38	278.02	30.67	397.16	27.23	4.506	.243	3.520
	Average	9.20	20.85	39.74	7.67	56.75	6.81	.751	.081	.880
7	Stephens (upper ore). Sample No. 1	10.50	26.30	38.82	4.80	55.46	1 05	.46		.76
8	Sarah Horner. Sample No. 1	6.50	11.20	52.22	.80	74.60	2.01	1.00		3.06
8	Sarah Horner. Sample No. 2			50.82		72.60				
	Total	6.50	11.20	103.04	.80	147.20	2.01	1.00.		3.06
	Average	6.50	11.20	51.52	.80	73.60	2.01	1.00		3.06

RECORD OF ORE TESTS.

Number of Opening.	Name of Opening, Sample Mark and Number.	Water. H_2O.	Silica. SiO_2.	Iron Fe. (metallic)	Alumina. Al_2O_3.	Ferric Ox. Fe_2O_3.	Lime. CaO.	Phosphorous P.	Sulphur. S.	Manganese. Mn.
9...........	Wm. Horner. Sample No. 1..............................	8.50	19.80	44.63	5.60	63.76	1.01	.89	....	.00
9...........	Wm. Horner. Sample No. 2..............................	....	25.14	38.63	8.62	55.18	1.80	.753	.754	.384
	Average..	8.50	22.47	41.63	7.11	59.47	1.40	.822	.754	.192
10...........	Gammon. Opening No. 1..............................	....	....	....	....	....	....	....	....	....
11...........	Gammon. Opening No. 2..............................	....	....	....	....	....	....	....	....	....
12...........	Stewart Opening. Sample No. 1..............................	....	23.52	31.82	4.94	45.46	2.80	.494	.476	.933
13...........	Johnson. Sample No. 1..............................	....	....	42.56	....	60.80	....	....	....	....
13...........	Johnson. Sample No. 2..............................	....	....	51.44	....	59.20	....	....	....	....
13...........	Johnson. Sample No. 3..............................	....	....	45.36	....	64.80	....	....	....	....
	Total..	....	....	139.36	....	184.80	....	....	....	....
	Average..	....	....	46.45	....	61.60	....	....	....	....
14...........	Thompson's Opening. Sample No. 1..............................	....	23.56	39.89	7.64	56.96	2.33	0.460	.086	.733
14...........	Boring. Sample No. 13 (43 feet to 45 feet)..............................	....	14.28	29.84	5.32	42.63	5.99	.273	.324	.561
	Total..	....	37.74	69.73	12.96	99.59	8.23	.733	.410	1.294
	Average..	....	18.87	34.86	6.48	49.79	4.12	.367	.205	.647
15...........	Mundey Opening. Sample No. 1..............................	....	6.06	35.85	5.54	51.21	6.78	.708	1.553	.448
15...........	Mundey Opening. Sample No. 2..............................	....	11.11	35.35	5.85	50.50	1.30	.406	.799	446
15...........	Boring. Sample No. 13 (29 ft. to 30 ft. 4 in.–32 ft. 4 in. to 40 ft.)	....	14.14	31.36	4.65	44.80	4.80	.478	1.170	.502
15...........	Boring. Sample No. 13 (62 feet to 68 feet 6 in.)..............................	....	6.30	36.05	2.74	51.51	7.20	1.099	.521	.354
15...........	Boring. Sample No. 12 (52 feet to 61 feet)..............................	....	15.44	29.75	7.71	42.49	3.70	.402	.343	.381
15...........	Boring. Sample No. 12 (69 feet to 80 feet 6 in.)..............................	....	18.20	31.56	5.06	45.09	4.10	.604	.156	.430
15...........	J. B. Loyd. Sample No. 1..............................	....	....	36.12	....	51.00	....	....	....	....
	Average..	....	11.87	34.79	5.26	49.30	4.65	.616	.757	.427
16...........	McKnight. Sample No. 1..............................	....	22.36	38.13	8.88	54.47	2.20	.629	.087	.416
17...........	Felton N. Bank. Sample No. 1..............................	....	26.79	33.94	10.22	48.48	1.80	.633	2.08	.626
18...........	Davisson. Sample No. 1..............................	....	30.10	36.36	8.36	51.94	.70	.249	1.37	.466
19...........	Way. Sample No. 1..............................	....	44.32	30.81	3.19	44.01	2.80	.323	.552	.650
20...........	Boring. Sample No. 9 (2 feet 6 in. to 13 feet)..............................	....	30.26	28.28	8.60	40.40	3.10	.879	.208	.573
21...........	S. of Road Cor. N. Johnson. S. H..............................	....	....	28.84	....	41.20	....	....	....	....

Other Counties.

In Jackson County the shales are mixed with thin bands of earthy carbonate of iron, similar to that found in Clark and Scott Counties. On Hough's Creek, south of Brownstown, the weathered lumps of ore at one time attracted attention, and some parties were induced to undertake the construction of a Catalan forge to work these ores. Some trace of the old mill race yet remains that was dug to secure sufficient fall of water for driving the blast and trip hammer, but the forge was never completed.

In Knox, Vanderburgh, Dubois and Pike Counties, and throughout the coal measures nodules of iron ore are found associated with the coal seams and shales. But these ores are not found in quantities sufficient to be of any economic importance.

Uses of the Indiana Ores.

The Indiana iron ores, as shown by the analyses, are relatively low-grade ores, containing on the average considerable silica, phosphorus, sulphur, etc. These elements, as will be seen, are more or less injurious to the making of first-class iron. However, the presence of these various substances in some classes of iron are very important, and it is especially in such productions that our iron ores can be successfully used.

Sulphur and Phosphorus.—(a) Sulphur, even in very small amounts, has a very injurious effect on wrought iron, making it red-short, although the metal may readily be worked in the cold. With cast iron a small quantity of sulphur is an advantage, making it stronger and more easily fused. Sulphur in pig iron tends to the production of the white variety; the surface and fractured portions often show black particles, which are characteristic of sulphur in iron.

(b) Phosphorus is also very injurious to iron. Even 0.1 per cent in iron is very noticeable; 0.3 per cent in wrought iron makes it harder and somewhat diminished in tenacity; 0.5 per cent. makes it cold-short, but not red-short; 1 per cent. makes it very brittle. Thus the effect of phosphorus on iron is to impart a coarsely crystalline structure, diminish its strength, increase its fusibility and make it cold-short; but on account of its importing fluidity to the metal, its presence is beneficial in making fine castings.

Iron and Silicon.—In early days when a furnace was "going bad," produced what was known as "burnt iron," no founder would use or purchase it, and it was considered a total loss. Later it was discovered that this was simply highly siliconized iron and that it was of great value as a softener. The name "ferro-silicon" was given it and it recently has commanded a premium.

There are several furnaces today producing "ferro-silicon" exclusively, and nearly every stack makes it occasionally. The silica content ranges from 6 to 12 per cent., and the electric furnace produces a still higher grade, running 50 to 75 per cent. or even higher. The manufacture of ferro silicon is considered a healthy branch of the electro metallurgical industry. In Europe, Keller, Leleux & Co. are the chief producers, averaging an output of 250 tons per month. In America the Wilson and Cowls companies are the leading producers.

If iron be heated alone with silica no action takes place. The effect of silica on cast iron is to set the combined carbon free, so that as a rule the greyer the pig the higher the amount of silica.

Ferro Silicon is now quoted at \$98@100 per ton f. o. b. export ships Atlantic ports.

Classes of Iron.—The Indiana ores may well be used in the manufacture of iron by mixing with the high grade ores of the north, or they may be used very successfully in the manufacture of ferro silicon. There are several advantages which either use may have. The high phosphorus content of some of these ores is less objectionable when we are informed that southern irons which are being used extensively are high in phosphorus. They rarely contain less than 0.8 per cent. and frequently run higher than 1.5 per cent. From these high phosphorus ores "Off Bessemer" may be made, that is, as the name implies, iron approximating the true, but unfit for steel making. There are no rigid limits set and this iron is popular with carwheel and malleable iron manufacturers.

In designing the classes or grades of iron the former method of inspecting fresh fractures of pig iron to determine the content of silica, sulphur, etc., is being largely replaced by the more accurate method of classification by chemical analysis.

A furnace charging a similar class of ore will usually produce iron carrying nearly uniform phosphorus and manganese, but silica and sulphur vary considerably. These latter elements produce a marked change in the appearance of the fracture, and were it not for furnace conditions and temperature the metalloids could be quite accurately approximated. But under existing conditions the individual judgment of fracture is very much in error.

The various classes of iron may be designated as northern, southern, basic, bessemer, forge, foundry, charcoal and ferro silicon.

The last two classes being comparatively rare, but both commanding a good price in the market.

Furnaces for Smelting Indiana Ores.—The close proximity of the Southern Indiana coal fields, and the increased railroad facilities make Martin and Greene counties admirable locations for blast furnaces, even if the ore should largely be shipped in from other localities.

As stated above, some of the siliceous ore from Martin County is at present being shipped 300 miles to Jackson, Ohio, where it is used for making ferro silicon. Upon investigating the work of the furnaces at Jackson, it was found that ferro silicon was being made very successfully from ores carrying as low as 28 per cent. metallic iron and much of it is taken from deposits less than two feet in thickness. This ore is costing a dollar or even more at the furnace, and they are paying two dollars for the Martin County ore.

If ferro silicon can be made on a paying basis under the above conditions, it would certainly pay a handsome dividend if furnaces for its production were constructed in the heart of the Indiana field. Here the cost of fuel, if brought from the southern field, or coke, if shipped in from distant points, would be about the same as at the Ohio furnaces. But the most economic plan would be the construction of regenerators and gas producers. By this means there would be no doubt about the coals of southern Indiana, including even the local coals, which in these furnaces could be used successsfully. The iron ore could be placed at the furnaces at a cost of 50 cents per ton or even less. Track could readily be laid from furnaces located near Shoals and Bloomfield to the larger deposits and the less and more inaccessible deposits would readily be worked out by the inhabitants and placed at the furnaces or on the cars at a comparatively small cost. By the latter means the tonnage would be greatly increased, since in these smaller deposits each man would be able to mine out several tons per day. The limestone for fluxing is found in contact with some of the ore and at other places it can readily be obtained in great abundance. From the above it is apparent that this ore can be used to advantage in the manufacture of ferro silicon. There is also sufficient timber on the lands to supply all needs in mining operations. As will be seen from the sections of the core drill holes there are large beds of shale in this same region and this shale could be mixed in the proper proportions with the slag from the furnaces, thus producing a good cement. Hence the development of one line of resources will lead to the utilization of other natural products, of which the manufactured products are greatly in demand.

The coming of iron manufacturers into the Indiana field should be encouraged. The reopening of ore deposits, the development of the coal fields, the building of furnaces within the state to smelt northern ores, the building of new railroads, and the extension of others, and the aggressive policy of existing roads to encourage industries along their lines, will undoubtedly again make Indiana a great producer of iron and the other products of commerce that will later be developed.

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THE PETROLEUM INDUSTRY IN INDIANA IN 1906.

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 Archaean 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 an advanced civilization.

During the year 1905, the latest date for which statistics are available, the United States produced 134,717,580 barrels of petroleum, which brought, delivered into the pipe lines, $84,157,399. In the same year there was produced in the world 214,398,187 barrels. The United States, therefore, produced 62 per cent. of the world's output for the year, or 12 per cent. more than all the rest of the countries of the world.

Oil Fields of the United States.

The oil from the different parts of the United States varies much in character and grade, and comes from six main areas or oil fields.

The Appalachian Field.—This field comprises fully 50,000 square miles of territory in Pennsylvania, New York, West Virginia, Southeastern Ohio, Tennessee and Kentucky. The most of the oil from it is known as Pennsylvania oil. It has a paraffine base, is considered best for making oil illuminating products and brings the highest price on the market, the average for the year 1905 being $1.39 per barrel.

The oil of the Appalachian field comes, for the most part, from porous sandstones and conglomerates which are imbedded in and underlain by great masses of shale. These sandstone beds occupy a position in the geological column of over 2,000 feet in thickness, extending from the Alleghany formation of the Carboniferous period to the base of the Devonian period.

From 1859, when the Pennsylvania oil was first produced in commercial quantities on Oil Creek, Pennsylvania, up to 1876, this field furnished all the oil produced in the United States. Between 1876 and 1885 other states produced less than 2 per cent. of the output, but with the discovery of oil in the Trenton rock at Findlay, Ohio, the percentage from the Appalachian field gradually decreased until, in 1905, it was only 21.8 per cent. of the total.

The Lima-Indiana Field.—In November, 1885, oil was first produced from the Trenton limestone of the Lower Silurian or Ordovician period, near Findlay, Ohio.

The territory yielding from the Trenton rock gradually expanded until it extends diagonally across Northwestern Ohio and into Indiana as far as Marion, Grant County. This territory is now known as the Lima-Indiana field. The oil from it ranks next to that from the Appalachian field in value, the average price in 1905 being 88 cents per barrel. 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 output of the Lima-Indiana field in 1905 was 22,294,171 barrels, or 16.4 per cent. of the total produced in the United States. Of this Ohio produced 11,329,924 barrels and Indiana 10,964,247 barrels.

The Illinois Field.—In 1905 Illinois began for the first time to come into prominence as an oil-producing state. Prior to that time the only production in the State had been a lubricating oil, found in small quantity near Litchfield, Montgomery County, the total yield for fourteen years being less than 6,600 barrels.

In October, 1904, a well which had an initial production of 35 barrels was drilled near Oilfield, Clark County, in the southeastern portion of the state. This gave rise to extensive drilling in the vicinity of Oilfield and Casey, where more than 300 bores were sunk in 1905, the output for that year being 181,084 barrels. During 1906 the field was extended southeast to the center of Lawrence County and the output was greatly increased in quantity.

The oil from the Illinois field is found in sandstones or limestones of the Upper and Lower Coal Measures. It is dark olive green in color and is "chiefly made up of members of the paraffine group and of the lighter members of that group." It is a lower grade oil than that of the Lima-Indiana field, and on December 1, 1906, was bringing 21 cents less per barrel on the market.

Near Princeton, in southwestern Indiana, a small area of oil territory has been developed, which, in 1906, yielded 103,843 barrels from about 130 wells. The oil is a dark, rather thick liquid, with a specific gravity of 31 degrees Beaumé, and comes from the Huron sandstone of the sub-Carboniferous age. Both geologically and geographically the Princeton field is closely related to that of Illinois and is therefore classified with it, although the production for 1905 was computed with that of the Lima-Indiana field.

The Mid-Continent Field.—This field comprises the oil producing territory of Missouri, Kansas and Oklahoma. It was first opened up in 1899 near Chanute, Kansas, and has extended rapidly in a southwest direction into Oklahoma.

The oil of the Mid-Continent field is produced "from the Pennsylvania series of the Carboniferous system. At the base of these rocks is the Mississippi limestone, with a thickness of from 300 to 400 feet. Directly above this are the Cherokee shales, with a thickness of from 400 to 500 feet, capped by the Fort Scott limestone. Above the Fort Scott limestone are alternating shales and limestones, extending to the surface. All of the shales, especially the Cherokee, contain sandstone beds in the form of lenses, some of which extend over a considerable area. These beds form the reservoir from which the oil is obtained. The most important sand so far discovered is near the base of the Cherokee shales. Two other horizons of pay exist, one near the top of the Cherokee shales and the other above the Fort Scott limestone."*

The oils of the Mid-Continent field differ very much in quality. The specific gravity runs from 18 to 40 degrees Beaumé. They are dark in color and carry some sulphur. The price in 1905 ranged, according to its specific gravity, from 25 to 80 cents per barrel. The output from this field for that year was 12,013,495 barrels, or 8.92 per cent. of the total produced in the United States.

The Gulf Field.—The oil producing territory of Texas and Louis-

*W. T. Griswold.—"The Production of Petroleum in 1905," page 41.

iana belongs to this field. An oil with a paraffine base had been produced at Corsicana, Texas, for a number of years before the low grade asphaltum oil was discovered at Beaumont. The output from Corsicana was, however, limited in quantity, and in 1905 formed only about one per cent of that from the Gulf field.

The Coastal Plain of Louisiana and Texas yields most of the oil from the Gulf field. The surface rocks of that plain consist mainly of unconsolidated clays, sands and marls, with some gravels and thin layers of hard limestone. These belong to the recent or Pleistocene geologic formations. Beneath these surface deposits are scattered limited areas of dolomitic limestone, very porous in character and with a hard, impervious top or cap. These form the reservoirs in which the oil is stored. They are very productive, but are soon exhausted when tapped. Five of these pools were discovered between 1901 and 1906, which yielded the enormous total of 104,066,198 barrels of petroleum.

The oils from the Coastal Plain have an asphaltum base or residue and a specific gravity of 18 to 28 degrees Beaumé. They are used mainly for fuel and in 1905 sold at from 27 to 37 cents per barrel. The output for that year from the Gulf field was 37,046,605 barrels, or 27.5 per cent. of the total production in the United States.

The California Field.—California produced petroleum in small quantity between 1865 and 1892. In the latter year a well was drilled in the city of Los Angeles, which yielded a small but steady flow of asphaltum oil, and from then on the output gradually grew until, in 1905, it was 33,427,473 barrels, or 24.8 per cent. of the total produced in the United States.

The oil of the California field is found in a number of porous beds of sandstone, all of which are saturated with petroleum and which, taken together, give a producing horizon many hundred feet in thickness, the wells varying in depth from 700 to 3,000 feet. Each bed yields an oil different in character from the others. All, however, have an asphaltum base and are used mainly as fuels, the price in 1905 averaging about 25 cents per barrel.

In addition to the six fields above mentioned, small quantities of oil were produced in Wyoming, Colorado and Michigan, a total of 387,792 barrels having been produced from these three states.

PRODUCTION AND VALUE.*

In the following table is given a statement of the total production of crude petroleum in the United States during the years 1904 and 1905, also the value of this production, with the average price per barrel of the petroleum from each state:

Total Quantity and Value of Crude Petroleum Produced in the United States and the Average Price Per Barrel in 1904 *and* 1905, *by States.*

State.	[Barrels.] 1904.			[Barrels.] 1905.		
	Production.	Value.	Average price per barrel.	Production.	Value.	Average price per barrel.
California	29,649,434	$8,265,434	$0.279	33,427,473	$8,201,846	$0.245
Colorado	501,763	578,035	1.152	376,238	337,606	.897
Illinois	....	....	....	181,084	116,561	.644
Indiana	11,339,124	12,235,674	1.079	10,964,247	9,404,909	.858
Indian Territory, Oklahoma	1,366,748	5,447,622	.970	12,013,495	6,546,398	.545
Kansas	4,250,779					
Kentucky, Tennessee	998,284	984,938	.9866	1,217,337	943,211	.775
Louisiana	2,958,958	1,073,594	.3628	8,910,416	1,601,325	.180
Michigan, Missouri	2,572	4,769	1.854	3,100	3,320	1.071
New York	1,113,264	1,811,837	1.6275	1,117,582	1,557,630	1.394
Ohio	18,876,631	23,730,515	1.257	16,346,660	17,054,877	1.043
Pennsylvania	11,125,762	18,222,242	1.638	10,437,195	14,653,278	1.404
Texas	22,241,413	8,156,220	.367	28,136,189	7,552,262	.268
West Virginia	12,644,686	20,583,781	1.628	11,578,110	16,132,631	1.393
Wyoming	11,542	80,794	7.00	8,454	51,545	6.10
Total	117,080,960	$101,175,455	.864	134,717,580	$84,157,399	.625

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."

*From "The Production of Petroleum in 1905," by W. T. Griswold, in Mineral Resources of the U. S. for the year 1905.

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 anaesthetic, particularly for local application to produce cold.

Both petroleum products and crude pertoleum are much used in the manufacture of artificial gas. In the making of "air gas," or carbureted air, gasoline is needed, while for "oil gas" and carbureted 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 cannot get enough of it. The vapors arising from the oil are condensed and re-condensed 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."

Origin of Petroleum.

Among geologists and scientists in general it is now commonly believed that petroleum has been derived from the decomposition of animal or vegetable bodies, or both. Many laboratory experiments and facts observed in nature tend to confirm this belief. For example, when the body of an animal or plant is distilled in a closed retort, or undergoes decay in the absence of air, certain gaseous and liquid products are always derived. Again, oily water frequently exudes from peat mosses; and marsh gas, the chief constituent of natural gas, bubbles up from every stagnant pool which contains rotting animal or vegetable matter at its bottom. There is, therefore, no need of far-fetched chemical theories to explain what is more or less a matter of common experience.

The Newberry Theory.—However, two distinct views prevail among geologists as to the manner in which the decomposition has been brought about. One of these views, first set forth by Prof. John S. Newberry, former State Geologist of Ohio, probably accounts best for the oil found in the sandstone strata of southwestern Indiana. Prof. Newberry claimed that the great beds of bituminous shales, such as the Huron, Genesee and Utica shales, have been the chief sources of petroleum—that the animal and plant remains in those beds have undergone a kind of distillation or secondary decomposition, resulting in petroleum which, by hydrostatic pressure, *has been carried to the rock strata in which it is now found.*

All shale beds are sedimentary in their origin, being composed of particles of clay which have been carried long distances and redeposited in water. Now it is well known that clay has a particular affinity for oily matter. Oily substances floating in muddy water have been found to attach themselves to suspended particles of clay and sink to the bottom and produce there a stratum rich in oil, which in time would be compressed by the newer overlying strata into shale. Much of the petroleum of the shale was doubtless thus derived from organic matter undergoing decomposition in other and remote strata.

At the time that the theory of Dr. Newberry was published, the large deposits of oil in the Trenton limestone rocks of Ohio and Indiana were unknown. His theory was based largely upon the Pennsylvania fields, and seems more clearly than any other to explain the origin of the petroleum there found. The Pennsylvania oil, like that of southwestern Indiana, occurs in sandstone strata which contain few, if any, organic remains, and could not, therefore, have furnished the original source of the oil. These sandstone strata lie, however, in close relation to the bituminous and other shales, and from their porous nature have served as reservoirs in which the oil, oozing from the shale, has passed and accumulated in large quantities.

The Hunt Theory.—The second theory was first promulgated by Dr. T. Sterry Hunt about 1862 and better than any other accounts for the oil in limestone rocks wherever found. Dr. Hunt asserted that petroleum has been formed from the remains of animals or plants in the *same rock strata now yielding the oil*, the decomposition having taken place under such conditions that the organism passed directly into petroleum, which has since remained in the rocks where it was formed.

Among the proofs of his theory, Dr. Hunt stated that in some cases petroleum is found filling the cavities of large fossil shells (*Orthoceratites*) in the Trenton limestone. "From some specimens nearly a pint of petroleum has been obtained." Again he cited the fact that a stratum of Niagara limestone near Chicago is so filled with petroleum that blocks of it, used in building, were discolored by the exudations which, mingled with dirt, formed a tarry coating upon the exposed surfaces.

The theory of Dr. Hunt was made known about 1862, long before oil was discovered in the limestone rocks of Ohio and Indiana. The facts gathered and observations made in the Trenton limestone field of these states have furnished much evidence in support of his theory; and it is now commonly believed by scientists that the oil found in limestone has been produced in the rock by the direct decomposition of organisms originally inhabiting the water in which the rock was deposited. Moreover, it is believed that, for the most part, these organisms were animals, since the limestone oil possesses more sulphur and nitrogen, is of a darker color, higher specific gravity and has a more rank and disagreeable odor than the "shale oil" produced in Pennsylvania, which probably owes its origin to the decomposition of plants in the manner set forth in the theory of Dr. Newberry, as given above.

Oil Fields of Indiana.

Petroleum in commercial quantities was first produced from the Trenton limestone 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, 1905, the industry gradually grew until it became one of the greatest in the State. From 33,375 barrels, valued at $10,881 in 1889, the output increased to 11,331,340 barrels, valued at $12,176,880 in 1904.

In 1905 a decrease both in production and value began which has continued to the present time, the output falling to 10,969,308 barrels, valued at $9,305,473 in 1905, while in 1906 it decreased still further to 7,873,937 barrels, valued at $6,968,089. This decrease was due to several causes, chief among which was a decrease in price. While at no time during the two years did this fall below the profit-making limit of 80 cents, yet it was so much below the average prices of 1903 and 1904 that new developments were retarded. Much less wildcatting was therefore done during the two years, and the area added to the known productive territory of the State was very limited.

The discovery of oil in Illinois and the rapid development of the Mid-Continent field were also causes leading to the decrease in Indiana, as the great majority of operators left their Indiana holdings for these more promising new areas. The average oil operator is much like the gold prospector. He is usually eager to let the bird in hand escape when he sees or hears of a new one in the bush. No sooner is a new discovery heralded, even though hundreds of miles away, than he loses interest in his present holdings, however profitable they may be. There is a chance of securing valuable leases at a low figure, and of making in six months what it may take five years to accumulate by the older and surer method of bona fide production. So away he goes, and the older field, tried and tested as it is, is left to decline, while the newer takes on a boom oftentimes far beyond its real merit. In a territory as large as that of the Trenton rock field of Indiana, hundreds or even thousands of new bores must be drilled each year to offset the decline in output of the older wells. These new bores will not be sunk if the interests of the operators are elsewhere, or if the price of oil is so low as to reduce the profit of production to anything like a mere living.

There is an abundance of oil yet beneath the surface of Indiana, but until the price rises above the dollar mark the output will not reach the great volume it did in 1904, and it may never do so again.

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 be taken up in order and its petroleum output treated.

TRENTON ROCK PETROLEUM.

Formation of the Trenton Limestone.—The Trenton limestone, one of the lower or older formations of the Lower Silurian period, underlies at variable depths the whole of Indiana. Along the Ohio River in Ohio and Switzerland counties it outcrops in a narrow strip. 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 one formation either underlying or forming a portion of the surface of our State.

Formation of Utica Shale.—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 the natural gas and oil of the Trenton rocks had a common origin, viz.: the destructive distillation, carried on through thousands of years, of the plants and animals which existed in the Trenton period. As already noted, 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 porous portions 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.

The majority of people who have never seen an oil field imagine that both petroleum and natural gas occur in immense caverns or hollow spaces in the rocks beneath the surface of the earth. They believe that great lakes or underground cavities of liquid oil or highly compressed gas exist, and that when tapped with a drill these yield in abundance the oil and gas of commerce. Such beliefs or imaginations are wholly wrong, for no large cavities or open spaces of any size occur in the rocks of oil or gas producing areas. All rocks are, however, porous; even shale of the closest grain will hold some liquid in the minute and microscopic cavities which it, in common with all rocks, contains. Now the oil and gas sands are simply very porous rocks which contain, not one great cavity, but millions upon millions of small or microscopic cavities, so that oil, gas, water or all three together, it may be, occupy these numerous little spaces, and thus saturate the rock just as water does a piece of cloth or a sponge. Not only Trenton limestones, but most other limestones, as well as many shales, have in the past produced petroleum in greater or less quantities. Distributed in minute proportions through the substances of the rocks, petroleum 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 where an impervious stratum of any other composition than shale occurs in the geological series. The larger the pores in an oil-bearing rock are, and the greater the volume they occupy in proportion to the volume of the rock mass, the greater will be the contained oil or gas supply, and this proportion, in fairly good producing sands usually varies between one-fifth and one-tenth; that is, a cubic foot of rock would hold, say, six to twelve pints of oil, and of course would contain an equal volume of cavities for water or gas, should either of these substances be present instead of oil.

If petroleum has been thus generally formed throughout the Trenton limestone, why does not all 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 general mass of the Trenton limestone is, however, too compact to permit the rapid passage of oil or gas through it or to form a suitable reservoir for the storage for large quantities of these fluids.

Conditions of Accumulation.

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:

1. A porous stratum of the Trenton rock to form a reservoir.
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 or more miles. The outline of all was irregular, with many indentations along the margins. In these more shallow portions of the Silurian seas the water in time became very briny and caused a chemical change in the rock. To the lime carbonate was added some chloride of magnesia from the brine, and a magnesia-lime carbonate called "dolomite" resulted. The following formula represents the chemical change which took place:

$$2\,CaCO_3 + MgCl_2 = Ca\,Mg\,(CO_3)_2 + Ca\,Cl_2$$

or two molecules of calcium carbonate + one molecule of chloride of magnesia = two molecules of dolomite + one molecule of calcium chloride.

Wherever the above 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. In other words each crystal of dolomite occupies less space than it did as a crystal of lime. Therefore, between each is a void or small pore which gives space for gas, oil or water, and allows the rapid passage of these substances through the changed limestone. *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 non-porous 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 three to ten, 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, non-porous limestone.

Until the year 1903 the shallow or upper pay streaks were thought to be confined entirely to the first hundred feet of the Trenton limestone. In that and subsequent years, however, developments have shown limited areas in Delaware, Randolph and southwestern Jay counties to contain another deeper pay streak lying from 270 to 310 feet below the top of the Trenton and separated from the upper pay by 200 or more feet of non-porous, non-productive 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 main Indiana oil field the Trenton rock is covered by a thickness of 200 or more 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.

If a shale or other impervious cover did not intervene between the porous reservoir and the surface, the oil would long since have volatilized and passed off as escaping natural gas, leaving behind a tarry, asphaltum-like residue, which represents the solid portion. In many localities in the United States sandstones or limestones occur which are highly impregnated with such an asphalt substance. These deposits are found close to the surface with no shale above them. Had a shale been present, the strata containing the tarry substance would be oil-bearing. Thousands of dollars have been spent in drilling such localities in search of an oil which long since escaped in the form of gas.

When the oil-bearing stratum lies close to the surface, with only a thin shale above it, a heavy lubricating oil results. Such an oil, registering 20.8 degrees Beaumé, is found in Jasper County, Indiana, where it occurs in the Corniferous limestone at a depth of only 100 feet, beneath 45 to 55 feet of close-grained black shale.

* Dana, "Manual of Geology," 4th Ed., p. 522.

3. *The Anticlinal Structure.*—The surface of the Trenton limestone is not, as many people suppose, level, 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 behind 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 lapsed 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 field the result of a new bore 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 15 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 non-porous 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.—Salt water also occurs in the Trenton rock in almost 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 or trough, in the Trenton, salt water is apt to be found before the 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 just 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 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 alone.

Quantity of Petroleum to the Acre.—If the amount of oil obtained from a productive sand be estimated at one gallon per cubic foot, and the sand is five feet in thickness, an acre (43.560 square feet) will yield about 5,000 barrels of forty-two gallons each. If the sand reservoirs be exceptionally thick or of very great porosity, the production will be much greater. It is estimated that Spindle Top Hill, in Texas, produced over 25,000,000 barrels from less than 200 acres. This, however, was a low-grade oil with an asphalt base. Such oils are usually more abundant in limited areas than those of higher grade.

By the ordinary processes of drilling and pumping it is impossible to get all the oil from any sand, even if a well be put down on every five acres. One-fourth or more will probably remain in the rock, held there by capillary attraction, which neither the accompanying gas nor the attraction of gravity can overcome.

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.

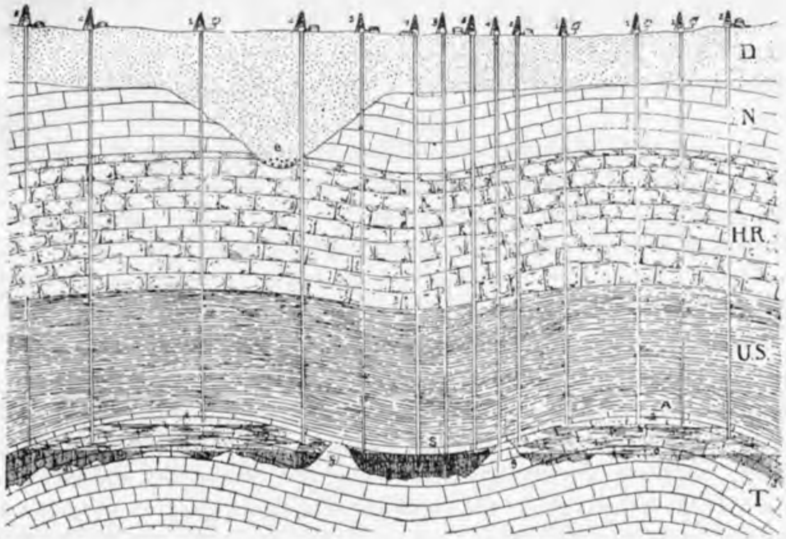


Fig 1 D., Drift. N., Niagara limestone. H. R., Hudson River limestone. U. S., Utica shale. T., Trenton imestone. A., anticline. S., syncline. a to b, gas bearing stratum. b to c, oil bearing stratum. c to d, water bearing stratum of porous rock. e, preglacial channel through Niagara limestone. f., non-porous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

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

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 and West Virginia 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.

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 700 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 and the surface, 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

*The Jasper County field is an exception to this, a heavy lubricating oil being there found in the Corniferous limestone at 100 to 120 feet below the surface. However, a shale, impervious to the oil, lies between it and the surface.

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.

Again, as already noted, 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 of 30, 45 or any number of degrees which the intelligent operator can follow and sink a productive bore 99 times out of a hundred. His operations in the State must always have 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.

One fallacy believed in by many would-be and some old operators is that the main Trenton rock field in Indiana is connected in some way with the ones at Terre Haute and Princeton. Any person with the slightest knowledge of geology should know that this is impossible. The Trenton rock belongs to the Lower Silurian period and was in existence millions of years before the Corniferous limestone at Terre Haute or the Huron sandstone at Princeton were formed. Neither is there any connection between the fields in Jasper County, Indiana, and those about Casey and Robinson, Illinois, the oil in each of these fields being in wholly different geological horizons. The belief in some kind of a northeast-southwest line or trend is probably largely responsible for the erroneous opinions held concerning the connection of these widely separated fields.

Condemned and Abandoned 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, fair to good producing wells have been developed where at one time it was thought that no oil existed. Examples of such territory are mentioned on a later page under the matter descriptive of new development in Bear Creek Township, Jay County, where some of the best wells drilled in 1906 were completed.

There is little doubt but that hundreds of producing wells could be drilled about the margins of the present productive area shown on the accompanying map of the main Indiana field, in territory which has been condemned or abandoned. The pools containing the porous reservoirs in which the oil is stored are so irregular in size and outline that no one can locate their boundaries. Oil doubtless exists beneath many localities in the State which never have been or never will be tested. Wildcat bores sunk at a venture will doubtless disclose the presence of many pools now unknown, but the majority of such bores will doubtless prove barren on account of the absence of some one of the necessary conditions to oil accumulation above enumerated.

From what has been written it will be seen that the operator in the Indiana oil field is taking chances whenever and wherever he sinks a bore. 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 ten-barrel well; he may miss it altogether and get a dry hole. One thing he can rely upon if he strikes a productive well, and that is that he is drawing upon a stored product which is not now being formed in the rock from which it is drawn and that, therefore, he must eventually exhaust the stock of oil from the immediate vicinity of his bore.

Need of Accurate Surface Levels.—In order to properly develop any oil producing area and reduce the number of dry holes to a minimum, the trend, width and dip of the anticlines and synclines in the top of the oil producing stratum should 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 oil bearing rock above or below tide should be carefully ascertained. This can be done only by running a transit level from the nearest point where the surface 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 the oil bearing stratum is first struck, the surface of the latter in terms of sea level will be obtained, provided it is below tide. Where the oil bearing rock occurs above tide, the depth of it will be less than the sea level elevation of the bore, and should be subtracted accordingly.

The location of the first half-dozen or so wells in any area a mile or two square must of necessity be a matter of guess work, but if the surface level of the top of the sand in each bore, productive or dry, be carefully ascertained, the trend of the anticline and the approximate limits of the field or pool can be soon determined. Too much guess work is carried on concerning the surface level of the spot on which the well is located. In a broken country it is difficult for any man to guess approximately the relative levels of two points a quarter of a mile apart, and the new level should always be ascertained with instruments. The surface level of the bore has nothing to do with the absolute height or surface level of the productive sand, 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 sand, 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.

Many Bores too Shallow.—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 these regions. have led me to believe that the majority of the early drill holes sunk in search of Trenton limestone failed to reach that formation. This failure to sink the bores deep enough was due to several causes, chief among which was the great difference in the strata overlying the Trenton 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 Terre Haute, Birdseye, Loogootee, Princeton, etc., have proven 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 or some other oil-bearing formation, 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 in 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 start future bores to Trenton to see to it that nothing stops the drilling before Trenton limestone is reached, or rather, before that formation has been pierced at least 300 feet. Beyond that depth there is little possibility of finding either gas or oil. A contracting driller of experience can easily and withou great expense, case off any salt water which may give him trouble An accurate record of the thickness of each formation passe through, together with a small vial of the drillings of each, w aid much in determining the horizon which the drill is piercin at any depth, and such record and samples should always be kept.

THE MAIN TRENTON ROCK OIL FIELD OF INDIANA.

The main area of Indiana at present producing Trenton rock petroleum in commercial quantities occupies a portion of nine counties northeast of the center of the State, viz., Adams, Wells, Huntington, Grant, Blackford, Jay, Madison, Delaware and Randolph. As shown on the accompanying map, it may be said to comprise about 1,280 square miles, being included within an oblong strip of territory approximately 50 miles long by 24 miles wide, extending from the Ohio-Indiana state line westward to the eastern limits of Liberty township, Grant County, and from Warren, Huntington County, south to Hartford City, Blackford County, and an irregular area of 80 or more square miles south and southeast in Delaware and Randolph counties. This territory comprises all or a part of each of the following civil townships: 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 and Richland, Jay County; Monroe, Greene and Stony Creek, Randolph County; Niles, Washington, Hamilton, Center and Liberty, Delaware County; Van Buren, Boone and Monroe, Madison County. Of these the townships mentioned in Randolph and Delaware counties and Richland township, Jay County, lie some distance outside the main field, but may in the future 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 Wabash, Miami, Hamilton 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 or productive sand is reached are, therefore, as follows: Drift, Niagara limestone, Hudson River limestone, Utica shale. In the eastern half of the field an average section showing the thickness of each formation passed through would be about as follows:

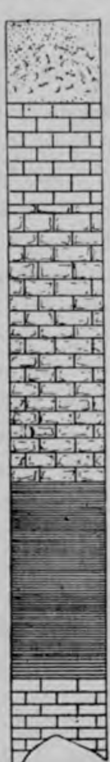


Fig 2.
Eastern.

		Feet.
1.	Drift	125
2.	Niagara limestone	150
3.	Hudson River limestone	425
4.	Utica shale	300

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

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

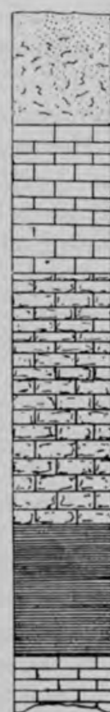


Fig. 3.
Western.

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.

As already noted, two or three "pay streaks" or porous layers are usually found in the Trenton, and it is only in them that oil occurs. The first or upper layer is usually 15 to 25 feet below the top of the Trenton; the second, where present, is 15 to 25 feet below the bottom of the first. In limited areas in Delaware, Randolph and Jay counties a deeper pay streak occurs at 270 to 310 feet below the surface.

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 the 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 fourth issued by this Department in the last ten years. The first, showing the exact area tested up to January first, 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 map brought the field up to January 1, 1904, and embodied 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. The fourth and present map shows the field as it was on January 1, 1907. From it we learn that the productive area has been decreased, several townships which showed a limited production in 1903, now being outside the bounds of productive territory. For the first time, the *abandoned territory*, or that formerly under lease and producing oil, but now having the iron in the wells pulled and the leases allowed to lapse, is shown.

The new productive territory shown on the present map is mostly in Delaware, Randolph and Jay counties. In the first two, the deep pay developments of 1904 and 1905 added an area of some 70 square miles, while in Jay County, several square miles in Bear

Creek township were added in 1905 and 1906. However, the amount of old territory abandoned since the former map was issued, far exceeds that added by the bringing in of new wells on the outside.

GRANT COUNTY,

in which the most westward extension of the main Indiana Trenton rock 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 and Marion and Wabash. The Marion, Bluffton and Eastern traction line also runs to the eastward. 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.

In 1902 and 1903, Grant County became the banner oil producing county in the State, easily outranking Wells, which had formerly held the lead in production. In 1904 and 1905 it was outranked by Delaware County on account of the discovery of oil in the deep pay east of Muncie. While the number of bores sunk in 1906 was less than in 1905, the production held up better than in Delaware, and the two counties are now very close together, with Grant once again in the lead.

Washington Township (*25 N., 8 E.*)—This area of 36 square miles north and northeast of Marion was probably as active in new work in 1906 as any section of equal area in the main field. Most of the new wells were, however, of light caliber, starting at five to 30 barrels. In six months the majority of such wells in the township drop to three to five barrels, and hold up to this production for a long time.

In the northern tier of sections Nos. 1 to 4 may be ranked as shown on the map, while 5 and 6 have produced gas only. The best bore of the year in this tier was on the Callentine lease in the northeast quarter of 3 and started at 30 barrels.

In the second tier of sections, Nos. 7, 8 and 9 are mostly gas bearing, there being only a few light oil pumpers on the Dickens tract in the southeast quarter of 8. Oil is beginning to show in a number of the wells. On leases operated in adjoining sections, as Nos. 10, 15 and 16, much gas is wasted by burning an excess in the boilers, the flames often running out of the stack for 30 or more feet. Section 10 is mostly oil territory, but the yield is light. The south half of 11 is among the best in the township, a half dozen or more wells on the Creviston and Williams farms starting during the year at 20 to 50 barrels. Section 12 is also above the average, the old wells making two to two and a half barrels each per day.

Sections 13 and 14 both comprise fair territory, none of the new wells starting above 35 barrels. The south half of 15 and the north half of 16 are also above the average. The Lewis Smith tract of 200 acres in the west half of 16 is yet untested, as the owner has so far refused to lease.

Bores No. 1 on the N. M. Bradford, and No. 1 on the Ira Bradford, in the north half of the southeast quarter of 16, and No. 11 on the J. T. Bradford, in the southwest quarter of 16, had the following records:

	No. 1, N. M. B. *Feet.*	*No. 2, I. B.* *Feet.*	*No. 11, J. T. B.* *Feet.*
Drive pipe	285	256	341
Casing	509	499	442
Top of Trenton	995	996	994
Gas	1020	1020	1020
Best oil	1040	1030	1055
Total depth	1071	1071	1094
Initial production, barrels	25	60	15

The larger portion of sections 17 and 18 belongs to D. Cretsinger, and was under lease by the Pittsburgh-Columbia Oil & Gas Company. Three bores were sunk on the west half of the southeast quarter of 18, but yielded only gas and a showing of oil. They were therefore abandoned and the leases cancelled. Section 19 is untested. The Wm. Bocock farm in the northeast quarter of 20, had on it two light producers which have been abandoned. The only productive wells are now on the Motter tracts in the south half of the section. All of 21 is now light producing territory. The Sears lease in the east half of the northeast quarter of 22 has been abandoned, but the remainder of the north half of the section remains fair, as does also the greater part of section 23, while the new wells in 24 are only average producers.

The north half of 25 is mostly light territory while the south half has only gas and dry holes to its credit. However, deep drives have prevented much drilling, the drift running 440 or more feet in thickness. The greater part of 26 is fair territory, the northern third of the section grading above the rest. The southeast quarter is in the deep drive and is, as yet, non-productive. Most of section 27 is now light territory, except the west half of the northwest quarter which has been abandoned. The Love tract on the southeast quarter has been a big producer in the past. Section 28 is at present all fairly productive, but a number of the best wells are only a year or two old, while the new ones of the year were mostly light. The northeast quarter of 29 was abandoned after a dry hole or two had been bored on it but was afterward re-leased and is now the best portion of the section.

Sections 30 and 31 and the greater part of 32 are as yet non-productive. The northeast quarter of 32 and the south half of 33 have each yielded a few light wells which have been pulled. The northeast quarter of 34 is the best part of that section. The Corey lease of 100 acres in the center of the south half has been abandoned. The remainder is for the most part light.

The greater part of both sections 35 and 36 has been abandoned.

the bores sunk having resulted in light wells or dry holes. The Allen farm in the northwest quarter of 35 is a fair producer, while all other pumping wells are light.

It will be seen that Washington township is mostly light to fair producing territory. Almost all of its area east of the Huntington-Marion pike has been tested. All recent wells have had a small initial production, but the older drilled portion holds up well, and the township will yield a good output of oil for several years.

Van Buren Township (25 N., 9 E.)—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 until the present the drill has been kept almost constantly going in Van Buren township, and 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. While most of its territory was classed as good on the former map, many of the leases had at that time been drilled out; i. e., had bores on all the locations. The production has naturally fallen until such territory must now be classed as fair or light. But few big producers have been finished in recent years, but the yield is yet large on account of the great number of wells. The present rank of most of the sections is shown on the accompanying map and only new developments of special interest are herewith noted.

Section 2 has increased in output and may be regarded as fair average territory. A record of No. 4, finished November 7, 1906, on the M. R. Green tract in the northeast quarter of the southwest quarter showed:

	Feet.
Drive pipe	174
Casing	460
Top of Trenton	992
Gas	1007
Oil	1020
Total depth	1046
Initial output, barrels	20

A deep pay well was sunk in 1904 on the Wisehart lease in the northeast quarter of section 2. This bore penetrated the Trenton limestone 347 feet, but found no oil except in the first pay.

Several wells starting at 40 to 60 barrels were drilled in sections 5 and 7 during the year. Of these, No. 22, on the A. Pulley tract, finished August 18, in the southwest quarter of 7, had the following record:

	Feet.
Drive pipe	156
Casing	439
Top of Trenton	1003
Gas	1012
First oil	1018
Best oil	1038
Total depth	1085
Initial output, barrels	65

A dry hole was drilled on the Kirkpatrick lease in section 15 where 14 producing wells were located. A bore on a town lot in Van Buren, finished in July, in territory once abandoned, started at eight barrels.

Section 32, marked light on the old map, is now fair to good territory. No. 17, finished in September on the Hayes farm in the southwest quarter, showed the following record:

	Feet.
Drive pipe	412
Casing	441
Top of Trenton	972
Gas	987
Oil	1005
Total depth	1032
Initial production, barrels	30

Monroe Township (24 N., 9 E.)—The north half of this township has in recent years produced considerable oil, but the territory has been very spotted, dry holes and gas wells alternating on many of the sections with fair to light oil producers. A number of the first leases developed have been abandoned. In the south half, much of the area is as yet untested on account of the presence of gas. No railway passes through the township and in winter and spring but little hauling of supplies can be done over the mud roads.

The first producing well in the township was drilled by Joshua Strange in October, 1895. It was on the southwest quarter of section 10 and the oil rose 600 feet in the bore, the top of Trenton having been struck at a depth of 987 feet. From that time to the present drilling has continued and in 1906 quite a number of new bores were sunk, the most of which came in as light to fair producers.

The five new bores in sections 1 and 2 were either light or dry. Two of these, on the Eikenberry farm in the west half of 1, came in as an eight barrel producer and a dry hole. The former producing wells in section 3 have been abandoned. The only production in sections 4 and 5 is in the north halves. On the A. Haines farm in the northwest quarter of 7 there are 18 bores, two of which came in during the year as 5 and 12-barrel producers.

On the Hockett farm in the northeast of section 6 two old gas wells were drilled deeper and put to pumping but only yielded one-half barrel each and were abandoned. The west half of the section is still fair territory. Some light producers have been drilled on the south half of 7, while those on the north half, formerly productive, have been pulled. Section 8 is undrilled, while the productive leases formerly in 9 have been abandoned. The north half of 10 is also undrilled, the northeast quarter never having been leased. The south half contains several light wells. Sections 11 and 12 still continue lightly productive, except the southwest quarters of each which have been abandoned. A bore on the Hoover lease in the northwest of 12 was barren. Four or five bores were sunk on section 13 during the year, one of which was dry, while the rest started at less than 20 barrels. The southeast and northwest quarters of 14 are light; the remainder undrilled.

Section 15, where some of the oldest wells in the township are located, is mostly light; many of the wells doing less than a barrel a day. Only gas is produced in 16, while the wells in 17, formerly productive, have been pulled.

All of 18 except the northeast quarter is productive but light, the new bores starting at 10 to 15 barrels. There is no production in sections 19 to 22, the few wells formerly yielding having been abandoned. There are a few light wells on the northeast of 23 and the north half of 24, while all of those in 25 are of the same kind. Sections 26 to 33 are either undrilled or produce gas only. A number of light to fair wells were sunk on the south half of 34 during the year; the best being on the Moore lease in the southwest corner.

There are several light producers on the Hogston, Myers and Hinicker leases in the south half of 35 and also a few in the southeast of 36. A dry hole on the J. Palmer in the southwest of 36, finished in September, had the following record:

	Feet.
Drive pipe	227
Casing	403
Top of Trenton	995
Gas	1030
Water	1049
Total depth	1077

Centre Township (Sections 1 to 24, 24 N., 8 E.)—This township, in which the city of Marion is mostly located, has been pretty thoroughly drilled, and its area has proven, for the most part, productive. A large portion of the older tested territory has, however, been abandoned and the later wells are mostly light producers.

But one bore was sunk in section 1 during the year. It was on the Mang farm in the southeast corner and started at only 10 barrels. All the section is light territory, as is also the east half of 2, the west half of the latter section being better. Two bores on the Myers and Levi farms in section 3 came in at only 5 barrels each, but the section as a whole ranks fair. There are but a few light wells in the east half of 4 now being pumped, the greater part of the section having been abandoned. There is no production in sections 5, 6 and 7, the southeast quarter of 5 having been abandoned, as has also all former production in section 8. In section 9 the Jones tract in the southeast quarter is fair territory, but the remainder is only light or abandoned. Section 10 is still producing, some of the wells having an average output, while more are light.

But one bore was sunk on section 11 during the year and it started at only three barrels, while section 12 is also light territory. The Overman and Nelson tracts, in the east half of 13, were abandoned during the year, while the remainder can only be classed as light. A deep pay bore on the Bartlett tract in the northeast of 13 was sunk 316 feet into Trenton. A light pay was reported at 285 feet in, but it was not sufficient to warrant the shooting of the well. Section 14 grades the same—the southwest quarter perhaps a little better. The greater part of the south half of 15 is yet fairly productive, but a portion of the west half of the section has been abandoned, although it was the best territory in 1903.

In section 16, the E. Van Vactor farm in the southeast quarter was once abandoned but is now fair producing territory. On the Horner tract in the northeast quarter of the section were sunk the best new bores of the year in the township; six of them, Nos. 14 to 19 inclusive, starting at 30 to 75 barrels each, while No. 13 was a dry hole.

The McClain and Steele leases on the west side of the river were in part abandoned. In section 17 the Hays and Overman farms are still fairly productive, while the rest has been, for the most part, abandoned, as has also all former productive territory in sections 18 and 19 except the Davis tract in the southeast of 19, which has on it several light pumping wells.

Section 20 is yet all light productive territory except the south half of the southwest quarter, which has been abandoned. A dry hole was put down on the northwest quarter of 21, while the remainder is light. The northwest quarter of 22 is yet up to the average in production, but the remainder is lighter. The greater part of the north half of 23 has been abandoned, the remainder of the section being lighter. The best portion of 24 is in the northwest quarter. The Coulter tract, comprising the northeast quarter, has been abandoned, while the remainder is very light.

On October 1, 1906, Bell & Kilgore sold to the Corn Planters' Refining Company 1,300 acres of leases in sections 22 and 23, Centre, and 26 and 27, Mill townships, on which were 79 wells, making a total of 85 barrels per day, for $65,000.

Mill Township (Sections 25 to 36, 24 N., 8 E., and 1 to 12, 23 N., 8 E.).—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. The area has proven very spotted in nature, and the map shows most of the available information regarding the grade of each section at present. A test bore sunk in July on the E. Thomas tract in the southwest quarter of section 25 resulted only in a small gas well. In 26 only the south half has been drilled and it has been abandoned. The Spencer tract in the center of the south half of section 29 has been abandoned, while new bores in the north half of 30 started at 40 or more barrels. Two dry holes were bored in section 35 and one in 36 during the year. A test on the Haines tract in the southeast quarter of section 11 started at 10 barrels. The northeast quarter of the section has on it three light producers and one dry hole. Several new wells with small output were drilled on the J. Hubert tract in the southeast of 12.

But 14 bores were sunk in Mill township during the year, while 19 old wells were abandoned. Of the new bores, three were dry and the 11 producers had a total initial output of only 77 barrels. The record therefore, is not a promising one for the future.

Fairmount Township (Sections 13 to 36. 23 N., 8 E., and 1 to 6 22 N., 8 E.).—This township first began to show oil in 1902. Most of its area had been for years under lease 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 southwest corner of the township, where three or four sections had an output above the average. Several sections along the north border have also yielded a number of light producers.

The wells sunk in the last two years have been much lighter and the output has dwindled to a small percentage of what it was in 1903 and 1904. During 1906 but ten new bores were sunk in the township. Of these six were dry while the number of abandoned wells was 48. The initial output of the four producing wells was but 23 barrels. The map shows the location of the abandoned territory, once productive, and also the grade of that now producing.

Dry holes were put down in the northeast quarter of sections 13 and 14 during the year. Some old gas wells were drilled deeper in the northeast of 14, but the results were not encouraging. A test on the La Rue farm in the southeast of 17 was also barren.

On the M. Wright tract of 136 acres in the southeast quarter of section 25, five wells two and a half years old were making a total of 7 barrels a day on November 1st. A record of No. 1 shows:

	Feet.
Drive pipe	190
Casing	370
Top of Trenton	950
First pay	975
Second pay	1030
Total depth	1050
Initial output, barrels	50

A bore, the site of which was located by a hazel rod diviner, was sunk on the Alfred tract north of Fairmount, to a depth of 1,300 feet, but found only salt water. All of the leases operated in sections 19, 30 and 31 by the Pittsburgh Plate Glass Company were closed down in February, as the production was very light and a heavy body of salt water retarded pumping. The leases in sections 4 and 5, southeast of Fairmount, which produced so heavily in 1903 and 1904, have also been for the most part abandoned, there being only a few light to fair producers in the west half of sections 4 and 3.

The only production in section 2 is on the southeast quarter. On the Mason tract of 42 acres there were three wells making six barrels per day on November 1st. Two wells had been abandoned. An average record showed:

	Feet.
Drive pipe	170
Casing	380
Top of Trenton	960
First pay	990
Second pay	1025
Total depth	1040

Liberty Township (23 N., 7 E., and sections 1 to 6, 22 N., 7 E.)—This township lies just to the west of the known productive territory of the main Indiana field. Only a few sections along its eastern side have produced oil in commercial quantities, and the most of the leases on them have been abandoned. At present there are only a few light wells pumping west of the town of Fairmount, in sections 23 and 25.

Franklin Township (24 N., 7 E.)—This township lies just west of Marion and only a small portion of it has been found to be productive. This was mainly in what is known as the West and South Marion Town Lot area, in sections 1, 11, 12 and 13, Franklin, and sections 17 and 18 Centre townships, where 209 producing wells were sunk in 1902 and 1903. These soon went the way of other town lot developments, the majority of them being abandoned before they paid out. All of section 11 was overcome by salt water and the last of the wells abandoned in October. The only production in the township is in the south half of 12, where 21 wells are yet pumping on the Coggeshall and other tracts, their average production being about one and a half barrels each per day.

Jefferson Township (23 N., 9 E., and sections 1 to 6, 22 N., 9 E.)—Up to 1903 this township was one of the big gas producing areas of the State. During that year a number of wells in different parts of the area began to show oil with the gas, and many of the old gas wells were drilled deeper and a number of new bores sunk for oil. Since then many of the undrilled sections have been tested for oil, but the results have, in the main, been disappointing, as only light to fair territory has been opened up. The status of the new wells may be gauged by the result of operations in the year 1906, when only 16 new bores were sunk. Of these three were dry while the 13 producers had a total of only 58 barrels initial output. During the year 40 producing wells were abandoned. The map shows the present grade of the territory which has been tested in the township.

In the north half of section 2, east of Upland, there are a number of pumping wells that average three and a half to four barrels each; yet this small output grades them at present as fair producers. A test on the M. J. Brown lease in the south half of 11 came in dry. On the Jones farm in the southeast quarter of 19, where a tract of new territory was opened in 1905, but one bore was sunk, which started at only two barrels. Its record showed:

	Feet.
Drive pipe	187
Casing	375
Top of Trenton	933
Total depth	1035

Some better wells were drilled in the north half of 20, one on the Waite lease starting at 25 barrels. Of three bores sunk on the northeast of 27, one started at five barrels while the other two yielded water and nothing. Sections 29, 30 and 31 have only eight producing wells scattered throughout their areas. All are light in output, the best, Nos. 1 and 2 on the John Little farm, in the northwest of 31, starting at 15 and 20 barrels respectively.

MADISON COUNTY

lies south of Grant 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 and Elwood.

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; Summittville, 879.

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.

Boone Township (Sections 7 to 36, 22 N., 7 E.)—A number of bores have been put down in section 9 of this township, which have produced oil in commercial quantities. The only one sunk during the year was on the W. H. Davis farm in the northeast quarter of the section. It had an initial production of only 10 barrels. This region has yielded a large amount of gas in the past, and may in the future be more productive of oil. Where sunk any distance below the top of the pay streak there is much trouble with salt water.

Van Buren Township (Sections 7, 11, 14, 23, 26 and 35, 22 N. 8 E.).—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 which have been abandoned, while three bores sunk on the C. M. Leach lease in the northwest quarter found gas alone.

Quite a pool was opened up in 1903 and 1904 in section 11, but the wells were for the most part light, and some of those in the northeast and southwest quarters have been abandoned, as has also the small productive territory east of Summittville. Not a bore was sunk for oil in the township during the year. Many of the old gas wells might yield oil if drilled deeper and cleaned, as they were originally sunk only a short distance into Trenton.

Monroe Township (Portions of 21 N., 7 E. and 21 N., 8 E.)—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 for a long time interfered greatly with their operation and the drilling of a number of dry holes in 1904 and 1905 has not added prestige to the region. As a consequence nearly all of the wells first in operation have been abandoned. But one bore was sunk in the township during the year. That was on the Frazier lease in the southeast quarter of section 28 and came in dry.

The only leases now producing in the township are the Bowers, in the northeast quarter of section 32, which may be classed as fair; the Jarrett in the southwest of 15, which is light, and the Painter lease in the southwest quarter of section 8, where a few light wells are still pumping.

HUNTINGTON COUNTY.

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, tenacious 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 the 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 Wabash Valley Traction line parallels the Wabash Railway across the county.

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. A bore sunk within known productive limits in this area is as sure a venture as one can make anywhere in the United States in the oil business. This is proven by the following table of statistics for the last four years:

	Total Bores.	Dry Holes.	Percentage of Dry Holes.	Average Initial Output, Bbls.
1903	312	10	3.2	19.4
1904	332	8	2.4	18.2
1905	161	2	1.2	19.3
1906	123	2	1.6	13.6

Not only is the percentage of dry holes less than in any other county in the State, but the wells hold up as well or better than elsewhere.

Wayne Township (E. 2-3 of 26 N., 8 E.).—This civil township comprises only 24 square miles in the southwest corner of the county. The oil production has been limited principally to the two eastern tiers of sections which lie east of the Huntington-Marion pike. Being on the western border of the main field and distant from railway facilities the operations partake somewhat of the wildcat variety. On that account, more new work was done in the township in 1906 than in either of the other two to the east.

Sections 1 to 4 and 9 and 10 are non-productive, the one or two light wells formerly drilled in the southeast of 1 having been abandoned. The east half of 11 and all of 12 are producing, but the wells are in general light.

The Pinkerton lease of 132 acres in the southeast of 12 has on it twelve wells which were producing an average of four barrels each in October. Two dry holes were sunk on the Billiter tract during the year. The east half of 13 is fair territory, as is also all of 24, the east half of 23 and all of 25. No. 3 on the Searles lease in the southwest quarter of section 24 pumped 90 barrels the first 11 hours, but No. 6 was dry. Several good producers were also finished on the Detamore tract in the southeast of 25, No. 4 starting at 80 barrels.

About 3,000 acres of leases in the southeast part of Wayne township are operated by the Wagner Oil Company. This company has sunk 121 wells in Wayne and Jefferson townships and claims never to have drilled a dry hole. But two bores were drilled by them in 1906, both on the southeast quarter of 36. A record of No. 7 shows:

	Feet.
Drive pipe	223
Casing	521
Top of sand	1037
Total depth	1087
Initial production, barrels	15

The net production of the Wagner company from their 121 wells operated on their leases during the year 1906, by months, was as follows:

	Barrels.
January	4961
February	3837
March	5029
April	3755
May	4290
June	4562
July	4428
August	3445
September	3880
October	5745
November	4052
December	4166

To the above the royalty of one-eigth should be added.

On the property of the Wagner company there is plenty of gas for operating. But little water is encountered, two-inch tubing being used in all the wells. Two pay streaks are found, one at about 25 feet, the other at 52 feet in the Trenton. Each pay runs five to 20 feet in thickness. A bore on the Bond lease in the west half of 36 was drilled 349 feet into Trenton in search of a deep pay, but without results. Ten wells drilled on the lease in 1904 and 1905 started at 70 to 120 barrels each.

Jefferson Township (26 N., 9 E.).—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. Sections 6, 7, 8, 17 and 18, marked as undrilled on the former map, have since been pretty thoroughly tested. This territory was formerly mostly owned by the Huntington Light & Fuel Company, and utilized for gas. It was sold to the Wagner Oil Company and opened up for oil in the spring of 1905. This company drilled 6 test wells and, on October 4, 1905, sold them and 1,300 acres of leases to the Beatty-Nickle Oil Company for $15,000 cash. The latter company drilled 26 additional wells, but most of them were light, and they only brought the daily production up from 15 to 100 barrels. The map shows the present standing of the tested territory in the township.

A dry hole was drilled on the Boyd tract in the northeast of 4, and others in the southeast and northwest of 5 and the northwest of 6. Several leases in 5, 6 and 8 have been recently abandoned without being tested and there is at present no production in any one of the three sections. A dry hole was sunk on the Boyd farm in the northwest quarter of 17 and two others on the northeast quarter of the same section. Section 21 and the north halves of 25 and 26 have yielded a number of light to fair wells.

In section 28 a number of wells, when first drilled, were only sunk 25 to 30 feet into Trenton. They have recently been drilled 50 to 60 feet in and then cleaned, resulting in 30 to 50 per cent increase in their output. Section 29 is one of the best in the township, almost every location being drilled. Some of the wells are three to four years old, but hold up remarkably well.

The Troy Oil Company has drilled 121 wells in sections 28, 29, 30 and 32 and are pumping every one. In 32 there are 68 wells on the 640 acres, which were averaging one and a half barrels to the well on November 1st. In November, 1903, the same 68 wells were making four barrels each. A record of an average bore on the section shows:

	Feet.
Drive pipe	200
Casing	450
Top of Trenton	1004
Total depth	1059

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.

Not over ten bores in the entire southern tier of sections 31 to 36 have proven barren. Two put down on the west half of the southwest quarter of 34 yielded salt water only. No. 7, on the Roberts lease in the southeast quarter, finished in July, had the following record:

	Feet.
Drive pipe	236
Casing	451
Top of Trenton	992
Gas	1007
Oil	1025
Water	1045
Total depth	1046
Initial production, barrels	75

Salamonie Township (26 N., 10 E.).—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:

	Feet.
Drive pipe	58
Casing	385
Top of Trenton	1007
Total depth	1087

The only drilling in section 13 has been on the McElhaney lease, northeast quarter, where two or three light producers were brought in. There is no gas in this region, and the wells, as well as those across the line in sections 7 and 18, Liberty township, Wells County, are pumped with a crude oil engine.

In sections 19 and 20, just west and north of Warren, a number of fair wells were drilled in 1900, but at present all have been abandoned except a few on the Jones tract, which yield one or two barrels each. Several dry holes on 20 stopped farther drilling northeast of Warren.

The oil bearing stratum about Warren is said to be rather solid and flinty and is not shattered as much by shooting as is the more porous pay streak in other parts of the field. It yields but little gas, but bears some pyrites, especially in the upper pay.

Section 36, near Mt. Zion, was formerly known as salt water territory. The water has now gone down and 25 or more new wells, all good ones, have been drilled on the section. The top of Trenton is here found at just about 1,000 feet and the bores are sunk 100 feet into that formation. The average well 18 months old makes about 2 barrels daily.

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 corner 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 and 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 and Fort Wayne traction line.

The elevations in feet above tide of the principal railway stations in the county are as follows: Hartford City, 896; Mill Grove, 931; Montpelier, 867; Renner, 907.

About one half 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 much spotted territory. Montpelier, near its northern boundary, being the closest railroad town to the rich fields of the southern part of Wells County, has since the beginning of operations 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.

Washington Township (24 N., 10 E.).—This township has a record for bringing in good producers in unexpected localities. Several of them were finished in 1906, and the township produced more oil than all the rest of Blackford County. The production has, however, fallen off gradually during the past three years, so that most of the sections marked good on the former map are now only fair or light.

A dry hole was sunk in November on the Williams farm near the center of 1, and most of the wells on the Leonard tract, northwest of 2 have been abandoned. Sections 1 to 6 are now all light, the old wells averaging one to one and a half barrels a day, while the new ones start only at 3 to 15 barrels.

The best wells drilled in Blackford County during the year were on the south half of section 7. On the Rix farm in the southwest quarter No. 1 started at 100 barrels while Nos. 2 and 3 made only 5 and 3 barrels respectively. No. 7 on the A. Nelson farm in the southeast quarter started at 100 barrels, and No. 4 on the L. Johnson farm, 500 feet south, at 140. The latter well, finished in May, is said to have yielded 80 barrels a day for three months, but by November 1st was down to five barrels.

All new bores in sections 8 to 10 were light. The southeast quarter of 11 and the north half of 12 have been abandoned, while the south half of the latter section is very light. The area embraced in sections 13 to 18 is now all light, though part of it was formerly among the best in the township. The Bird lease in the southwest of 19 has been abandoned, as has also the Zimmerman tract, east half of the southwest quarter of 22. A bore on the J. Groff farm in the northeast quarter of 22 was sunk 600 feet into Trenton but was barren except in the shallow pay.

Section 31 in the southwest corner of the township developed a number of light to fair wells during the year. The Miles lease in the northeast quarter was the best, one or two of the wells starting at 100 barrels. A large supply of gas was produced with the oil. This lease had been previously cancelled by a company which had not deemed it worthy of testing. The Miles lease in the west half of the northwest quarter of section 32 also yielded two fair wells, while a test on the Fortner lease, just east, was barren. The south half of the section has as yet produced gas only, all the bores being sunk only a short distance into the pay. The southwest quarter of 33 and the southeast of 34 are as yet untested, while the remainder of the sections are light or abandoned. Section 36 has yielded oil only in the northeast quarter, but all the wells are now abandoned.

Licking Township (23 N., 10 E., and Sections 1-6, 22 N., 10 E.)—This township has 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 wildcat bores sunk in the township 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 two or three of them were finally abandoned. While 70 per cent. of the wells in the pool probably paid out, not over 5 per cent. made a profit.

At present the production is limited to the northern two tiers of sections, the only new territory added since the former map being in sections 6, 7 and 8, where a number of light wells were brought in, most of which have been abandoned. The leases on a large acreage of territory in the southern part of the township, taken up for gas and oil, have recently been returned to the farmers. These were mostly in sections 12, 13, 14, 19, 25, 27, 28, 33 and 35. The new map shows the present grade of the producing sections.

In 1906 a test on the Steele farm in the north half of section 5 started at 15 barrels. New work on the Johnson tract in the north half of 6, which in 1905 had yielded a number of fair wells, was not encouraging, as five bores resulted in two dry holes and only 13 barrels initial output from the three producers. The southeast quarter of 6, the east half of 7 and the northwest quarter of 8 were abandoned during the year, as was also all the producing territory in 9.

The northwest quarter of the northwest quarter of 10 has on it two producers, one a crevice well five years old, that is said to be still yielding 10 barrels a day. All other former producing wells in the township have been abandoned except a few in the southeast quarter of 22 and the north half of 27.

Four producers with an initial output of 28 barrels and four dry holes were completed in the township during 1906, while 20 wells were abandoned.

Jackson Township (23 N., 11 E.)—Although this was formerly counted one of the best gas producing townships in the State, only a few sections in the northwest corner have yielded oil, and the wells on them have been abandoned. Where the gas has been exhausted salt water has taken its place. Therefore the chances of successful drilling for oil over the greater part of its area seem at present very slight. Many of the leases held for gas and oil were cancelled during the year.

During the deep pay excitement in the Muncie field in 1904 several bores were sunk in search of deep pay oil in this township, but without results, gas only being found and that in the upper pay. The location and depth of three of the bores were as follows:

J. A. Painter tract, S. E. 1/4 Sec. 1, 300 feet in Trenton.

Thomas Day tract, S. 1/2 N. W. 1/4 Sec. 13, 450 feet in Trenton.

H. Flatter tract, E. 1/2 S. W. 1/4 Sec. 21, 440 feet in Trenton.

Harrison Township (24 N., 11 E. and Sections 6, 7, 18, 19, 30 and 31, 24 N., 12 E.).—This township comprises 42 square miles, 27 of which have produced oil in commercial quantities. One of the oldest wells in the State, drilled in 1890, is located in the southern outskirts of the town of Montpelier. It started with a good flow of gas and about 25 barrels of oil and is said to be still pumping. Many of the first producing leases in the township have been abandoned in the last two years and the output of all has greatly decreased. The map shows the present grade of those still yielding.

Section 6 in the northeast corner is one of the best in the township. On the Shinn farm of 80 acres in the northeast quarter, 10 wells were sunk, the last one of which yielded eight tanks the first month and seven tanks the second. It was the best well on the tract, and proves that one cannot foretell what a lease will yield until it is thoroughly drilled. The well is now three years old and yielding only one and a half barrels per day.

On the Dawley lease in the northeast corner of the section a bore to deep pay was drilled which came in barren and had the following record:

	Feet.
Drive pipe	106
Casing	330
Top of Trenton	1061
Total depth	1436

The Lacy tract, southeast quarter of 11, after being once abandoned by the Ohio Oil Company, was taken up by the Federal Oil Company and nine wells drilled on it, all of which were light producers. It was abandoned a second time in June, 1906, when the nine were making a total of only two and a half barrels a day.

Leases on the Stoller tract of 160 acres in section 35 and the Walker farm of 80 acres in 29 have been recently cancelled. A bore on the Deerduff lease, east half of the northeast quarter of 30, was sunk 352 feet into the Trenton, but without results. Another deep pay, also dry, was sunk on the Taylor farm, southwest of 32, to a depth of 435 feet into Trenton.

But five producing wells, with an initial output of only 27 barrels, were drilled in the township during 1906, while 42 were abandoned.

WELLS COUNTY

comprises an area of 367 square miles lying south of Allen, west of Adams, north of Jay and Blackford, and east of Huntington and Grant counties. 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 abundantly 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. The Chicago & Erie touches its northern border, while the C. B. & C. runs southeast from Bluffton to Portland, Jay County. The Muncie, Hartford & Ft. Wayne electric line parallels the Ft. W., C. & L. Railway and furnishes easy outlet to the northeast and southwest; while the Marion, Bluffton & Eastern, just completed, furnishes another mode of transportation to the westward.

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 and Delaware counties. However, the townships of Nottingham and Jackson still rank as among the best productive territory in Indiana. As few dry holes are drilled in them as in any other similar area, and a number of new productive wells are each year added to those already existing. Chester township is more spotted, and a number of the more recent bores sunk within its area have proven very light or dry. 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 western part of Liberty township may yet develop several sections of light productive territory.

As in other areas of the main field, the old wells have fallen down greatly in production, while numerous leases have been wholly abandoned. The map shows the present grade of the area now producing.

Jackson Township (25 N., 10 E.)—This township is now regarded as the best territory in Wells County. Nottingham has produced more oil, but recent bores sunk in Jackson have had a larger initial production and the old wells are holding up better than farther east in the county. The G. W. Huffman tract on the southeast quarter of section 1, just southwest of Mt. Zion, has had a checkered career. It was first leased by the Ohio Oil Company, which drilled 13 fair to good wells upon it. Some of them were overcome by salt water, others were pumped dry and the lease was finally abandoned. In 1906 it was re-leased by M. Long of Bluffton, who sunk three new bores between some of the old locations. These started at about 35 barrels each and No. 1, 40 days old, was making five barrels in November. The top of Trenton is found at 1,000 to 1,010 feet and the oil between 25 and 40 feet lower. Below this a heavy body of salt water is encountered. Several bores on the L. Huffman lease, just east, started at 5 to 15 barrels, while one was dry. The Alexander tract in the southwest of 5, after having four dry holes drilled upon it, was abandoned, then re-leased and another one yielding salt water only, was completed.

Some of the best territory in the township is found in the north half of 13, the west half of 14 and all of 15 and 16. The old producers in this area hold up well and the new ones start above the average. A test bore on the Tucker lease in section 20 came in dry. Seven or eight bores were put down during the year on the Jones tract, southeast quarter of 32, which started at five to 20 barrels, with the exception of No. 4, which was dry. One on the L. Cocheran farm, section 33, was also dry.

It will be seen by the map that every section in Jackson township is productive. Very little territory has as yet been abandoned. The new wells average much lighter than were those first drilled, but a very high per cent. of them yield oil, there having been only 4 dry holes drilled in the township during the year, while the number of producers finished was 73, with an average initial output of 7.2 barrels.

Chester Township (25 N., 11 E.)—More new work was done in Chester township in 1906 than in either Jackson or Nottingham. This was mostly on leases already in operation, which had not been as closely drilled as in the other townships. While the producers were mostly small, starting from five to 15 barrels, they hold up well and in time yield a fair profit to both operator and farmer.

Section 1 has so far yielded only a few light wells in the southwest quarter, while the northeast quarter of 2 is undrilled. In section 3 the C. Starr and J. Bowers tracts have been abandoned, as has also the Shadle farm in the southwest of 18.

A number of new wells on the north half of 20 and the south half of 21 came in as light producers. Some of the best wells of the year in the township were on the Irvin leases in the southeast of 23 and the southwest of 24, several of them starting at 50 to 90 barrels. Two dry holes were drilled on the Showalter tract just east of the Irvin in the southeast of 24. Sections 25, 26, 35 and 36, in the southeast corner of the township, have fallen off greatly in production and a number of the old wells have been abandoned. On the Spellacy lease in the south half of 26, 15 wells were making but one-half barrel net each per day in November, but as only one man was required to pump them the lease yet pays well to operate. A dry hole was sunk on the C. Abshire lease, northeast of 25. The sections in the southwestern part of the township are all light in output.

Nottingham Township (24 N., 12 E. and the west two tiers of sections in 25 N., 13 E.)—This is one of the oldest and best producing oil areas of the State, a number of the wells having been drilled in 1891. In late years, however, the decline in production has been rapid, as the new wells were mostly light. As a consequence many leases have been abandoned.

As shown by the map, there has been little or no production in the northeast quarter of the township. A large portion of section 5, in the northwest corner, has been recently abandoned, as has also a part of the southeast of 7 and the southwest of 8. A number of "second crop" wells, starting at 15 to 30 barrels, have been drilled in sections 17 and 18 on farms which had been abandoned and then re-leased. One of these on the Dickinson tract, in the northeast quarter of 18, had the following record:

	Feet.
Drive pipe	38
Casing	332
Top of Trenton	1005
Total depth	1050
Initial output, barrels	30

When 40 days old the production was seven barrels per day, and it is estimated that the well will yield two barrels at the end of six months. A bore on the Bryan farm, northwest quarter of 19, was sunk 370 feet in the Trenton in search of deep pay, but without results.

Nos. 1 and 2, on the Dulinskey farm, southwest of 22, started at eight and ten barrels respectively. The Dall tract in the same section has been abandoned, as has also the southeast of 26 and scattered wells in 27. In sections 30 to 34 many of the wells have been abandoned and those remaining are pumped long distances, isolated wells sometimes being one-half mile from the power. The north half of 35 has been abandoned, while a test on the Romans farm in the southwest quarter of 36 came in barren. In fact, the southern two tiers of sections, comprising 16 square miles, once the cream of the main Indiana Trenton rock field, have been reduced to strippers which yield not more than one-third of their former output.

Harrison Township (26 N., 12 E.)—Only the southern portion of this township has been tested and the results were mostly negative. Dry holes have been drilled on the center of the southwest quarter of section 19; in the northeast corner of the northeast quarter of 29; on the southwest quarter of the same section; on the southeast corner of the northeast quarter of 31; on the south line of the west half of the northwest quarter of 32, and on the northwest quarter of 36.

Light producing wells were completed in 1904 and 1905 on the J. E. Valentine tract in the southeast quarter of 32, and on the Harnish, in the southwest corner of 33, but have since been abandoned. Two light producers on the Barton farm in the southwest of 32 are still pumping. No bores were sunk in the township in 1906.

Liberty Township (26 N., 11 E.)—The only producing territory in this area of 36 square miles is on three or four sections in the southwestern corner. Bores have been put down on eight or ten other sections, most of which came in dry or very light producers.

In the northwestern part of the township, sections 7 and 18 have developed four or five light wells and several dry holes. The production is mostly on the Thompson lease, in the southwest quarter of 7, and is from a part of the pool opened up just to the west in section 12, Salamonie township, Huntington County. A dry hole has been sunk on the southeast corner of the same lease, and another on the Messburg farm on the same section. There is no gas to operate the power and crude oil is used for that purpose.

The light producers marked on the former map as yielding in the southwest of 18; the northeast and southwest of 17; the southeast of 19 and the southwest of 21 have all been abandoned. During 1906 dry holes were drilled on the southwest of 19, the northeast of 31 and the northwest of 34. In the latter the top of Trenton was struck at 1,016 feet. The salt water was cased off and the drilling continued to a depth of 1,593 feet, or 487 feet into Trenton. What the drillers call "buckwheat sand" was found all the way below 1,116 feet.

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 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 wells; while Jefferson and Blue Creek, on the east, have, in recent years, yielded quite a number of producers, but they do not hold up as well as those farther west.

As in other parts of the Indiana field, many of the older wells are being abandoned, and all of them are much lighter in output than a year or two ago. The map shows the present status of the producing sections.

Blue Creek Township (Sections 3 to 10, 15 to 22 and 27 to 34, 26 N., 15 E.)—Most of the new development in recent years has been in this township and in Jefferson to the south. Only about half of the area of 24 miles is or has been productive, and that is in the southern portion. All former production in sections 9, 10, 16 and 17 has been abandoned, but a few light wells are yet pumping on the south half of 15. The Grim tract in section 27 has been recently abandoned, but the remainder of the section, as well as 22, to the north, is lightly productive.

In 21 and 28 dry holes represent the only bores. The Pruden lease in the southwest quarter of 29 has seven light wells and one dry hole to its credit, while the only production in 30 is from a single well in the southwest quarter.

Section 31, once famous for its good wells, which were the first drilled in the township, is now all light territory, with many of the old wells abandoned. The Federal Oil Company, which a few years ago bought the holdings of the Superior Oil Company, the pioneers of Blue Creek Township, operates the most of the wells in section 31. The 214 wells of the Federal Oil Company in Adams County, yielded an average of only 175 barrels a day during the months of September and October, which was about eight-tenths of a barrel per well per day. However, even at this rate they pay well for operating.

The west half of 32 is still producing, but the east half has been abandoned. A dry hole on the southeast was put down 232 feet into the Trenton. In 33 the only bores finished have been barren, while 34 has some light producers on the southeast quarter.

But one bore was sunk in Blue Creek township during the year 1906, while 17 old producers were abandoned. The new bore was drilled on the Studebaker lease in the southeast of 31 and started at 20 barrels.

Jefferson Township (Sections 3 to 10, 15 to 22, and 27 to 34, 25 N., 15 E.)—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 wells have been drilled in the south half of the township, but except in sections 5, 6 and 16, most of the tests in the north half have proven dry or very light.

Section 3 in the northeast quarter is one of those which so far have proven barren, while the only production at present in 4 is in the south half. Sections 7, 8 and 9 are as yet also barren, a dry hole on the Macy tract in the southwest quarter of 7 and two or three of the same kind in each of sections 8 and 9 representing the bores hitherto put down. The southeast quarter of 16 has eight fair wells to its credit, but the remainder, as well as most of the territory in 15, 17 and 18, is abandoned or dry. Section 22 has proven one of the best in the township, several bores on the Yaney and Fetters tracts starting during the year at 40 to 60 barrels, while the Huffman lease in the northeast quarter is up to or above the average.

Tests drilled during the year on the Finety and Rehart leases in the north halves of 27 and 28 started at 8 and 40 barrels respectively. The best well of the year in the township was No. 7 on the H. Fogle farm in the northwest of 32, which yielded 110 barrels the first 24 hours, while three others on the same lease started at 15 to 20 barrels. During 1906, 29 bores were drilled in the township, while 32 old wells were abandoned. Of the new wells but one, Huey lease, section 31, came in dry. The 28 producers had an average initial output of 9 barrels each.

Wabash Township (25 N., 14 E.)—Excepting three or four of the southwestern sections, the greater part of this township has proven very spotted, unsatisfactory territory. The lob, or "deep drive," passes from northeast to southwest diagonally across the township and has, up to the present, prevented drilling in a number of sections which might produce much oil. Many of the old wells were pulled during the year and the materials shipped to other points.

All tests made to date in sections 1 to 6 have yielded salt water only, while 7 to 12 have proven but little better. A test on the A. L. French tract in the northwest of 7 came in dry, while all old producers in 8 and 9 were abandoned during the year. One fair well was drilled several years ago on the Farlow tract in the southeast of 10, but as there was no pipe line and no gas for fuel, it was abandoned, as was also all the former producing light wells in sections 13, 14, 16 and 17. The Koeser farm in the southeast of 19 yielded two 75-barrel producers during the year and two others of about one half the size. The south half of 20 has some light wells, but all former producing territory in 21 to 26 has been abandoned.

Sections 28, 30 and 31, which were marked good on the old map, have dwindled in output until the territory is mostly very light; the west half of 30 being the best. In the south half of 31 the top of Trenton is found at 980 and the oil at about 1,005 feet. Many of the wells which started at 50 to 75 barrels two or three years ago are down to one and a half barrels or less at present.

A test bore on the Kramer tract in the southwest of 34 started at 12 barrels, but the former production in 35 has been abandoned, while that in the north half of 36 soon will be.

During the year 1906 nine producing wells and one dry hole were drilled in the township, while 47 old producing wells were abandoned.

Hartford Township (Sections 1 to 4, 9 to 16, 21 to 28 and 33 to 36, 25 N., 13 E.)—The southern half of this township has been the most productive territory in Adams County. It was the first drilled, yielded the biggest wells, and has held up better than any other. Here, as elsewhere, however, the output has fallen off greatly within the past few years. But few if any leases have been wholly abandoned, but the weaker wells on many of them have been thinned out.

The productive territory farthest north is in section 12, where two or three light wells were finished on the Yoder tract in the southeast corner, while a test on the Martin lease in the northwest was too light to pump.

On the Zehr tract in the southeast of 24 are two big water wells thirteen years old. These are but 75 feet apart, yet they made hundreds of barrels of water and enough oil each day to fill eight tanks a month for seven years and are still producing three tanks of oil a month. The Porter lease of 240 acres in the southeast corner of section 25 is an average one for the south half of the township. It is fully drilled, having upon it 27 wells, two of which have been abandoned, while the last one drilled was completed in 1904. The production of the lease in November, 1906, was 40 barrels per day.

During the year the township yielded six producing wells and one dry hole, the former having an average initial output of only seven barrels, while, of the old producing wells 20 were abandoned.

All of the old productive territory in Monroe township north and east of Berne has been abandoned.

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, and the C. B. & C. runs northwest from Portland to Bluffton. In addition to these the Muncie and Portland traction line passes from Muncie through Redkey to Portland, so that the facilities of transportation in all directions are excellent.

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 past two years Jay County has been the seat of the most active operations in the main Indiana Trenton Rock Oil field. Practically the only new territory added to the area of that field in 1905 was in Bear Creek township, and in 1906, while but one or two new sections were opened up, they yielded more new production than any similar area in the State. The new territory does not start off so well as the famous Pennville, Harris and McCallister pools, which a dozen years ago were known and talked of wherever oil men congregated, but it is very much above the average of new development in recent years, and the wells hold up remarkably well.

Many of the older wells in Jackson and Penn townships have been abandoned, and in a number of cases the leases re-leased and re-drilled, the "second crop" wells yielding sufficient profit to more than justify the expense.

Bear Creek township especially was the seat of active operations in 1905 and 1906, most of the territory drilled with success being that which had been condemned by an occasional dry hole, ten to a dozen years before. The map shows the grade of the producing territory at present being operated, and only new developments of general interest are herewith noted.

Wabash Township (Sections 3 to 10, 15 to 22 and 27 to 34, 24 N., 15 E.)—Some new territory has been added to the productive area of this township shown on the former map, but a number of dry holes have rendered it a far more uncertain quantity than the township to the west.

Most of the south halves of sections 4 and 5 have been abandoned. On the Ralston tract in the southwest of 4, several bores were drilled in 1906, but all were light, starting at one to 12 barrels, and they have been abandoned. No new drilling has recently been done in sections 6, 7 and 8. The west half of 7 was once very productive, but all the wells have dwindled until they are very light.

Tests on the Stolz tract, north half of 9 and on the Bricker and Lesher leases in the west half of 17 came in dry or very light. A number of dry holes have from time to time been drilled in the south half of the township. One in the northeast quarter of 32 is said to have been located by "spirits," who assured the owner that he had a lake of oil beneath a certain portion of his farm, and that a bore there located would surely strike it. However, the "tip" of the spirits proved no more successful than that of the hazel rod in the hands of the oil wizard or other fakir. Two light wells are located in the south half of the section.

Bear Creek Township (24 N., 14 E.)—As above noted, some of the best territory drilled in 1905 and '06 was in this area of 36 square miles, sections 28 and 29 proving especially rich. The depth to top of Trenton ranges from 1,014 to 1,035 feet, due mainly to the variation in surface level, there being an actual difference of 12 to 15 feet in the exact level of the Trenton in different parts of the township. Sections 1 and 2 have so far proven mostly light or dry. A bore which came in wholly barren on the Boehn tract in the northeast of 2 was shot and started at more than 100 barrels.

A number of fair wells were drilled in new territory in the north half of section 3 during the year. On the Bryan lease in the northwest quarter Nos. 1, 2 and 3 started at 60, 20 and 40 barrels respectively, while a test on the Shoemaker lease in the northeast made 42 barrels. The southwest quarter has so far yielded only one dry hole, while a light well on the southeast quarter was abandoned.

Some good wells have been found on the southeast of 5, one on the Lineberry tract starting at 125 barrels. Section 7, once good, has decreased much in output. A crevice well on the Sanders tract in the northwest quarter has had quite a history. It started at 90 barrels and held up to 50 barrels for some months, then began to alternate with oil and water, pumping one or the other alone often for weeks at a time. It is now six years old and doing ten barrels of oil per day. A number of second crop wells between the old locations have been recently drilled on this and adjoining sections, most of them starting at 20 to 35 barrels each.

Sections 9, 10 and 16, now in part fairly productive, were at one time owned by the Cudahys, who, after drilling two or three light wells or dry holes, abandoned the territory.

In section 19 there appears to be a high streak of the Trenton, and the tests have yielded gas with only a showing of oil. The leases have mostly been abandoned, but the section may be re-drilled with profit after the gas pressure subsides. Sections 20 to 27, inclusive, have as yet only light oil or gas wells. Several dry holes have also been drilled within their bounds. A bore on the Beal tract in the southwest of 26 yielded 3,000,000 cubic feet of gas which will be piped to Portland.

On the west half of Section 28, fifty or more wells were sunk during the year, it being the most active territory in the Indiana field. The Scotland Oil Company of Bluffton have been among the most successful operators. This company bought the untested Kuhn tract of 40 acres in the southwest of the northwest of 28, paying therefor $1,100. On it they sunk six bores, all of which came in as good producers. Up to November 1st the farmers' royalty of one-sixth had amounted to $2,400. The records of Nos. 1 and 6 on the Kuhn lease showed:

	No. 1. *Feet.*	No. 6. *Feet.*
Drive pipe	78	104
Casing	245	238
Top of Trenton	1004	997
Total depth	1050	1048
Initial output, barrels	80	180

No. 1 was completed January 20 and No. 6 on March 17, 1906. The latter well was making 15 barrels on November 1st.

The Scotland Company have thirteen producing wells and one dry hole on the Kuhn and Flauding tracts, the latter being in the northeast quarter of section 29. Two powers are used, while one well is pumped from the beam. The net output of the 13 wells by months for the year 1906 was as follows:

	Barrels.
January	453
February	1126
March	3124
April	2561
May	2035
June	1696
July	1636
August	1898
September	1325
October	1347
November	1323
December	1304
Total	19.828

To the above the royalty of one-sixth should be added.

The Shimp tract just north of the Kuhn and operated by the Superior Oil Company, of Geneva, was also an excellent one, 14 producing wells having been completed on it during the year.

The wells on the east half of section 28 were lighter, the sand being more erratic. On the Roseborough and Easterday farms in the south half of the section there are 21 producing wells which were making 150 barrels net on November 1st. Nos. 1 and 2 Easterday, and No. 6 Roseborough started at 150 barrels each, both flowing oil for a day or two. But one pay streak is found in this portion of Bear Creek township, being struck anywhere from 15 to 40 feet below the top of Trenton.

In section 29 the best production is on the Flauding tract in the southeast quarter of the northeast quarter. On the Ray, in the northeast of the southeast quarter two bores resulted in a dry hole and light producer. The field record for the dry hole and of the No. 1 Flauding were as follows:

	Ray. Dry hole.	*Flauding No. 1.*
Drive pipe	138	65
Casing	235	235
Top of Trenton	1005	1000
Total depth	1087	1046

The west half of 29 and all of 30 have developed gas only. Sections 31 to 33 are in part lightly productive, while on 34 the only two tests developed big gas wells which sprayed large quantities of oil for a long time.

Jackson Township (24 N., 13 E.)—In the northern part of this area of 36 square miles is some of the oldest and formerly the most productive oil territory of Jay County. In recent years, however, a number of the farms have been abandoned, while the output of all the wells has fallen down to a small fraction of what it was when the territory was first drilled. In a number of instances the farms have been re-leased and a second crop of wells drilled, usually with fair results; though few if any of these new bores started above 40 barrels.

Sections 1 to 5, marked good on the former map, are now light, the average production being little if any over 1 barrel per day for each producing well left. During 1906 one dry hole and a very light producer were drilled on the H. Bair lease in the northeast quarter of section 3, while the south half of 6 and the northwest quarter of 7 were abandoned.

On the Buchtell tract in the southeast of 10 is a crevice well ten years old which, when first drilled, made 101 250-barrel tanks in 100 days. In it the best pay was found 52 feet in Trenton, while in other wells around it the oil was found only 15 to 18 feet below the top. In the spring of 1906 this well was down to three barrels a day and was cleaned and shot, but without increaseing the output to any extent. Another well 150 feet distant on the adjoining lease, was soon after cleaned and shot, also without results, except to cause the Buchtell well to break loose and produce 50 barrels a day for several months.

The south half of the township, sections 18 to 36, inclusive, is very spotted territory. Many of the leases formerly drilled have been abandoned, while a number of bores which came in dry have been sunk in the past two years. The Richison tract in the northwest quarter of section 30 is probably the best lease in this part of the township, No. 17 on it coming in during the year at 45 barrels.

Penn Township (24 N., 13 E., with the exception of the west tier of sections.)—Some of the famous pools in the early history of oil operations in Jay County were located in this township. On account of the lob, or "deep drive," which runs through the north central portion and renders drilling very tedious and often expensive, a number of sections are as yet non-productive. An old preglacial river channel doubtless exists beneath the lob. This was cut 200 feet or more into the Niagara limestone, then filled up and covered with drift by the glacial invasion, so that it is not uncommon to use 400 or more feet of drive pipe in the bores sunk in it before striking limestone. As a result, the region of the lob has been avoided. The wells sunk near it have mostly come in as fair to good producers, and should the price of oil ever rise to a figure which would justify the expense, there is little doubt but that the lob district would become very productive territory. In the last year, the only new work in the township has been in territory formerly condemned or abandoned, then re-leased and redrilled to 65-foot pay, the older wells having yielded most of their production from the upper or shallow pay. Sections 25 and 26 and the east halves of 27 and 35, comprise the bulk of this newly drilled territory, and a number of others now in part or wholly abandoned would doubtless well repay a second and deeper drilling.

Section 2 and the south halves of 3 and 4 have been abandoned, while all the remainder of the north tier is now light. No. 8 bore on the Pugh tract in the northeast quarter of section 8 started at 105 barrels in November, being the best finished in the township for some time.

Noble Township (23 N., 15 E.)—But little oil has as yet been produced in this area, though a number of bores have been sunk in search of it. The northwest quarter of section 3, the northeast of 4 and the northeast of 17 have each from one to three light producers to their credit, while others which pumped a while have been abandoned in the northwest of 5 and the southwest of 27. No pipe lines have as yet been laid to any of the producers, so that their real capacity has not been determined.

Wayne Township (23 N., 14 E.)—But few wells are at present producing oil in commercial quantities in this area. About one-third of the 36 sections have been tested, but the bores have, for the most part, produced gas or salt water only. Such as did produce oil had such a small output that pipe lines were not laid to them and they have been abandoned.

One or two bores which are said to have started at ten to 40 barrels each were drilled in the northeast quarter of section 4, the southeast and southwest of 5 and the southeast of 6, but no one of them is pumping at present.

Three old gas wells in the north half of section 22 are said to have been recently drowned out with oil. A bore in the southwest quarter of the section was drilled 26 feet into Trenton and shot, when the oil rose 300 feet and the well pumped 40 barrels. It was concluded that the sand had not been penetrated far enough, so the tubing was pulled and it was drilled 15 feet deeper and a second shot made, which reduced the output to ten barrels, so that it was soon abandoned.

Other small producers have been abandoned in the southeast of 10, the northeast of 18, the southeast of 21 and the northwest of 26.

Greene Township (23 N., 13 E.)—About one-third of this township has also been tested, but without paying results, there being only a few light producing wells within its area.

There is one light well in the southeast quarter of section 1 and two or three gas wells, which show a quantity of oil in the 65-foot pay, in the southeast of 17; also a light producer in the northeast of the same section.

On the A. Ziegler tract in the north half of the southwest quarter of 19 there is a well which has filled two 250-barrel tanks from the 65-foot pay and would make 15 barrels a day if pumped, but there are no pipe line facilities. A second attempt on the same lease resulted in a dry hole. Some former producing wells near the center of 24 have been abandoned.

Knox Township (Four eastern tiers of sections of 23 N., 12 E.)—Only three sections of this area of 24 square miles have been tested for oil. Three light wells have been brought in on section 1, two in the northeast quarter and one in the southwest quarter. They are not now being operated but have not been abandoned, as have the other producers in the southwest of 11 and the northwest of 4.

Richland Township (22 N., 12 E.)—This civil township, in which the thriving towns of Dunkirk and Redkey are located, comprises but 26 square miles. It lies east of Niles township, Delaware County, and in it have been sunk a number of deep pay bores, some of which came in as fair producers but, as in the deep pay territory east of Muncie, most of them have recently been abandoned. The million-dollar gas pumping station at Redkey has also been abandoned on account of the failure of that volatile fuel.

There are two or three light producers on the south half of 10, but a recent test on the McKinney in the northeast of 12 came in dry. Former producing wells on the northeast of 13 and the southwest of 16 have been abandoned. A bore 2,600 feet deep, was drilled through the Trenton into Potsdam sandstone on the Phillips tract, southwest of 22. A little oil was found 410 feet below the top of Trenton, but not enough to pay for shooting.

A dozen or more good deep pay wells were completed just east of Redkey on the north half of section 24, but the companies operating them have recently broken up financially and the majority of the wells have been abandoned. Some of them started at 100 to 180 barrels per day and when put to pumping regularly made 50 to 60 barrels, but there was no gas to operate and salt water soon got the better of most of them. The south half of the southwest quarter of the section is yet fairly productive.

The best well drilled in Jay County during the year was No. 3 on the Landauer tract in the east half of the northwest quarter of 25, which yielded 300 barrels the first 24 hours, but No. 4, only a short distance away, made but five barrels; while of three on the Corder lease just west, one was barren and the other two light. Four dry holes have been drilled on the southwest quarter and one on the southeast quarter of the same section, while the northeast quarter has been abandoned. The top of Trenton in this vicinity is found at about 1,040 feet.

Pike Township (22 N., 14 E.)—Bores for oil have been sunk only on four or five sections of this township, but none of them have developed the fluid in good paying quantity. A test sunk in 1906 on the Cook tract in the northwest quarter of 19 started at only two barrels. In the south halves of sections 8 and 9 are some seven or eight wells which average about one barrel each per day, the product being pumped into tanks. A bore drilled for gas on the northeast quarter of 34 filled up with oil and ran over the casing but as the farm is distant from railways and pipe lines no farther tests were made.

Madison Township (22 N., 15 E.)—Six sections in this area of 30 square miles have been tested, but most of them yielded gas only. A light well was drilled in on the southeast quarter of 15 and another in the northwest of 23, but as there were no pipe lines they were not pumped. In them the top of Trenton was struck at 1,080 feet, but in some big gas wells in the south half of 33 it was 40 feet higher.

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 contain 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. The G. R. & I. bisects it from north to south and the P. C. C. & St. L. cuts across its northeastern fourth, while the C. C. & L. touches its southwestern corner. The Dayton & Muncie Traction Line also connects Union City, Winchester, the county seat, and Muncie, Delaware County.

The highest land in Indiana is on the middle ridge near Bloomingsport, on the "Summit" between Greens Fork and Martindale Creek, where the elevation on the Peoria Division of the Big Four has been found to be 1,234 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, 1,083.

But a small portion of the western half of Randolph County has as yet yielded oil in any quantity. In 1903 a number of big wells were brought in just northeast of Parker, one of which started at 420 barrels, and averaged more than 300 barrels a day for four months. This led to extensive drilling in that vicinity, and the development of some 15 to 20 square miles north of Parker, in Green and Monroe townships, and south in Stony Creek township. The territory, however, proved to be very spotted, 39 per cent. of the bores in 1903, 24 per cent. in 1904 and 42 per cent. in 1905 proving wholly barren. In the past year a number of leases have been abandoned, while the output of all the wells was greatly diminished.

Outside of this Parker pool but few isolated producing wells have been drilled in the county, and they have been very light in output.

Jackson Township (21 N., 15 E.).—In this township, which lies in the northeastern part of the county, adjacent to the Ohio line, several small producers have been finished in recent years. Two of these, on the Clough lease, northeast quarter of section 9 and northwest quarter of 10, were sunk 285 feet in Trenton, but got oil only in the upper pay and started at about 20 barrels each. Three or four others were drilled on the southwest quarter of section 3 and the southeast of section 4, about 15 miles southeast of Portland, and near the town of Jordan. One of these started at 50 barrels. About 1,200 barrels of tankage was filled and a pipe line put in from the Ohio production to the east. Three of these wells are yet pumping. Other bores just to the west developed gas only, one or two showing a rock pressure of 300+ pounds and a volume of 1,250,000 feet. The top of Trenton occurs at 1,065 feet and the gas and oil about 20 feet lower.

A test bore on the northwest quarter of section 6, near Pittsburg, started at 30 barrels and filled two tanks. A second bore on the same lease resulted in a dry hole and the company went bankrupt.

Ward Township (21 N., 14 E.).—Only two or three sections in this township have been tested. On the Huber farm, northwest of 15, one mile northeast of Deerfield, three light producers have been drilled, but on account of lack of pipe line are not operated. The record of No. 3 showed:

	Feet.
Drive pipe	37
Casing	250
Top of Trenton	975
Oil	993
Total depth	1030
Initial output, barrels	10

Two small producers, which have since been abandoned, were also finished on the Fitzmartin tract in the southwest of section 10. A light well has also been drilled on the Warren farm in the northwest quarter of section 25, one mile north of Saratoga.

White River Township (Parts of 20 N., 14 E., and 20 N., 13 E.).—This is the township in which Winchester, the county seat, is located. The only bores which have produced oil in any quantity within its bounds are on the Pickett and adjoining tracts in the southwest quarter of section 23, two miles east of Winchester. Here six bores were sunk in 1903 to 1905, one of which started at 100 barrels. A pipe line was put in and several thousand barrels of oil produced, but dissension broke out among the members of the operating company and the wells were closed down in the fall of 1905 and have not since been operated. Five of them were yielding a total of 20 barrels per day when shut down. The power house and six 250-barrel tanks are yet in place. The top of Trenton is here found at 1080 feet and the oil 30 to 35 feet lower.

A bore on the Benson tract in the north half of section 15 was sunk 514 feet below the top of Trenton, passing entirely through that formation. The total depth was 1594 feet, and it developed only a small amount of gas.

A number of gas wells in 29 and 30 and adjoining sections, southwest of Winchester, have made quite a showing of oil, but have not been drilled deep enough to fully develop their capabilities of yield.

A test on the A. Brown lease, six miles southeast of Winchester, which developed a light showing of oil and some gas, had the following record:

	Feet.
Drive pipe	227
Casing	335
Top of Trenton	1113
Total depth	1214

Monroe Township.—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.).

More oil has been produced in this township than in all the rest of Randolph County, but in the last two years the new developments have been few and the output has greatly diminished. Most of the producing territory is in the three western tiers of sections.

On the J. F. Wood tract in the southeast quarter of 28, three or four bores were sunk during the year, two of which were dry. The Cowgill tract, in the southeast of 29, developed three light producers during the year and was the only new territory added in the township. Two dry holes and a gas well were completed on the Huston lease in the north half of section 8. The east half of section 9 is yet the best in the township, No. 11 on the Jones lease in the northeast quarter starting at 187 barrels and No. 12 at 75 barrels.

Several good wells were also completed on the Barnard tract in section 16. No. 2, when shot at 270 feet in, was thought to be dry, but was drilled to 300 feet and re-shot, when it started at 100 barrels.

Greene Township.—This township comprises 31 square miles and lies just north of Monroe township. Only four or five sections in its southwestern corner produce oil in commercial quantity, and the wells in these are light. The only bore sunk in the township in 1906 was a dry hole on the C. Reed tract in the northwest of 29.

Stony Creek Township.—This township lies just south of Monroe on the western side of the county. A number of bores have been put down within its bounds, but they, for the most part, resulted in very light wells or dry holes. Some of the more lightly productive which have been abandoned were on the McIntire lease in the southeast of 19 and on the Knobe farm in the northeast of 30.

On a tract of 1,200 acres, leased by the Parker-Marion Oil and Gas Company, part in Perry township, Delaware county, but mostly in Stony Creek township, eight test bores were sunk, all of which were practically dry holes. The company bought the leases, paid rentals for two years, spent, in all, more than $20,000, and got nothing. The record of one of the dry holes on the Thornburg lease, in the southeast corner of section 32, Stony Creek township, may be taken as the average. It showed:

	Feet.
Drive pipe	64
Casing	320
Top of Trenton	956
Total depth	1307

Five of the other dry holes were located as follows: One just south of Windsor; one in the northwest quarter of section 32, Stony Creek township, one in the southwest corner of section 4, in the extreme southeastern corner of the tract, and one in the northeast quarter of section 1, Perry township. One bore on the Swingley lease, in the northwest of 33, Stony Creek, started at about five barrels per day, the oil being found in the upper pay.

No bores were sunk in the township during 1906. The only wells now pumping are some very light ones in the west half of section 21.

DELAWARE COUNTY,

comprising an area of 395 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 and 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 & Eastern, from the northwest; the Central Indiana from the west, and five interurban traction lines, two running west, one north, one northeast and one east, have their terminals in Muncie.

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

Petroleum was first produced in Delaware County, near Gaston, Washington township, in 1897. Several bores on the W. H. Broyles lease in section 36 produced large quantities of both gas and oil. On account of the waste of gas the wells were soon shut down by injunction. The gas pressure in that part of the county has since, for the most part, been too high for the production of oil.

In 1901 and 1902 a number of producing wells were drilled in the shallow sand in Delaware, Liberty and Center townships, north and east of Muncie. Several of these came in as large producers, and while the most of them have been abandoned, a number of the best ones are still yielding.

In the latter part of 1903 a bore on the Michaels lease, in the northeast quarter of section 15, Delaware township, passed through the shallow sand, in which the oil had heretofore been found at a depth of about 50 feet in Trenton, without finding either gas or oil; but at a depth of 270 feet in Trent, struck a pay sand which yielded 160 barrels per day without shooting, and for 35 days pumped natural an average of 70 barrels per day. This was the beginning of what is known as the "deep pay" drilling in Delaware county, which caused the famous oil boom of 1904, during which year the county went to the front as an oil producer. In that year 831 producing wells were drilled in the county with an average initial production of 44.4 barrels. However, in finding the approximate bounds of the productive area, 121 dry holes were drilled during the year. Many of the productive wells were sunk too deep. They were drilled through a second pay in search of a third, and got salt water instead of oil.

During the year 1905 many of the best producers were drowned out, while the output of all was largely diminished. By the first of January, 1906, nearly forty of the forty-nine oil and gas companies of 1904 had gone to the wall. A number of these were stock companies which depended on the boom to aid them in disposing of their gilt-edged certificates to gullible buyers. They were the first to close up, as their promises on paper could not be kept. But few companies made any money in the deep pay field, and such as did were, for the most part, composed of men from the East, who got hold of large leases, partly developed them, and then sold for a good price before the heavy body of salt water made its appearance.

In general, the oil in the deep pay wells in Delaware County is found between 270 and 300 feet in Trenton. An occasional bore is sunk as low as 350 feet in, but they are poor producers. Sometimes what is known as a "stray pay" is found at 150 to 200 feet. The bores in which they occur make quite a showing for a few days, but soon drop to little or nothing. The average deep pay well holds up better than the more shallow ones, a 250-barrel one yielding about 50 barrels at the end of six months. But little gas is now developed in the bores sunk in the county, and drilling is in many places done with Hocking Valley coal.

The oil from the deep pay wells is a little heavier than that from the more shallow ones, and has a tendency to hold together with water, so that most tanks have to be steamed. It is said to be a higher grade product than any other Indiana oil, but the Standard does not recognize that fact and pays the same per barrel as for South Lima. The average deep pay well is shot with 160 quarts of nitro-glycerine. The "sand" or pay streak usually runs from eight to ten feet in thickness, but in some of the best wells occurs 30 to 50 feet thick.

Much of the territory now marked light and fair on the accompanying map was high grade in 1904 when first developed, but has since fallen down greatly in output.

During the year 1906 but little new territory was added to the productive area in Delaware county. In the southwest part of Delaware and the southeast part of Hamilton townships several sections before untested have yielded a number of good wells, while in other parts of the county a number of leases formerly productive were abandoned. The oil map shows the relative value as well as it could be ascertained, of the productive area on January 1, 1907.

Liberty Township (Sections 31 to 36, 21 N., 11 E., and 1 to 25, 20 N., 11 E.).—This township has included the most productive oil territory in Delaware County. The large majority of the deep pay bores sunk in 1904 and 1905 were within its bounds. At one time nearly every section could be classed as fair to good territory, but several of them have been wholly abandoned, while a number of others are only light producers.

In section 36, in the northeast corner of the township, the new wells of the year started only at 15 to 25 barrels, as against 100 to

500 in 1904. Several leases in this section have been abandoned. It was on the Jas. Baughn farm in the southwest quarter of this section that the banner well of the State for the year 1904 was drilled. It is said to have started at 800 barrels and to have filled forty 250-barrel tanks in the first two weeks. From the time the first oil was struck at 1,181 feet to the bottom, a distance of 32 feet, the drill passed through a very porous brown limestone or pay streak. No shallow or top pay occurs in this part of the township.

The northeast quarter of section 35 was abandoned after four or five wells had been sunk, while bores on other parts of the section have resulted mostly in dry holes or light producers. Sections 34 and 33 are undeveloped, while 32 and 31 have only dry holes or abandoned light territory to their credit.

The northwest quarter of section 1, Liberty township, was a part of the famous Mt. Pleasant pool, opened up in 1904, but the remainder of the section has been non-productive or very light in output. In the southeast quarter of section 2, No. 9 bore on the Hitchcock lease started at 75 barrels in January, 1906, while Nos. 1 to 7 on the same lease were pulled in October, as were also five wells on the Stephens farm just to the west.

On the Swander lease in the northwest quarter of the section, the average record of three light producing wells showed:

	Feet.
Drive pipe	100
Casing	350
Top of Trenton	935
First oil	1195
Total depth	1201

Here, as elsewhere in the deep pay, much water has to be pumped to secure the oil.

A dry hole was bored in the northwest quarter of 3, but the remainder of the section is fair to good territory, two wells on the Shroyer lease, northeast quarter, starting at 180 and 100 barrels, respectively. Sections 4 and 5 have produced gas only, while several light wells in the northwest of 6 have been recently abandoned. The north half of section 7 is undrilled, while the wells on the south half, formerly light producing, have been pulled.

The county farm of 240 acres in the southeast quarter and the east half of the southwest quarter of section 8, has proven one of the best leases in the Muncie field. Of the 33 bores sunk on it, only two or three have come in dry, while six have been abandond. On November 1, 1906 there were, on the farm, 21 producing wells yielding a total of 75 barrels per day. The total production up to that time had been 133,398 barrels, from which the county had received $20,000 in royalty.

Just to the west of the county farm the Ohio Oil Company paid $10,000 bonus for 126 acres. All the wells sunk on it were light and the lease has been abandoned.

Section 9 has yielded some good producers in the south half, while the north portion is much lighter. The Burt Oil Company, composed of Muncie business men, sunk twelve bores to the deep pay on 60 acres in the southwest quarter of the section, and paid 65 per cent. on $20,000 capital in less than a year. One of the bores was a "freak" or crevice well, which started at 400 barrels, and was down to nothing in three months. The eleven producing wells were yielding 20 barrels a day in October, 1906. A record of No. 11, finished February 3, 1906, shows:

	Feet.
Drive pipe	114¼
Casing	330
Top of Trenton	894
First oil	1173
Total depth	1177½
Initial output, barrels	240

The bore was sunk but 4½ feet into the pay in order to avoid the salt water.

A bore on the Neal lease in the southwest corner of the section produced quite a quantity of gas in the second, or deep pay, which is quite unusual at that depth. The top of Trenton is struck at 895 feet on this lease. Another bore on the same lease started at 320 barrels and was down to 25 barrels in six months.

Sections 10 and 11 have proven very spotted territory. None of the recent wells have come in at over 40 barrels, while several leases formerly productive have been abandoned. Most of the production in sections 12 and 13 is from the shallow pay, the deeper sand yielding salt water or nothing. The new wells of the year started at 10 to 20 barrels each.

The Black and L. Winget leases in section 14 have proven very productive from both the shallow and deep pays. The former lease of 80 acres yielded over 80,000 barrels, but has been, for the most part, drowned out and in part abandoned. The 10 wells yet remaining were producing a total of 35 barrels daily in October. The remainder of the section has been only fairly productive, two of the recent bores on the W. Dunkin lease in the southeast quarter coming in dry.

The greater part of section 15 has been abandoned. Most of the wells were drilled too deep and though a number of them were at first fair producers, the salt water soon drowned them out. The Clark lease in the southwest quarter was a fair example. Eight wells were drilled on 90 acres and when pulled the operating company had lost $11,000 on the venture.

The north half of 16 produced during the year a number of fair to good wells, but those on the south half came in light, and several of the leases were abandoned. On the Burt lease of 54 acres in the northwest quarter of 17 there are 14 producing wells, several of which started at 100 barrels or more. The remainder of the section is only fair to light in production. The Daniel Boone Company has been fortunate with its holdings on the Guthrie lease in the northeast quarter of 18, but it has recently begun to show salt water in quantity. The Heaton lease, southwest quarter of the same section, has been abandoned. The remainder of the section is light in output.

The greater part of the west half of 19 has been abandoned, while the remainder is light, but 20, to the east, is yet fair to good. The top of Trenton on the Cecil and Truitt leases in the south half of 20 occurs at 925 feet. In 1904 this ranked as among the best territory in the Muncie field and it has since held up well, the new bores in 1906 starting at 40 to 130 barrels. The south half of 21, where some of the best producers in the deep pay were located, has fallen to a fair standard, with an occasional dry hole. A pumping station is located on the northeast quarter of this section from which most of the oil of Liberty township is piped to Montpelier, Indiana.

All of the leases in section 22, where, in 1904, was located the famous Smithfield town lot pool, have fallen off greatly in production. Not one of the 40 producers of the hamlet, in June of that year, is now pumping, and several of the leases to the west have also been abandoned. The once famous Lewis lease is still operated, but can only be graded as fair territory. The north half of 23 continues productive, though two of the 31 wells sunk on the Cecil lease have been abandoned and one dry hole drilled on the south side. A record of No. 20 may be taken as an average, and shows:

	Feet.
Drive pipe	109
Casing	305
Top of Trenton	933
First oil	1169
Second oil	1207
Total depth	1213

The wells south of White River, which crosses the center of the section, yield a little more water and are less productive.

The north half of 24 may yet be regarded as fair territory, but the south portion is light, several of the new wells starting at 2 to 15 barrels each. No. 8, on the Naylor lease, which came in as a light producer, showed:

	Feet.
Drive pipe	105
Casing	308
Top of Trenton	970
Gas showing	980
First oil	1242
Total depth	1242½

The only production in section 25 is on the Odle lease in the northwest quarter, and there is no yield east of that quarter section. To the west, in 26, the Cline lease has a number of fair wells. No. 14, drilled in August, started at 250 barrels, while No. 15, in September, was dry. A test bore on the School farm, in the northeast quarter, was light and abandoned. The northeast quarter of 27 contains a number of fair producers. On the Williams lease ten wells were making about 30 barrels a day, in October. One of these came in at 150 barrels and held up to 100 barrels for several months, while only 200 feet away, another bore started at only four barrels. The southwest quarter of the section has been recently abandoned. Section 28 is now light or abandoned territory. The Dunkin lease in the east half of the northeast quarter was, in 1904, one of the better grade deep pay farms, but has been mostly drowned out, while the Williams, just west, has been abandoned. On the Howell lease of 80 acres, in the south half of the section, three good wells and one old gas well were located in March, 1905. The lease was making a tank a day and sold at that date for $27,500. The new owners put down four bores on the west side of the lease, all of which were very light producers. In this case the slump in value was due to absence of the article sought.

In the west half of section 29 the once productive Collins lease has, in part, succumbed to salt water, and several of the wells have been abandoned, as has also the Reese farm to the north. The remainder of the section is fair to light territory. Section 30, most of which was light producing territory in 1904 and 1905, has been wholly abandoned.

A number of sales of property in Liberty and adjoining townships were made during the year. The largest of these, consummated in December, 1905, was that of the holdings of the Republic Iron and Steel Company to the Ohio Oil Company. The property consisted of leases on several thousand acres of gas and oil territory and above 325 producing wells. The leases were all finely equipped, and in 1904 had the largest output of any company in the field; the Lewis farm in section 22 and the Cecil and Collins leases in 20 and 29, Liberty, being the cream of the territory. Up to the time of the sale the Lewis farm of 177 acres had yielded 500,000 barrels of oil. In June, 1904, the property of the Republic Company was estimated at $1,100,000, but due to the slump in value of all deep pay property, the selling price was only about one-half that sum.

The Commonwealth-Jewell Oil Company sold several hundred acres of leases and 90 producing wells, in November, to Claud A. Ulsh of Rising Sun, Ohio, for $65,000. These wells were mostly located in the northeast portion of the township and comprise a part of the Mt. Pleasant pool, which yielded so freely in 1904. The Norton Oil Company bought about the same time 220 acres, embracing the Lennon tracts in sections 21 and 22.

Liberty township will continue to produce oil for a number of years, as new wells are continually being sunk on leases already in operation. However, the output will gradually decrease, as more wells are being abandoned than are being drilled, while those now pumping are slowly failing, as is always the case when a stored product is being drawn upon.

Perry Township (Sections 31 to 36, 20 N., 11 E., and sections 1 to 25, 19 N., 11 E.).—This township lies just south of Liberty and below the area shown on the accompanying oil map. The only production within its bounds has been in the northern half. Most of the bores resulted in light wells or dry holes.

In the northwest quarter of section 32, two or three light wells were sunk on the Markley and Whitney leases, but these have been pulled. Several dry holes were bored in the northeast quarter of the section. In the north half and the southwest quarter of 33 were also several light producers, now abandoned. The northeast quarter of 34 has two or three light wells to its credit; as does also the northwest of 35, these being at present the only producers in the township. A bore on the Will lease in the northeast quarter of 36 was dry.

In the second and third tiers of sections some light producers were drilled in the north half of section 4, and also in the southwest quarter of section 8, but these have all been pulled.

Center Township (Sections 31 to 36, 21 N., 10 E., and Sections 1 to 25, 20 N., 10 E.).—But little producing territory has been developed in this township, in which the city of Muncie is located. Test bores have been sunk upon ten or a dozen sections, but all but one or two resulted in light wells, which have been abandoned, or in dry holes. The most of the oil was found in the shallow pay.

Northeast of Muncie, in the north half of section 36, three or four bores were sunk in the early history of the field, which were light or dry. As there was no gas with which to operate, the leases were abandoned. The greater part of the section was afterward leased by the Ohio Oil Company, and several light wells drilled on the southeast quarter. A bore sunk in 1906 on the Sears lease in the north half was dry.

All the bores drilled to shallow pay in sections 1 and 2 have been abandoned. One of these, on the McGalliard farm, north half of the southwest quarter of 1, created much excitement in the early history of the Muncie field by starting at 12 barrels an hour and making 1,800 barrels in seven days. In it the top of Trenton was found at 969 feet. A bore drilled to deep pay on the Richison lease in the southeast quarter of the section came in dry in May, 1906. The north halves of sections 11 and 12 at one time contained several light wells, but all have been abandoned. Several light wells on the southeast of 13 and the north half of 14 have also been abandoned, while a few in the northeast quarter of section 24 are still pumping.

Mt. Pleasant Township (Sections 1 to 30, 20 N., 9 E., and 1, 12, 13, 24 and 25, 20 N., 8 E.)—But few test bores have been sunk in this township, which lies west of the city of Muncie. Two light producing oil wells were drilled during the year on the O. Williamson lease in the northeast quarter of 14, and one on the H. E. Gilbert farm in the southeast quarter of the same section. An excellent gas well was finished near Yorktown in November, on the J. K. Campbell farm, in the southeast quarter of 23.

Hamilton Township (Sections 1 to 30, 21 N., 10 E.)—The only producing territory in this township is in the eastern three tiers of sections. The first producing wells were sunk in 1904, on the J. G. Lefler farm of 80 acres, in the northeast quarter of section 22, near the town of Royerton. They were put down to deep pay, and one of them came in at 60 barrels while another was a dry hole. Two additional bores were sunk in 1905, both of which were light producers. The lease has since been abandoned. In the four bores the top of Trenton was struck at the following depths:

	Feet.
No. 1 in the southeast corner	960
No. 2 in the northwest corner	914
No. 3 in the northeast corner	935
No. 4 in the northwest corner	910

As the surface levels differed but little, the top of the Trenton is seen to be very uneven.

Several good wells were sunk on the McCullough lease, in the south half of section 24, in the year 1905. One of these started at 180 barrels and led to extensive drilling in the vicinity, which resulted, during the year 1906, in a number of fair to good wells and one dry hole, the latter being in the southeast corner.

The greater part of section 1, in the northeast corner of the township is fair territory. Eleven bores have been sunk on the Burt lease which started at ten to 80 barrels each. A dry hole and two or three light producers were sunk on the Beal farm in the northeast quarter of section 3, while another dry hole was put down just north, in the southeast corner of 34, Union township.

The northeast quarter of 12 is light territory, while the northwest of 13 grades higher. The southeast of 13 is light, while dry holes were sunk in the southeast of 15, on the Stradling and Smith leases, just west of Royerton, in which the top of sand was found at 935 feet.

Other deep bores which were barren of production have been sunk in the west half of the township on the following tracts:

W. A. Bell, southwest quarter section 7, through Trenton.

M. J. Cummings, southwest quarter section 16, 385 feet in Trenton.

M. B. Cooley, northeast quarter section 20, 350 feet in Trenton.

On the Bell lease the Trenton was 476 feet in thickness. Just below it was a blue shale 20 feet thick, which merged into a sandstone with an abundance of salt water.

The best production in Hamilton township is on the three sections 24, 25 and 26, in the southeast corner. The Norton Oil Company, in May, 1906, bought of Riley Allen 460 acres of leases in the east half of 23, the northwest quarter of 24 and the north half of 25, together with 180 acres just to the east in sections 19 and 30, Delaware township. When sold the property had on it 25 oil and two gas wells, which had produced an average of 110 barrels per day for three months. The price paid was $500 per barrel, or $55,000, a very low figure. Six additional wells were sunk during the summer, which brought the production up to 150 barrels daily by October 15th. Three of the best of these were on the Payton lease, in the northeast of section 25, where Nos. 9, 10, 11 and 13 are said to have been started at 200, 200, 140 and 150 barrels, respectively. The records of No. 9 and of No. 10, 500 feet south, showed as follows:

	Feet. No. 9.	*Feet.* No. 10.
Drive pipe	29	34
Casing	332	330
Top of Trenton	927	933
First oil	1215	1222
Total depth	1220	1226

The gas wells yield an abundance of fuel, and it was stated that on this account the oil could be produced for 12½ cents per barrel, which is thought to be the most economic production in Delaware County. The ten wells on the Payton lease were producing 65 barrels a day in November.

The east half of 23 is as yet untested. On the Wilson Heirs' farm in the southeast quarter of 25, six bores were sunk during the year which started at 300, 100, 18, 180, 40 and 50 barrels each, respectively. One bore on the Kaufman lease in the northeast quarter of the same section started at 125 barrels, while a second, one location away, was wholly dry.

Delaware Township (Sections 1 to 30, 21 N., 11 E.).—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. This lease has since been abandoned. The first deep pay well in Indiana was finished November 3, 1903, on the David Michael lease, northeast quarter of 15 and a short distance southwest of the Krohn producer. Here a test bore started without shooting at 160 barrels, and for 35 days pumped natural 70 barrels per day. No oil was struck until the drill had pierced Trenton 270 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, 1904, 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, and the deep pay production of Delaware County, in which a few operators made money and a large number lost their all, was fairly started. The records of the Michael and Black wells were as follows:

	Michael well.	*Black well.*
	Feet.	*Feet.*
Drive pipe	40	27
Casing	370	310
Top of Trenton	920	921
Total depth	1195	1232

There is no production in sections 1 and 2 of Delaware township. On the Davis lease in the northwest quarter of 3, there are three small oil wells, while just south are two bores yielding gas and one oil. An average record shows:

	Feet.
Drive pipe	40
Casing	325
Top of Trenton	944
Gas	1010
Total depth	1200

The gas is found in upper pay only. A bore on the Current lease in the southwest corner was barren. The north half of section 4 was drilled to shallow pay in 1903 and yielded a number of fair wells and a dry hole in the southeast corner. The south half has only dry holes or light territory to its credit. The south half of section 5 has at present a light production, as has also the north half of the northeast quarter, the rest of the section being abandoned.

The greater part of 6 has had a light production, but it is now shut down and partly abandoned. In the northeast quarter of 7 five wells were sunk on the Stafford lease, three of which were drilled in 1905. One or two of them started at over 100 barrels a day, but in June, 1906, all five were making only six barrels daily. The power house soon after burned and the lease was abandoned. The record of these wells showed:

	No. 1.	*No. 2.*	*No. 3.*	*No. 4.*	*No. 5.*
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Drive pipe	103	152	96	101	118
Casing	310	320	335	316	330
Top of sand	884	925	940	913	907
Gas	....	....	....	925	920
First pay	1170	1218	1015	....	1195
Second pay	....	....	1239	....	....
Third pay	....	....	....	1202	....
Total depth	1190	1239	1251	1220	1218½
Initial production, bbls.	....	....	55	110	15

A bore on the Wingate lease in the southwest quarter started at 200 barrels. All of section 8 is light, while 9 has yielded only a number of barren bores. The north half of 10 has been for the most part abandoned, as most of the ventures of the year were dry holes. The south half is still producing fair wells. Almost all of 11 has been abandoned, the new bores being light or dry, while 12, 13 and 14 are yet untested.

On the Michaels tract in the east half of the northeast quarter of section 15, just west of where the first deep pay well came in, another bore, No. 8, started in July at 230 barrels, while on the Goings lease, west half of the northwest quarter, four good wells and one dry hole were drilled. Three dry holes were also drilled in the southwest quarter of 15, and one on the southeast quarter, thus showing the spotted nature of the field.

The dry hole on the north half of the Goings tract showed:

	Feet.
Drive pipe	30
Casing	347
Top of Trenton	935
First showing of oil	965
Second showing of oil	1200
Total depth	1203

Section 16 is as yet non-productive, dry holes having been drilled in the southeast and northwest quarters. The north half of 17 contains a number of fair wells, the Friddle, Marsh and Holloway leases being the best, one bore on the first mentioned tract having made eight tanks a month for several months. The west half of 18 is also fair, one bore on the Dick lease in the southwest quarter starting at 200 barrels. The east half of the section is lighter.

The spotted nature of the deep pay field has been well shown in this vicinity. The Ohio Oil Company put down a bore on the D. E. Brammer tract, southwest quarter of 18, which started at 175 barrels and when three months old made 40 barrels per day. No. 2, 500 feet south, started at only one barrel, while No. 3, 1,500 feet east, was absolutely dry. A bore 500 feet south of No. 3 was a 150-barrel producer, while another on the Dick lease, 700 feet to the east of this, was barren. In most territory one can hazard a guess as to the results of future bores but in the deep pay of Delaware township every bore is a gamble.

The southwest quarter of 19 has yielded a number of fair producers, while the remainder is light or untested. In section 21 the northeast quarter, formerly producing, has been abandoned. Section 22 has so far proven, for the most part, gassy or barren. No. 8, on the Dowell tract in the southeast corner, had the following record:

	Feet.
Drive pipe	50
Casing	325
Top of Trenton	942
First oil	967
Second oil	1232
Total depth	1237

In this and a number of wells in deep pay territory both pays are shot and pumped. The lower pay is first shot and cleaned out, then a squib is put in and the upper pay shot and cleaned. The oil from the upper pay then falls and is pumped from the bottom.

In section 23 a bore on the Richey tract in the southwest quarter started at 100 barrels, and at the end of 12 months was yielding seven barrels, which is above the average for a deep pay well of that age. The south half of the section yielded a number of fair wells during the year. On the Evans lease in the southeast quarter one started at 180 barrels in June, and was making six barrels in November. On the Pittinger lease, just north, No. 1 started at 130 barrels, while No. 2 was dry. The records of Nos. 1 and 2 Evans and No. 2 Pittinger were as follows:

	Evans No. 1. *Feet.*	*Evans No. 2.* *Feet.*	*Pittinger No. 2* *Feet.*
Drive pipe	41	49	30
Casing	335	323	350
Top of Trenton	921	927	932
Upper pay	939	952	....
Second pay	1198	1203	1201
Total depth	1207	1208	1227
Initial production, barrels	180	42	....

A big water well was drilled on the Pogue tract, south of the center of the section. In shallow pay such wells are often the best producers, but in deep pay the water increases and stops all production. Some operators put in their pumps a duplex barrel, by the aid of which they are enabled to handle twice as much fluid as with an ordinary barrel.

Section 24 has a number of fair producers on the southeast quarter, the southwest quarter being lighter. On the Bartlett lease, in the northwest quarter of 25, two fair wells and three dry holes were sunk. On account of much water and no gas with which to operate, the lease has been abandoned. A dry hole was sunk during the year on the Lewellen lease in the southeast quarter. The remainder of the section is light territory.

A test bore on the F. D. Pittinger, west half of the southeast quarter of section 26, after striking the sand in deep pay, pumped a quantity of oil, then nothing but salt water for the first day. On the next morning it yielded a large quantity of oil for an hour, then went back to salt water and furnished but little oil for a month, when it was abandoned. It was at first thought to be a 100-barrel well. With the exception of another dry hole north of the center the remainder of the section is untested. Section 27 is very spotted. The Payton lease in the northwest quarter has two fair wells, while farther east are some light ones. All bores in the south half have been non-productive. The southeast quarter of 28 has several light wells to its credit, but the remainder of the section has proven dry or gassy.

Section 29 is as yet unproductive, but 30 contains some of the best territory in the township. The Wm. Reed farm, in the southwest quarter, has on it eleven wells, four or five of which started at more than 100 barrels each. The Shreve lease, just east, has been abandoned, while the north half is mostly fair.

While Delaware township has yielded some big producers, its area may be classed as among the most spotted in the Indiana field. Many good wells will yet be sunk within its bounds, but the man who drills them is taking a big chance for his money.

Niles Township (Sections 7 to 36, 22 N., 11 E.)—The first producing wells in this township were drilled in its central and southwestern portions in 1903. Most of its area has been tested, but only a few sections have proven paying territory, many of the test bores being barren. The following is a list of the dry holes in the non-productive sections as far as they could be secured:

Lease	*Location.*
Hughes	S. E. ¼ Section 8
Manor	N. E. ¼ Section 10
Manor	S. E. ¼ Section 17
Saunders	S. W. ¼ Section 20
Manor	N. E. ¼ Section 20
Motlen	S. E. ¼ Section 24
Wingate	N.W. ¼ Section 26
Wingate	S. E. ¼ Section 27
Williams	N. E. ¼ Section 33
Gregory	S. W. ¼ Section 34

There are some light producing wells on the southeast quarter of section 15 and the northeast quarter of 22, but none farther east in the north half of the township. Besides the dry holes mentioned above as having been drilled on section 20, the southeast quarter of that section contains five light wells and a dry hole, the records of the producers showing:

	No. 1.	*No. 2.*	*No. 3.*	*No. 5.*	*No. 6.*
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Drive pipe	138	203	222	138	284
Casing	330	307	300	300	312
Top of Trenton	954	959	955	959	960
First pay	1262	1260	1260	1265	1267
Total depth	1297	1300	1290	1305	1305
Initial production, bbls.	....	....	45	20	3

The north part of section 21 is better, several wells in the northeast quarter having started at 90 barrels or more during the year. Farther east, near the Jay County line, there are several light producers in the deep pay on the Bales and Gray tracts, in the north half of section 25.

The best lease in the township has been that of the Racer Oil Company, on the J. E. Racer lease of 22 acres, in the southeast of the northwest of section 28. Seven bores were put down on the farm, six of which were producers, yielding 60,000 barrels in three years, and doing 20 barrels per day in November, 1906. The lease was recently sold for $10,000.

The Miller, Barley and Eaton leases in the same section also contain a number of fair wells. In them the top of Trenton occurs at about 960 feet and the deep pay, in which most of the oil is found, at 1,215 feet. Leases aggregating 160 acres with six producing wells were sold in this section for $4,000 in 1906. For the same property $32,000 was refused in the fall of 1904.

Only the east half of section 29 is productive, the Clark lease in the northeast quarter and the Bosman in the southeast being the best. On the Clark lease four bores have been sunk, the record of No. 4 being:

	Feet.
Drive pipe	36
Casing	340
Top of Trenton	932
Gas	947
Oil	1244
Total depth	1264
Initial production, barrels	10

Sections 35 and 36, north and northeast of Albany, produce gas only.

Union Township (Sections 7 to 36, 22 N., 10 E.)—In 1904 and 1905 some oil was produced in sections 14, 16, 17, 20 and 22, near the central part of this township, but none of the wells are at present being pumped, and in November there was no production in the township.

A bore on the southwest quarter of section 18 came in wholly barren, after being sunk 500 feet into the Trenton. Other dry holes were put down on the Young lease in the southwest of 21; on the Barley lease in the northeast of 24; on the Hartle in the northeast of 33; on the Taylor in the southeast of 34, and on the Peterson, in the southeast quarter of 36.

Washington Township (Sections 7 to 36, 22 N., 9 E., and 12, 13, 24, 25 and 36, 22 N., 8 E.)—The first wells sunk in this township, those on the Broyles farm in the northeast quarter of 36 (22 N., 8 E.) have been abandoned on account of gas pressure. The most of those in the north half of section 12 have also been pulled out. At present there is no production in the township.

From what has been written it will be seen that the oil industry in Delaware County during the year 1906 was at a low ebb. The number of new bores fell off greatly, while the percentage of dry holes and abandoned wells increased. While the county will doubtless produce a large quantity of oil for a number of years, the industry will never again be as important as it was in the long to be remembered year of 1904.

Isolated Areas Producing Trenton Rock Petroleum Outside the Main Indiana Field.

In Wabash County.

For a long time the only productive area in this county was 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. The output was never large and a number of those first producing have been abandoned. The gas supply for fuel is very light and power for pumping is now in part supplied by the Fort Wayne and Wabash Valley Traction Company, whose line passes through the pool. No new bores were sunk in 1906, and at the close of the year there were 28 producing wells in the pool.

In Liberty township, which is in the southeastern part of the county and near producing territory in Grant and Huntington counties, a well was drilled for gas in 1903 on the Scott tract in the southwest quarter of section 34. It showed a little oil, and in July, 1905, was drilled 40 feet deeper and shot, when it started at 25 barrels and made seven and a half barrels after 30 days' pumping. The original record was as follows:

	Feet.
Drive pipe	202
Casing	470
Top of Trenton	945
Total depth	965

A second well was drilled one location east on the same tract in the fall of 1905, and in October, 1906, the two were said to produce eight barrels per day.

Two miles east, on the J. S. Davis lease in the southeast quarter of section 36, two small producers were finished in 1906, while another was completed on the Miller tract in the same section. A test bore on the Daugherty tract one mile east of Treaty, in the southwest quarter of section 5, was put down 500 feet into Trenton, but produced only salt water. Liberty township at present furnishes part of the gas for the city of Marion.

In Miami County.

The Peru oil field which created such a furore 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, but 16 are still in operation, twelve being abandoned in 1906, while but one, No. 3 on the N. Bruck lease, was completed. It had an initial output of but 15 barrels. The 16 producers were yielding about 1,430 barrels per month.

The best well in the Peru pool, that on the Artis lot, started at 400 barrels a day and is still making five to six barrels. But two or three of the first companies in the field made any money, and more than a quarter of a million 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. Four of the old producing wells were abandoned in 1906 and no new ones drilled, and at the end of the year there were but three producing in the township.

A bore sunk to the depth of 966 feet on the Milton Dougless farm northwest of Converse in September, 1906, developed a good showing of oil and 175 pounds of rock pressure of gas. A number of old gas wells in the vicinity have also been showing oil for some time, so that the region offers some inducements to prospectors. The well is in the southeastern part of Miami County, not far from the western line of Grant County.

*In Hamilton County.**

The oil development in Hamilton County is scattered in small pools; the two of main importance being in sections 1 and 2 (17 N., 5 E.) and 35 and 36 (18 N., 5 E.), Fall Creek township, and in sections 13, 23 and 24 (19 N., 3 E.), Washington township.

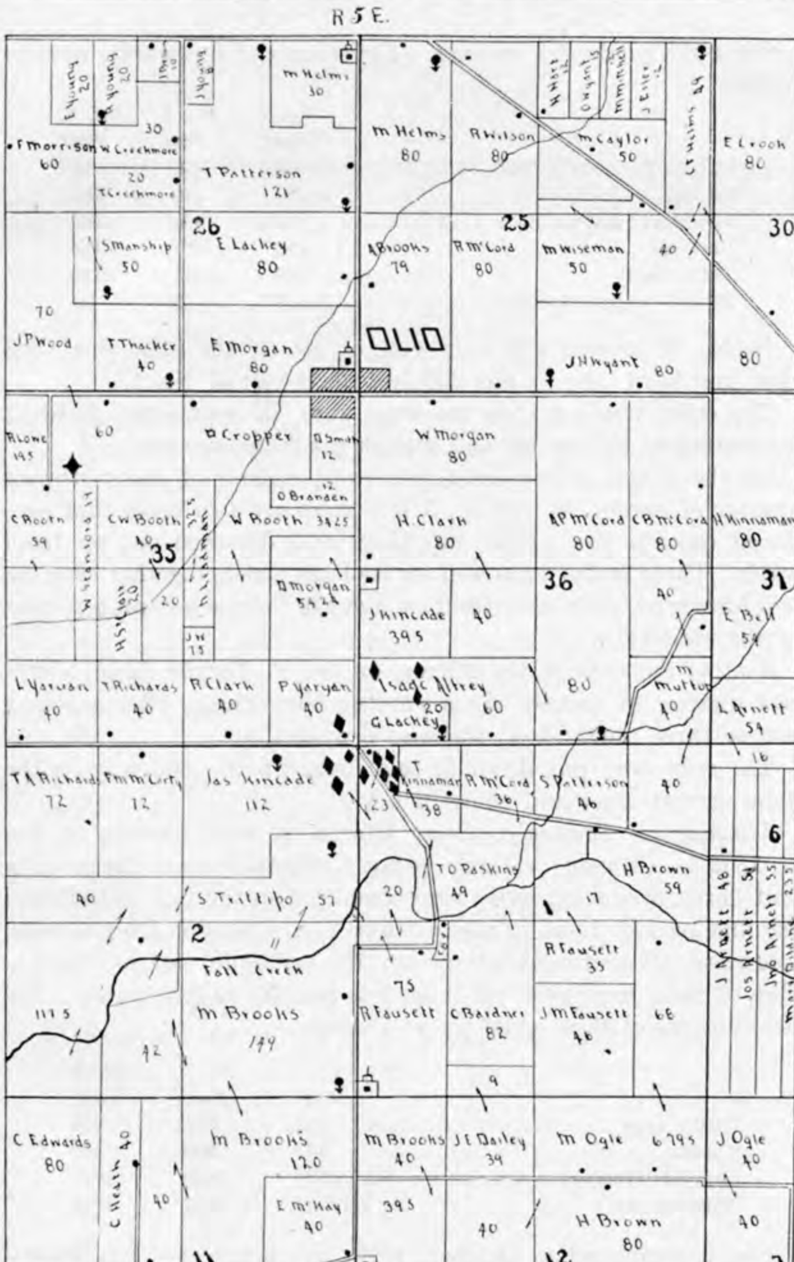
The early gas drilling showed the presence of oil in these pools and after the abandonment of the gas leases, wildcatting resulted in a few light to fair producing oil wells.

Fall Creek Township.—In this township, which is in the southeastern corner of the county, the first producing wells were drilled about one mile south of Olio in 1901, and a few others each year to 1905.

On the Kinnaman tract in the northwest quarter of the northwest quarter of section 1 (17 N., 5 E.) there are five wells, three of which were pumping in September, 1906, the total output of the three being about seven barrels per day. The top of Trenton is found at about 900 feet and the best oil at about 918 feet.

On the Kincade tract in the northeast of the northeast of section 2 there are five wells, three of which, completed in the spring and summer of 1905, were producing up to January 1, 1906, when they were closed down on account of the operating company being

*The data for this county was gathered and the maps drawn by R. S. Blatchley.



OLIO OIL FIELD

Legend: ◆ Oil Well - ⚲ Gas well - ✦ Abandoned Oil Well put into the hands of a receiver. The records of these wells were as follows:

	No. 1. *Feet.*	*No. 2.* *Feet.*	*No. 3.* *Feet.*
Drive pipe	56	64	54
Casing	380	384	381
Top of Trenton	886	889	885
Best oil	914	918	914
Total depth	926	955	935
Initial output, barrels	65	2	50

In No. 2, located 700 feet west of No. 1, the sand was very close and hard. No. 3 was 200 feet northwest of No. 1.

The other two bores on the lease were, in September, yielding five barrels of oil per day and enough gas for power use.

On the James Alfrey tract, southwest quarter of the southwest quarter of section 36 (18 N., 5 E.) there are two bores that produced quite a flow of oil, but they were drowned out by fresh water. There is also a gas well on the lease which, together with the two former oil wells, now yield enough gas for the pumping powers in the vicinity.

Just to the west of the Alfrey, on the P. Yaryan farm, southeast quarter of section 35, is another bore which, after yielding two or three tanks of oil was also drowned out.

The only bore put down in this township in 1906 was on the John Arnett tract and came in dry.

Washington Township.—Near Horton, a small station on the C. I. & L. (Monon) railway between Westfield and Sheridan, a half dozen producing wells were completed in the fall of 1905 and the first part of 1906. Three of these are on the W. Horton lease, southwest of southwest of section 13, one mile east of Horton. Two of them were yielding 14 barrels per day in September. The field records of these wells are as follows:

	No. 1. *Feet.*	*No.* 2. *Feet.*	*No.* 3. *Feet.*
Drive pipe	305	231	234
Casing	560	500	500
Top of Trenton	1024	1020	1022
Total depth	1042	1037	1050

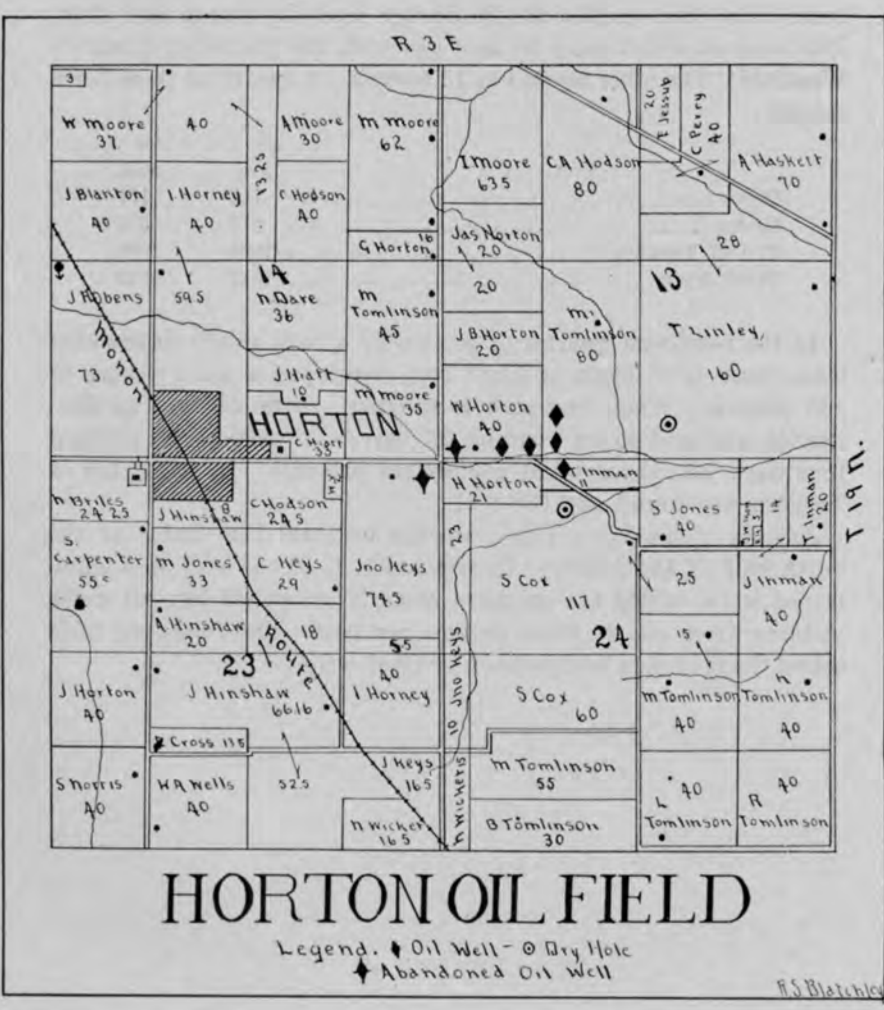
No. 1, completed in October, 1905, was never shot but showed about six feet of oil in the casing. No. 2, finished in February, 1906, started at 164 barrels and in September was yielding 10 barrels per day. No. 3 started in May at 50 barrels and was down to four barrels on September 1st.

On the Tomlinson tract, just east of the Horton, east half of the southwest quarter of section 13, two bores were sunk in 1906 the record of No. 1 showing:

	Feet.
Drive pipe	291
Casing	570
Top of Trenton	1021
Total depth	1045
Initial output, barrels	60

On September 1st this well was yielding about six barrels per day.

The second bore, finished in September, yielded 30 barrels of oil and a large flow of gas.



A bore on the S. Cox farm, northeast quarter of the northwest quarter of section 24, had a fair showing but was spoiled in shooting. One on the J. Keys lease, northeast of 23, started in June at 25 barrels and has since been abandoned. Dry holes were also drilled on the Inman tract, north half of the northwest quarter of 24, and on the Lindley farm, southwest quarter of the southeast quarter of section 13.

The oil from the producing wells above mentioned is piped to a loading rack at Horton. Altogether eight bores were finished east of Horton during the year, of which six came in as producers, while two were dry.

On the east half of section 20 of Washington township, two bores were sunk on the E. D. Barker tract in March and July, 1906, one of which came in as a gas well, the gas being piped to Westfield. The other started at 15 barrels. A record of these bores showed:

	No. 1.	*No. 2.*
	Feet.	*Feet.*
Drive pipe	160	161
Casing	515	515
Top of Trenton	1005	1000
Total depth	1032	1019

In the northwest quarter of section 20 a bore on the Sturdevant lease, sunk to a depth of 1,023 feet, developed a gas pressure of 160 pounds. When first shot it spurted a little oil, but in September was said to be yielding 24 barrels a week when pumped four days, and showed 100 pounds gas pressure. In it the top of Trenton was found at 1,003 feet.

Jackson Township.—This township occupies the center of the north half of the county. In sections 5, 6, 31, 33 and 36 a number of wells drilled for gas have recently developed into oil wells, yielding from one to three barrels per day. The following table shows the field data and location of these wells:

Lease.	Date of Completion.	Drive Pipe, Feet.	Casing, Feet.	Top of Sand, Feet.	Total Depth, Feet.	Location.
A. Graham, No. 1......	1904	203	525	1,003	1,063	S. ½ N E. ¼ Sec. 6, 19 N., 4 E.
A. Graham, No. 2......	1904	226	530	1,000	1,049	
A. Graham, No. 3......	1905	197	535	1,008	1,065	
J. Foulke, No. 1........	1905	240	545	1,010	1,064	N. W. ¼ Sec. 5, 19 N., 4 E.
Geo. Foulke, No. 1.....	1904	169	520	981	988	N. W. ¼ Sec. 5, 19 N., 4 E.
Geo. Foulke, No. 2.....	1904	162	520	1,003	1,020	
Geo. Anthony, No. 1....	1904	150	510	980	994	S. W. ¼ Sec. 31, 20 N., 4 E.
Geo. Anthony, No. 2....	1904	265	535	1,005	1,057	
M. Blanton, No. 1......	1904	406	550	1,013	1,032	N. ½ S. W. ¼ Sec. 3, 20 N., 4 E.
A. Geiger..............	1903	308	525	1,008	1,115	S. ½ S. W. ¼ Sec. 33, 20 N., 4 E.
J. Hiatt, No. 1.........	1905	275	535	1,010	1,064	E. ½ S. E. ¼ Sec. 6, 20 N., 4 E.
J. Hiatt, No. 2.........	1905	203	560	1,019	1,078	
J. Jacobs, No. 1........	1901	70	....	916	927	N. W. ¼ Sec. 36, 20 N., 4 E.

In Marion County.

The greater part of the productive area near Broad Ripple, Marion County, was abandoned in May, 1906. This pool was opened up in 1896 and 1897, and at one time about 60 producing wells were being operated. The majority of these paid out and yielded the operators a good profit on their investment. The top of Trenton in this vicinity occurs at about 935 feet, or about 120 feet below tide, and the one pay streak lies very near the top.

On December 15, 1906, there were but seven producing wells left in the pool. These were being operated by H. M. Gilchrist and are located on the Wiggins and Lee tracts in the southeast of section 2 and the northeast of section 11 (16 N., 3 E.), about a mile and a half southwest of Broad Ripple. The seven wells were producing about 180 barrels a month, or six barrels per day. The one on the Lee tract, northeast of 11, was making as much as all six on the Wiggins lease, although one of the latter, located across White River, just north of the Lee well, was one of the best in the field, starting at more than 100 barrels. The majority of the wells abandoned in May were still pumping at a profit, but the territory which they occupied had been platted into city lots and the presence of the wells hampered the sales.

There is doubtless quite a quantity of oil yet stored in the Trenton in the immediate vicinity of the old Broad Ripple pool, the limits of which were never clearly defined. The proximity to Indianapolis and the fact that no big wells, or "gushers" were struck prevented the rapid growth and greater extension of the pool at the time it was most productive.

The Production of Petroleum in the Trenton Rock Fields of Indiana.

The raising of petroleum from the porous stratum or reservoir in the depths of the rocks, where it has lain for thousands of years, to storage tanks upon the surface of the earth, where it can be utilized by man, is termed the production.

The evolution of the processes involved in the present advanced methods of production from the primitive one used by the first oil producers in the United States has been a wonderful one and would prove a story of surpassing interest to the practical operator of to-day.

The different steps necessary to the successful development of a good oil property are many, and the tyro who enters the field against operators who have spent a lifetime in mastering the details of producing oil at a minimum cost often finds himself handicapped before he has completed his first well.

Choosing a Locality for Operating.—The first step necessary in the production of oil is the choosing of the locality in which the operations will be carried on. In this step it will be found that the old operator, who has watched the growth of a field from the beginning, is usually wise enough to locate his future wells within the limits of known productive territory, provided he can procure the necessary leases. The beginner more often betakes himself to "promising" territory just outside the limits and puts down a "wildcat" bore. Any one who makes a special study of the oil business will soon note that the Standard Oil Company and other large operators do little "wildcatting," but profit by the experience of the small operators who do it. "Wildcatting" must, however, be done by somebody, as there is no known method of fixing the limits of a field except by test bores put down by speculative individuals.

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 this 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 cannot afford to be idle five-twelfths of his time, and so operates those leases along pikes over which he can readily 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.

Usual Terms of a Lease.—After deciding on a piece of territory it must either be bought outright or leased from the owner for a term of years. In most cases it is leased, usually for a period of five years or as much longer as production continues. If the adjoining territory is untested, the farmer usually receives from one-eighth to one-sixth royalty on the future production, with a stipulation that drilling is to begin within one or two years, or that a stated rental per acre shall be paid until the first well is drilled. The land owner retains all rights over the surface of the land with the exception of the portion necessarily occupied by the derricks, power houses and storage tanks. On a farm of 80 acres, not more than five need necessarily be kept from cultivation, even though it contain, in time, its full quota of wells. If a good well has been put down on adjoining territory the farmer often receives a bonus of from \$10 to \$50 an acre, or even more, in addition to the royalty and rental. In many instances the supposed rich strike in time proves of little value. The lease expires without being drilled and the farmer is ahead a sum equal to the bonus advanced.

If on the area leased some good wells are developed, the lease, like the franchise of a street railway, becomes the most valuable part of the so-called "oil property;" and with the wells already in operation is often sold for large amounts. Even though no wells are drilled on a leased farm, the lease often changes ownership a number of times before it expires. The following is a form of lease in common use in Indiana:

This Agreement, made this .... day of .... A. D., 190..
Witnesseth, That ....
.... Lessors,
in consideration of one dollar in hand duly paid by John Doe, of Lima, Ohio, lessee, do hereby grant, demise, and let unto the lessee all the oil and gas in and under the following described tract of land; also the said tract of land for the purpose of operating thereon for said oil and gas with the right to use water, oil and gas therefrom, except water from wells now on said premises, and all rights convenient for such operations; also the right at any time to remove a part or all of the property, machinery or fixtures placed thereon by lessee. Said land being situated in the................

of ....County, State of .... described as follows:
....
....
....
....
Containing .... acres more or less. To have and to hold unto the lessee for the term of five years from the date hereof, and as much longer thereafter as oil and gas are found in paying quantities thereon. The lessee shall deliver into tanks or pipe lines to the lessor's credit, the one-eighth part of all the oil produced, and saved from the premises; and shall pay at the rate of one hundred dollars per year for each gas well during the time gas is sold or marketed therefrom.

The lessors may have gas free of cost from any gas well on said premises for use in the dwelling house thereon at their own risk as long as the lessee continues to operate such wells, the lessors making connections for gas at such point or place as may be designated by the lessee.

No wells are to be drilled within two hundred feet of the dwelling house now on the premises without the lessors' consent; whenever the lessors shall request it the lessee shall bury all oil and gas lines which are laid over tillable ground and shall pay all damage to growing crops caused by burying or removing said pipe lines.

It is provided that this lease shall become null and void if a well is not completed on the premises within two years from the date hereof, unavoidable delay excepted, unless the lessees thereafter pay at the rate of 25 cents per acre per year (payable quarterly) until a well is completed, which payments may be made direct to the lessors, or deposited to their credit in the ....
....
....

All the provisions hereof shall extend to the heirs, successors, and assigns of the respective parties hereunto, and upon the payment of one dollar, at any time, by the lessee, his successors or assigns, to the lessors, their heirs or assigns; said lessee, his successors or assigns shall have the right to surrender this lease for cancellation; after which all payments and liabilities thereafter to accrue under and by virtue of its terms shall cease and determine, and this lease becomes absolutely null and void.

Witness the following signatures and seals:

Witness:

....	.... (Seal)
....	.... (Seal)
....	.... (Seal)
....	.... (Seal)
....	.... (Seal)

State of Indiana,
County of ....
ss:

I, ..., in and for said county in the State aforesaid, do hereby certify that..
....
....

personally known to me to be the same person.. whose name............ subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that ...... signed, sealed and delivered the said instrument as .... free and voluntary act, for the uses and purposes therein set forth.

Given under my hand ....seal, this .... day of .... A. D., 190..

....

....

Locating the Wells.—After securing a lease, the operator must choose the site for his first well. It is usually the custom to drill at some point about 200 feet from the property line in order to first obtain the oil which might otherwise be raised by operators of adjoining leases. Various circumstances, such as the dip of the oil bearing rock, variations in the surface level of the tract leased, the location of a permanent power house, etc., are to be considered in determining the site of the well. If wells are down on adjoining leases, the production of the first well, as compared with that of the older ones, can be used to gauge the location of future bores. If a well holds up to ten or 15 barrels a day for three months or more the chances are that it is close to or connected with a large area of porous rock, and that better wells may be located somewhere in the immediate vicinity. The wells are usually put down 400 to 600 feet apart; that distance, in the language of the oil field, being termed a "location."

An unwritten law exists among operators that the lessee of a tract of land shall immediately put down wells when producing wells are drilled on adjoining territories. This is done to offset and protect property lines and prevent the oil underlying one tract from being drained off through another.

As to the amount of acreage to be assigned to an oil well, opinion varies greatly. On the larger leases, ten acres are often given to the well. On the smaller leases, one to every five acres is often drilled. The degree of the porosity of the rock should to a large extent govern the acreage allowed each well. Where comparatively open, the well drains a larger territory and fewer bores are necessary to secure the oil than where the pores are small. One common and very good method of locating the wells on an 80-acre lease is to have them 200 feet back from the outside line and 460 feet apart. This leaves a distance of 920 feet clear in the center, on which the power house can be erected. By this method 14 wells can be placed on each 80 acre tract, and have the center to draw on.

Contracting for the Drilling.—Having selected a site for his first well, the operator next contracts for the drilling. 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," 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 300 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 out, the latter being a tedious and expensive process. By beginning with a large opening there is often much saving of both time and expense.

In the main Indiana field in 1906 the average price for drilling was 50 cents per foot, with 25 cents per foot extra for all drive pipe over 100 feet. At this price the operator furnished fuel and water and paid the contractor for cleaning out the well after the latter was shot. The operator furnished the rig and all drive pipe, casing and other supplies.

The Rig or Derrick.—In the Indiana fields but few drilling machines are used, most of the work being done with a standard rig which the operator must first contract for and have erected before the drilling begins. This rig consists of four strong uprights held in position by ties and braces and resting on strong wooden sills, which are preferred as a foundation to masonry. The derrick is used as a support for the sheave called the crown pulley, which must rest at a sufficient height to swing the heavy drilling tools free from the ground. The average height of the derrick is 72 feet, and it forms the most conspicuous object which characterizes an oil field.

With the derrick are included under the term "rig" all the woodwork and its necessary iron fittings so put together that when boiler and engine are in place drilling can at once begin. The bull wheel and shaft on which the cable supporting the drilling tools is wound; the walking beam to give the vertical motion to the tools, and the band wheels for transmitting power from the engines to the movable parts are, next to the derrick, the most important parts of the rig.

The construction of the rig is usually undertaken by a contractor known as a "rig-builder," for a certain specified sum. In the Indiana field in 1906 the price paid for a new rig complete ranged from $425 to $550. After the well is completed the rig is, in most cases, left standing, though many operators take it down and use it for another well. A considerable saving of outlay for lumber and rig irons is thus effected, but if the well stops flowing or needs cleaning out, a new rig, usually smaller and less expensive, must be built, or else a pulling machine be purchased.

The larger operators own their own "strings of tools" and employ rig builders, drillers, etc., by the month instead of contracting for each well. The head driller or contractor owns his own string of tools and portable engine. His tools cost anywhere from $1,000 to $2,500, according to number and quality. His engine is of a pattern built especially for the purpose and costs about $600. Sometimes the contractor owns several, perhaps a dozen, strings of tools, and is drilling a number of wells at the same time.

Drilling the Well.—The drilling crew consists of four men, two drillers and two tool dressers, who work in pairs, twelve hours each. It is the duty of the driller to stay close to the mouth of the bore and attend to the drilling proper, turning the cable and the temper screw when necessary and controlling the machinery by cords and lever when changing the tools or sand pumping. The tool dresser is the helper to each driller. He fires the boiler, attends to the engine and machinery and dresses or sharpens the bits as each in turn becomes worn.

The wages paid the drillers in the Indiana field in 1906 were $4.50, and the tool dressers $3.50 each per day. The contractor is responsible for accidents and failure to complete a well. The time necessary to put down a bore 50 feet into Trenton varies much, but is usually from nine to 12 days.

Shooting the Well.—As soon as the porous stratum is passed through, if there is a fair showing of oil, the well is torpedoed

"Ef ther' ez any Standard oil on my farm I perpose t' control th' outpurt."
—Kin Hubbard in Indianapolis News.

or "shot" in order to open up fissures in the porous rock and form a cavity therein into which the oil may flow. In the Indiana field it is now the custom to drill into the Trenton to the bottom of the second pay, if that be present, and then, if possible, gauge the shooting so that the rock will be shattered from the bottom of the drill hole to the top of, but not above, the porous stratum. This prevents the explosion affecting the Utica shale overlying the Trenton and so filling up the cavity with loose debris and rendering the well worthless. Nitro-glycerine is the explosive used, and the amount depends largely upon the texture of the porous rock or so-called "sand." If it is hard and close pored, more explosive is necessary than where coarse and friable. In the latter case a large shot shatters too great a quantity and causes too much trouble in cleaning out after the shooting. An average shot in the Indiana field is now 140 quarts, though some operators persist in drilling deep and using 200 quarts in all wells.

The shooting is done by a contractor who follows it as a vocation. He is usually an agent of the company who manufactures the explosive, and often works on the percentage system, receiving from the company a stipulated sum per quart for the explosive sold.

The nitro-glycerine is hauled overland from the factory in square tin cans holding eight to ten quarts each, and stored in quantity in buildings erected in some out-of-the-way place at various points in the oil field. When a well is ready to be shot, the agent who does the shooting transports, in a light buckboard buggy, padded and fitted for the purpose, a number of these cans to the well. There the glycerine is poured into cylindrical tin cans, called "shells," about five inches in diameter and long enough to hold 20 quarts of the explosive. The average shell is five feet five inches in length. Each shell is conical at the lower end and slightly concave at the upper. As soon as the first shell is filled it is lowered into the bore. When it reaches the bottom the lowering line, by a special device, becomes detached and is drawn up. The second shell is then filled, and when lowered its conical end fits into the cavity at the top of the first. In this manner each of the shells, after being lowered, rests in close connection with the one preceding. The last, or top shell, is fitted in a special manner with a waterproof percussion cap so arranged beneath a flat iron plate that when the latter is struck the cap is exploded and in turn sets off the nitro-glycerine. After the lowering line of the last shell has been reeled up, an iron casting, called a "go-devil," is dropped into the bore, and the "shooter" and spectators retreat some distance from the derrick.

In some places the percussion cap is so arranged that it can be readily set off with an electric spark, communicated to it by a wire which is connected with a hand battery. This device is more commonly used where the casing is removed section by section after the explosive has been placed in the bore and then reset as soon as the shooting is over. Such removal takes but an hour or two and all danger of collapse or breaking the casing is thereby obviated.

When the ntiro-glycerine is exploded, a person 100 yards away will, aften an interval of 30 to 50 seconds, experience a slight

"By ginger, that glicereen makes a feller rise in his perfession."
—Kin Hubbard in Indianapolis News.

jarring of the earth, accompanied by a muffled report somewhat louder than a pistol shot. A minute or so thereafter a roaring sound is heard and a solid column of oil and water is seen issuing from the mouth of the bore. This rises higher and higher until it often reaches far above the derrick and there breaks into spray. Blown up with it are many fragments of stone and the remains of the tin cannisters and "go-devil," shattered into a thousand particles. Pieces of porous rock blown up from a depth of a thousand feet often weigh six to eight pounds.

The flow of oil resulting from the explosion usually soon subsides and, as soon as possible, tubing two to two and a half inches in diameter and reaching to the bottom of the bore, is put in and connected with a tank which has been erected near by. These tanks are cylindrical, are constructed of wooden staves, and are usually gauged to hold 250 barrels each. In such a tank each inch in depth equals two and a half barrels of oil; therefore, in oil field vernacular, a yield of "ten inches a day" means 25 barrels. The cost of such a tank in the Indiana field in 1906 was $90.00.

Pumping the Oil.—After tubing the well and connecting it with the tank, the necessary pumping apparatus must be attached. If a number of wells are to be drilled a power house is located near the center of the lease and a small gas or steam engine placed therein. Each well is supplied with a jack and balance weight, to which the necessary pumping or sucker rods which ply up and down inside the tubing are attached. When a number of wells are pumped by one engine the power is transmitted to the pumping jack of each by means of steel pull rods or wire ropes provided with suitable angle knees to change the direction of the pull. Where the surface is level the rods run about two feet above the ground and rest in notches cut in the tops of short posts or props. Where the surface is broken or uneven the rods are suspended above ground by ropes attached to poles or posts which are set in a row between the power house and well.

The engine in the power house runs an oscillating pull-wheel which gives horizontal movement to the rods radiating from it to the different wells. The pull-wheel draws the rods in one direction, and on the return the weight of the sucker rod, hanging from the jack, draws them back. In this way wells have been pumped one mile from the power house, and often as many as twenty wells, and sometimes as many as forty, are pumped by a single engine. More than twenty-five or thirty are, however, too many, for if the power should happen to break down all the wells are stopped. Again, a pumper (the man in charge of the engines and wells) cannot look after more than that number and do it right. The fuel used for pumping is usually gas, the wells on the lease often furnishing enough; though in many instances it is piped from a distance. The material pumped is run first into a barrel tank to settle out the water, and from this the oil passes off into storage tanks.

After a tank has been filled with oil, the latter must often be steamed to reduce the impurities of sediment to a minimum. This is done by connecting pipes from the engine with the bottom of the tank and forcing steam through the oil. From three to four hours is usually necessary to steam a 250-barrel tank. The process of "production" is then complete and the oil is ready for the market.

Marketing the Oil.—When a tank is full or nearly so the pumper notifies a gauger of the purchasing company (Indiana Pipe Line Company, a branch of the Standard Oil Company), who comes and measures its contents. It is then turned into the lines of the company (the Standard) and the pumper notifies the Indiana branch of that company at Montpelier. There, after deducting two per cent. for sediment, leakage, etc., certificates are mailed to both the producer and the party owning the land, stating the number of barrels to their credit in the lines of the purchasing company, together with the market price of the same. These certificates can be cashed at the various banks throughout the oil field, or are payable over the counters of the company at Montpelier.

Cost of a Producing Well in the Main Indiana Oil Field in 1906.—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 considerably 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 by a leading operator in each of the Jay and Huntington county portions of the field in October, 1906. These estimates resulted as follows:

	Jay.	*Huntington.*
Rig or derrick	$425	$550
Drilling	575	580
Drive pipe	140	180
Casing	95	170
Shooting	100	140
Cleaning	30	40
Tubing and pumping outfit	210	225
Power house and power	1,000	1,500
Two 250-barrel tanks	180	200
One 100-barrel tank	35	35
Belting, lead lines and surface rods	170	210
Incidentals	100	100
Totals	$3,060	$3,930

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 95 cents in the Jay County field and $1.00 in the Huntington; 6¼-inch casing at 36 cents in Jay and 37 cents in Huntington; tubing at 16 cents; sucker rods at 3¾ cents; jack and pumping outfit at $50 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 $1,600 to $2,000 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 producing 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. Some operators use but one or two derricks on 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. The cost of the lead lines and surface rods on a lease will increase proportionally to the number of producing wells. In 1906 the price of a two-inch lead line pipe was 11 cents, while that of surface rods was 4¼ cents per foot.

If the rig is moved and used for successive wells a pulling machine to clean the pump and valves will be necessary on the lease and will cost about $225. Where the oil requires steaming an extra boiler and boiler house, both costing close to $500, will be necessary. Some companies also put up a dwelling costing on an average $500 for each of their pumpers.

One operator stated that the average cost per well of 16 to 20 wells on a 160 acre lease in Huntington County was $2,000. A second operator stated that he expended an average of $2,200 each for 16 wells in the same county. Another said that in Wells County he could, after the power was located, hitch a well onto it for $1,200. In the deep pay in Delaware County, the average cost is probably near $3,000. The actual cost of 39 wells in the Trenton rock fields of Indiana and Ohio was $1,724.85 each. This last is perhaps as fair an estimate as can be given.

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 operate a lease of eight or more wells, even if the yield is only one barrel each per day, provided the price of oil is as high as it was throughout the year 1906.

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

Income per month—		
200 barrels of oil at $0.85 (average price in 1906)		$170 00
Salary of pumper	$60 00	
Cost of fuel	40 00	
		100 00
Net income per month		$70 00

With twelve one-barrel wells on the lease the income would be $255 and the expense $100, a net gain of $155 per month.

The running expenses of 21 wells in Huntington and Grant counties were said by one operator to be $144.42 each per annum. Another stated that in Huntington County ten wells on an 80-acre lease will cost $1,000 a year, while 20 on a 160-acre tract would not cost over $1,200 per year.

The actual average cost of producing oil in Indiana at present is variously estimated at from 30 to 50 cents per barrel, though one operator claimed that on a very productive lease in Delaware County he was producing it for 12½ cents. This includes the interest on the investment. Out of the profit above cost of production, the principal invested in leases and wells, and also the taxes, must be paid. In the early history of the field when the average output was much greater, the cost of production was not over 20 to 30 cents per barrel, and whatever was received above that was clear gain.

From what has been written it will be seen that, with the possible exception of the field at Casey, Illinois, the cost of drilling and operating a lease in the main 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.

Whatever the price of oil, 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.

Above all one should be on the lookout 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.

Statistics of the Indiana Trenton Rock Petroleum Industry for 1906.

For the second time in recent years the output of Trenton rock petroleum fell off in 1906, the loss for the year being 3,129,613 barrels, or 28.8 per cent. This loss was not due to decrease in price as the average price was higher than in 1905, but was primarily due to a large decrease in the number of new bores, brought about by the migration of the leading operators to the Illinois and other more productive fields.

The fluctuations in price during the year were very slight; there being but eight cents difference between the minimum and maximum prices paid. Starting the year at 89 cents per barrel, it held this figure until April 13, when it rose to 91 cents and again on April 25 to 93 cents, the maximum. This price was paid until July 25, when it dropped to 91 cents. On August 1st there was a decline of 2 cents, and again on August 15 and 25, when the minimum price of 85 cents was reached. This price it held to the end of the year. The average price for the year, taking both days of time and amount received into consideration, was 88 3-5 cents, as against 84 4-5 cents in 1905 and \$1.07½ in 1904.

The total production of Trenton rock oil in Indiana in 1906 was 7,762,825 barrels which, at the average price of 88 3-5 cents had a value of \$6,877,863. Compared with 1905, this shows a loss of 3,129,613 barrels, or 28.8 per cent., as against a loss in 1905 over 1904 of 3.4 per cent. On account of the higher average price, the amount received by the producers was \$2,358,925, or 25.5 per cent. less than in 1905.

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 16 years beginning January 1, 1891, and ending December 31, 1906. 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 1907, BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	6,171	15,841	111,824	259,000	300,568	365,582	290,746	317,014
February	5,981	18,946	96,025	232,107	230,559	241,743	309,922	272,780
March	5,159	24,794	134,549	282,376	310,303	386,586	341,961	325,301
April	4,973	26,184	146,493	287,330	352,077	395,032	328,779	310,034
May	5,757	31,033	186,939	321,502	397,001	417,963	340,023	311,208
June	8,136	40,888	209,616	333,479	403,569	434,167	369,803	320,477
July	10,809	49,203	241,666	327,349	434,376	422,968	375,249	314,861
August	11,603	56,109	248,353	345,031	420,132	407,238	371,921	332,777
September	16,500	66,034	245,615	319,588	409,169	415,675	362,528	326,264
October	19,029	95,699	252,568	339,424	393,153	394,283	408,179	319,490
November	20,801	129,270	245,607	304,030	373,789	337,331	430,958	300,644
December	21,715	144,067	236,038	337,450	361,436	362,164	423,069	300,457
Totals	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,128	3,751,307

MONTH.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
January........	297,291	353,451	425,140	554,038	651,355	714,594	1,038,324	759,518
February.......	220,440	302,493	384,735	460,073	568,789	664,058	804,100	657,201
March..........	290,257	364,590	432,922	573,412	724,969	797,133	1,037,320	678,788
April..........	325,774	381,804	447,261	579,711	680,921	804,121	964,242	684,810
May............	344,831	426,363	482,118	635,752	751,348	851,071	1,011,859	701,766
June...........	334,282	446,492	481,807	633,452	809,438	940,391	1,011,965	692,390
July...........	329,086	437,087	506,065	696,911	831,005	998,229	937,960	684,056
August.........	347,621	466,127	523,106	697,040	838,615	1,084,560	916,803	673,721
September......	332,283	418,716	519,087	672,611	857,117	1,104,771	840,804	563,100
October........	326,781	467,521	532,960	725,973	873,160	1,139,000	791,881	607,178
November.......	326,802	406,684	510,788	656,457	778,323	1,098,832	765,078	547,134
December.......	332,266	441,347	479,485	650,131	796,291	1,084,270	772,102	513,163
Totals.....	3,807,714	4,912,675	5,725,474	7,535,561	9,161,331	11,281,030	10,892,438	7,762,825

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1907, WITH VALUE.

	1891.	1892.	1894.	1894.	1895.	1896.	1897.	1898.
Total production (barrels of 42 gal.)..	136,634	698,068	2,335,292	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307
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
Value per bbl.	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63	$0 43	$0 59$\frac{3}{8}$

	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
Total production (barrels of 42 gal.)..	3,807,714	4,912,675	5,725,474	7,535,561	9,161,331	11,281,030	10,892,438	7,762,825
Total value at wells of all oils produced, excluding pipeage..	$3,331,750	$4,740,731	$4,775,045	$6,450,440	$10,457,659	$12,127,107	$9,236,788	$6,877,863
Value per bbl.	$0 87$\frac{1}{2}$	$0 96$\frac{1}{2}$	$0 83$\frac{3}{8}$	$0 85$\frac{5}{8}$	$1 14$\frac{3}{20}$	$1 07$\frac{1}{2}$	$0 84$\frac{4}{5}$	0.88\frac{5}{8}$

From the first of the above tables it will be seen that the largest production of the Trenton rock petroleum in Indiana in any one month to date was in October, 1904, when 1,139,000 barrels were brought to the surface. The total production of Indiana Trenton rock oil for the 16 years reached the enormous sum of 85,109,048 barrels, which sold for $70,999,592, or an average of $4,437,474 per year.

In the third table there is shown the number of wells completed in the Indiana Trenton limestone fields by months from June, 1891. to January, 1907:

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1907 BY MONTHS.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	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
1904	235	157	234	202	296	393	394	383	378	388	320	344	3,724
1905	194	130	149	185	196	157	159	145	130	108	163	166	1,882
1906	135	90	84	68	106	142	120	100	93	69	66	59	1,132
Total	......	......	......	......	......	......	......	......	......	......	......	......	23,713

From this table we learn by subtraction that 750 fewer bores were sunk for oil in the Trenton rock fields of Indiana in 1906 than in 1905. This was a loss of 39.8 per cent., as against a loss in 1905 of 49.5 per cent. over the year previous.

From the table it may also be learned that, up to January 1, 1907, 23,713 bores had been drilled in the Trenton rock fields of Indiana for oil alone. On that date there were 16,221 producing wells in the Trenton rock fields as against 16,266 on January 1, 1906, a loss of 45 for the year.

By subtraction it will be noted that of the total number of bores sunk for oil in the Trenton rock fields of the State, 7,492 have proven dry, or have been abandoned as non-productive. The number abandoned in 1906 was 1,053, or 446 more than in 1905, while the number of dry holes drilled during the year was 124, or 113 less than in 1905. Of the total number of bores sunk in 1906, 10.9 per cent. were dry, as against 12.6 per cent. of those drilled in 1905, and 10.2 per cent. of those sunk in 1904.

For the first time in the history of the field, the number of dry holes and abandoned wells exceeded the number of bores sunk, the excess of the former being 45, while the number of former producing wells abandoned was 45 greater than the number of productive wells completed. During the months of August, October, November and December, the number of wells abandoned exceeded the number drilled by 239.

On October 15, 1906, there were approximately 16,397 producing wells in the Trenton rock fields of the State. The production of oil for the entire month of October was 607,178 barrels, or an average of 1.19 barrels per well for each day of the month. The average daily output in October, 1905, was 1.59 barrels for each productive well. This loss was due mainly to the greatly decreased number of new bores sunk during the year, and to the large number of old producing wells abandoned.

The following table shows the number of producing wells, number of dry holes, total bores, average initial production of wells drilled, and number of wells abandoned in each of the Trenton rock oil producing counties of Indiana in 1905 and 1906.:

Counties.	Producing Wells, 1905.	Producing Wells, 1906.	Dry Holes, 1905.	Dry Holes, 1906.	Total Bores, 1905.	Total Bores, 1906.	Percentage of Dry Holes, 1905.	Percentage of Dry Holes, 1906.	Av. Initial Output of Productive Wells, Bbls., 1905.	Av. Initial Output of Productive Wells, Bbls., 1906.	Abandoned Wells, 1905.	Abandoned Wells, 1906.
Adams	83	44	11	4	94	48	11.7	8.3	9.5	10	104	120
Blackford	55	55	10	9	65	64	15.4	14	7.3	12.6	95	152
Delaware	570	141	83	39	653	180	12.7	21.7	32.6	33.2	16	208
Grant	369	216	34	20	403	236	8.4	8.5	10.7	8.1	139	307
Hamilton	3	6	0	3	3	9	0	33.3	15	26.6	0	2
Huntington	159	121	2	2	161	123	1.2	1.6	19.3	13.6	35	6
Jay	171	178	33	27	204	205	16.1	13.1	15.8	15.4	41	65
Madison	30	2	25	1	55	3	45.4	33.3	15.7	15	13	32
Miami	4	1	1	0	5	1	20	0	8.7	10	2	16
Randolph	46	18	34	8	80	26	42.5	30.7	36.8	33.7	0	5
Wabash	1	2	0	0	1	2	0	0	6	10	11	0
Wells	154	224	4	11	158	235	2.5	4.6	11.4	9.4	151	125
Totals	1,645	1,008	237	124	1,882	1,132	*12.6	*10.9	*20.6	*14.6	607	†1,053

*Denotes average.

†Includes 15 abandoned in Marion County

From the table it will be seen that in most of the counties the number of productive wells drilled fell off very greatly. However, in Wells County there was a gain of 70, or 45 per cent., in the number of such wells, the county again taking the lead in new work, after having been in second or third place for several years. Jay County also gained seven over the previous year, while Blackford just held her own.

The average initial output of the new wells fell off six barrels per well, which was the largest loss in recent years. The initial output of the productive deep pay wells in Delaware and Randolph counties changed but little, there being a gain of one-half barrel in the former and a loss of 3.1 barrels in the latter. The percentage of dry holes in these two counties was, however, much above the average.

Huntington still maintains its good record among the older producing counties, there being but two dry holes among the 121 bores sunk within its bounds. This was a percentage of but 1.6 against the average of 10.9 for the field. The average initial output of the wells in Huntington fell, however, from 19.3 to 13.6 barrels.

Jay County made an excellent record, the average initial output of her wells falling off but .4 of a barrel, while her percentage of dry holes was reduced from 16.1 to 13.1.

Grant County forged ahead of Delaware in the number of new productive wells, and was ahead of Wells County in the number of bores sunk, but her percentage of dry holes was nearly double that of Wells, the latter ranking, as she has for several years, next to Huntington in low percentage of barren bores. From a careful study of the table one can learn many other facts of interest 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. 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 of 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 latter 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 and 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 spores of low forms of fresh water or brackish marsh plants known as Rhizocarps, which flourished in vast numbers during the time the materials afterwards compressed into the shale were being deposited. The shale is rich in bitumens derived from the destructive distillation of the spores of these ancient Rhizocarps. When kindled it will burn until they are consumed, and it is, therefore, by the uninitiated 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, near Salem, Washington 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. But one well which yielded petroleum in commercial quantities from the Corniferous limestone was sunk in Indiana in 1906.

Terre Haute Field.

Early History.—Crude oil was first discovered in the Corniferous rocks of Indiana in the city of Terre Haute in 1865. In that year Chauncy Rose started a bore near the present site of the Terre Haute House, in search of water. At 1,629 feet oil was struck in the Corniferous limestone, the yield being almost two barrels per day. This was shut out and the bore continued to a depth of 1,793 feet, where a strong vein of sulphur water was encountered.

In 1869 a second bore was drilled expressly for oil. It was located on the Wabash river bank between Walnut and Poplar streets. In it oil was found in the black shale and a gray limestone at a depth of 1,642 to 1,667 feet, but the amount was not sufficient to justify pumping.

A detailed section of the second well was published by Prof. E. T. Cox, then State Geologist, in the Second (1870) Report of this Department*. Of it Prof. Cox wrote: "In this well experienced borers were employed and the record of the strata passed through may be relied on as accurate. The record has been carefully made and each layer of rock tested to determine its character, consequently the sandstone and other strata are correctly placed."

Since a number of new bores will probably be sunk in the vicinity of Terre Haute in 1907, the section of the well is reprinted herewith, in order that operators and drillers may have for ready reference a detailed statement of the strata overlying the oil-bearing Corniferous limestones in that region. The section begins about 20 feet above low water in the river.

Section of Bore Sunk on River Bank at Terre Haute in 1869.

		Feet.	Inches.	Feet.	Inches.
1.	Sand and gravel	100	..	100	..
2.	Soapstone	64	6	164	6
3.	Coal	6	2	170	8
4.	Hard sandstone	2	3	172	11
5.	Soapstone	10	..	182	11
6.	Coal	3	..	185	11
7.	Soapstone	4	3	190	2
8.	Gray sandstone	5	10	196	..
9.	Blue soapstone	...	10	196	10
10.	Gray sandstone	...	6	197	4
11.	Blue soapstone	12	9	210	1
12.	Soft black shale	6	..	216	1
13.	Coal	...	9	216	10
14.	Soapstotne	7	7	224	5
15.	White sandstone (conglomerate)	30	3	254	8
16.	Blue shale	7	2	261	10
17.	Coal	2	3	264	1
18.	Black shale	10	..	274	1
19.	White soapstone	3	..	277	1
20.	Black shale	15	..	292	1
21.	White soapstone	8	..	300	1
22.	Black shale	3	3	303	4
23.	Coal	3	..	306	4
24.	Soapstone	17	8	324	..
25.	Sand rock	3	..	327	..
26.	Soapstone	20	..	347	..
27.	Sand rock	10	..	357	..

*This section was reprinted by Dr. J. T. Scovell in the Twenty-first (1896) Report of the Department, now out of stock.

		Feet.	Inches.	Feet.	Inches.
28.	Blue shale	22	..	379	..
29.	Limestone	2	..	381	..
30.	Blue shale	31	..	412	..
31.	Light shale	5	..	417	..
32.	Blue shale	60	..	477	..
33.	Sandstone	7	..	484	..
34.	Blue shale	24	..	508	..
35.	Sandstone	3	..	511	..
36.	White shale	10	..	521	..
37.	Blue shale	147	..	668	..
38.	Hard gritty slate rock	11	7	679	7
39.	Hard gray sandstone	14	5	694	..
40.	Hard limestone	11	..	705	..
41.	White limestone	24	..	729	..
42.	Gray limestone	2	..	731	..
43.	Limestone	14	..	745	..
44.	White limestone	82	..	827	..
45.	Soapstone	3	..	830	..
46.	Brown limestone	35	..	865	..
47.	Soapstone	5	..	870	..
48.	Lime rock	9	..	879	..
49.	Soapstone	6	..	885	..
50.	White limestone	7	..	892	..
51.	Soapstone or gypsum?	2	..	894	..
52.	White limestone	21	..	915	..
53.	Gray limestone	5	..	920	..
54.	Limestone and soapstone	5	..	925	..
55.	Gray limestone	5	..	930	..
56.	White limestone	15	..	945	..
57.	Fine blue limestone	2	..	947	..
58.	Dark gray limestone and flint	73	..	1020	..
59.	Light gray limestone	7	..	1027	..
60.	Blue gray limestone	7	..	1034	..
61.	Soapstone (fire-clay)	26	..	1060	..
62.	Gray limestone	24	..	1084	..
63.	Gray sandstone	3	..	1087	..
64.	Soapstone (fire-clay)	5	..	1092	..
65.	Quartz and shale mixed	166	..	1258	..
66.	Quartz, slate and soapstone	3	..	1261	..
67.	Slate rock	21	..	1282	..
68.	Soapstone	33	..	1315	..
69.	Slate rock	7	..	1322	..
70.	Soapstone	235	..	1557	..
71.	Soapstone and sandstone	10	..	1567	..
72.	Fine sandstone	15	..	1582	..
73.	Blue soapstone	40	..	1622	..
74.	Black shale	15	..	1637	..
75.	Red shale	5	..	1642	..
76.	Black shale	15	..	1657	..
77.	Lime rock	5	..	1662	..

	Feet.	Inches.	Feet.	Inches.
78. Black shale	5	..	1667	..
79. Gray lime rock, oil near the top	149	..	1816	..
80. Gray sand rock	23	..	1839	..
81. Lime rock	73	4	1912	4

According to Prof. Cox, salt water was found at 254 feet in white sandstone, No. 15 of the above section; strong sulphur water at 947 feet in "fine blue limestone" No. 57; strong salt water at 1,557 feet in the soapstone No. 70; oil at 1,642, 1,657 and 1,667 feet in the shales and gray limestone, Nos. 75 to 78; sulphur water at about 1,800 feet in the gray lime rock No. 79; and sulphur water at 1,840 and 1,912 feet in the lime rock No. 81.

Prof. Cox also stated that a third bore, located a quarter of a mile northeast of the Rose well, was sunk in 1869, and "passed through the black slate at 1,600 feet and 25 feet lower, in limestone which I refer to the Corniferous, a vein of oil was found which yields 25 barrels per day."*

In the later report on Vigo County by Prof. Cox, he stated: "Three wells that reached petroleum bearing strata have been bored at Terre Haute. One of these furnished from two to four barrels of moderately heavy oil in 24 hours. It did not flow out at the top, but had to be pumped. This materially advanced its cost, and owing to the extremely low price pertoleum has commanded in the market for some years, the well was abandoned and closed up."†

In the report for 1870, Prof. Cox also stated that "The Wabash River at Terre Haute runs on an anticlinal axis,"‡ and Dr. T. Sterry Hunt in the same volume states**: "This locality (Terre Haute) on the Wabash River is, according to Prof. Cox, on the line of a gentle anticlinal or uplift, which is traced a long distance to the west of south."

Phoenix and Other Wells.—In May, 1889, oil in large quantities was struck in the Diall or Guarantee No. 1 well located on the alley between 9th and 10th and Chestnut and Eagle streets, near the center of Terre Haute. When the drill first struck the oil bearing stratum on the night of May 6th, the flow was so great that quite a lake of oil accumulated around the derrick, and there was some alarm lest a destructive fire should result. The drill was then pulled out of the well, and as soon as the end left the

*Second Report of the Geological Survey of Indiana, 1870, p. 135.
†Seventh Ann. Report, Geological Survey of Indiana, 1875, p. 111.
‡Page 126.
**Page 136.

mouth of the casing, a solid stream of oil four and a half inches in diameter shot into the air a distance of 40 to 50 feet. While running at this rate, there was probably a little over a barrel a minute pouring from the well, and when the pressure decreased from the first spurt, which lasted only fifteen minutes, the flow steadied down to a four and a half inch stream spurting about three feet above the mouth of the well. A tank with a capacity of 20 barrels was put under the pipe, and it was filled to overflowing in just 22 minutes.

The result of this strike was like that of every other similar one in the history of the petroleum industry. Hundreds of oil operators from far and near flocked to Terre Haute. Real estate almost doubled in price. Twenty-four new companies were formed, 18 of which made locations. Twenty or more bores were put down in 1889 and 1890 to the required depth within three miles' radius of the first gusher, struck the proper stratum, and for the most part found—nothing. Two, within a short distance of the original well, yielded oil in quantity. The yield of one was soon overcome by salt water, as was also that of the original well. The other, the Phoenix well, now owned by the firm of Prox & Brinkman, has continued to yield to the present day, and has proven the most productive oil well ever sunk in the State.

No further prospecting was done until 1899, when two bores were completed. One of these, about two miles north and one-half mile west of the Phoenix, was a salt water well. It was located on the Aaron Conover farm, the site being 30 feet lower than that of the Phoenix well. The following is the driller's record of the strata passed through:

Record of Conover Well No. 1.

		Feet.	Feet.
1.	Gravel	102	102
2.	White shale	56	158
3.	Blue shale	3	161
4.	Gray shale	29	190
5.	Coal	6	196
6.	Blue and white shale	96	292
7.	Coal	2	294
8.	Gray slate	31	325
9.	Sandstone	10	335
10.	Light and dark shale	125	460
11.	Brown and white sandstone, bottom close and hard	40	500
12.	Very dark shale and soapstone	45	545

		Feet.	Feet.
13.	White sandstone, top soft	110	655
14.	Very hard white limestone	360	1015
15.	Sandstone, bluish	20	1035
16.	Limestone, white	10	1045
17.	Sandstone, dark bluish	30	1075
18.	Blue shale	150	1225
19.	Black shale	5	1230
20.	Sandstone, white, close	15	1245
21.	Black close shale	50	1290
22.	Sandstone, bastard, gray	15	1310
23.	Black shale, top sandy	30	1340
24.	Light colored sandstone	15	1355
25.	Slate	25	1380
26.	Light gray sandstone	80	1460
27.	Shale	25	1485
28.	Limestone, shells and shale	65	1550
29.	Soapstone	35	1585
30.	Limestone	5	1590
31.	Black shale	90	1680
32.	Corniferous limestone	15	1695

A little sulphur water was struck in the sandstone No. 11, at about 475 feet. The last 70 feet of No. 13, i. e., from 585 to 655 feet, was hard, with a great deal of iron ore scattered through it, and with a plentiful supply of water which rose to the top of the bore. At intervals in the white limestone No. 14, which was doubtless the Mitchell and Bedford oolitic stones, there were three or four small breaks, from two to five feet in thickness. The upper 15 feet of No. 18 was sandy and shelly. A large vein of very salt water was struck at about 1,420 feet in No. 26. This filled the bore and flowed 200 or more barrels daily until it was shut off. Another weaker vein was encountered in No. 28, at a depth of 1,510 feet. After drilling 15 feet in the limestone immediately below the black shale, the bore was abandoned, on account of salt water which overflowed the top.

In the second bore, known as the McWhinney well, located about 40 rods northeast of the Pheonix, oil was found which partially filled the hole.

For 12 or more years the Phoenix well yielded an average of 1,000 barrels per month. In the last few years this has gradually lessened and in 1906 the average was 450+ barrels per month. The combined output of it and the McWhinney well for 1906 was 7,269 barrels as against 7,044 in 1905. This was sold to local consumers at an average price of $1.15 per barrel, the whole amount received being $8,456.

The Vi-Clay Well.—In the fall of 1906 a test bore was put down on the Joslin tract of 20 acres in the southeast quarter of the northeast quarter of section 23 (11 N., 8 W.) Riley township, about 12 miles southeast of Terre Haute, and two miles southeast of Riley, a station on the E. & I. Railway. It was completed in November by the Vi-Clay Oil Company, composed of farm owners and citizens of the vicinity. This company had about 4,000 acres under lease, and the Joslin well was their first test-bore. The elevation at the well is said to be ten feet lower than that at the near-by 12-mile post, which is 130 feet higher than that of the Union Station at Terre Haute. This would make the site of the well about 605 feet above tide. The record of the well as furnished by George Scott, the contracting driller, was as follows:

Record of Vi-Clay No. 1 Well.

		Feet.	Feet.
1.	Surface soil, clay and gravel	15	15
2.	Sand rock	75	90
3.	Shale	5	95
4.	Coal	5	100
5.	Black to bluish shale	50	150
6.	Fire-clay	5	155
7.	Light grayish shale	145	200
8.	Light sand rock	100	300
9.	Light shale	200	500
10.	Dark slate	75	575
11.	Light sand	35	610
12.	Gray limestone	400	1010
13.	Gray limestone shells and dark shale	390	1400
14.	Light shale	65	1465
15.	Black shale	133	1598
16.	Gray limestone (oil bearing)	22+	....
	Total depth	...	1618

The iron used was as follows:

	Feet.
Drive pipe, 10 inch	15
Casing, 8 inch	707
Casing, 6⅝ inch	1405

More 8-inch casing was used than is necessary, as no water of consequence was found between the fire-clay, No. 6, which caved badly, and a point near the bottom of the limestone shells, No. 13. At the latter point were 10 or 12 feet of sharp grained limestone containing a quantity of briny water. This was shut off with the 6⅝-inch casing.

The black shale No. 15 is without doubt the Genesee or New Albany shale which immediately overlies the Corniferous or oil-bearing limestone. The top of the latter is said to be very hard and close-grained. The first oil was found 11 feet after striking it, and the porous or productive stratum was drilled in but six or seven feet before shooting. Upon being shot, about November 15, the well yielded 132 barrels the first day. It was pumped only at intervals, to December 27th, when it had filled three 250-barrel tanks. At that date it was said to be yielding at the rate of 50 barrels in 12 hours. A pipe line was then being constructed to the siding at Riley, where a loading rack was being built. No gas was found above the oil, and the only gas in the bore is that arising from the oil.

It is estimated by Mr. Scott that 40 to 50 days will be required to complete the average well in the vicinity. Coal for drilling and pumping can be had in quantity from nearby mines for about $2.10 per ton delivered.

The oil is a very blackish, very ill-smelling liquid, similar to that of the Phoenix well, the analysis and constituents of which are given on another page.

The usual excitement fostered by a new strike in wildcat territory followed the successful shooting of the well. Oil men from everywhere flocked to the vicinity and leases were taken on hundreds of farms within a radius of 20 miles. The Vi-Clay Company was offered $100,000 for their holdings, but refused that price, and let the contract for a second well. This, with six others, was soon located, and the timbers for their derricks were being hauled in on January 1st, 1907.

Elevations in Vigo County.—The following table of elevations in Vigo County was compiled by Dr. J. T. Scovell. They are mainly taken from railway levels and are adjustable to the level of the rail at the Union Station at Terre Haute, near the center of section 22-12-9. This point, as given by Gannett, is 485 feet above tide.

Table of Elevations in Vigo County.

	Feet above tide.
Rail at the Union Station (Gannett)	485
Ellsworth, on the Logansport road	492
Atherton, on the north county line	523
Hill one-half mile east of Atherton	625
Rosedale, one mile north of county line	537
Grant, on Big Four railroad	516
Fontanet, Nevins Township	539
Coal Bluff, on Otter Creek	553

	Feet above tide.
Lodi, on the county line	564
Perth, on the plateau in Clay County	633
Point one mile west of Seelyville	596
Seelyville Station	585
A point one mile east of Seelyville	604
East county line on the Vandalia	583
Spring Hill Junction, west of center of section 11-11-9	516
Honey Creek bridge, northeast northwest 17-11-8	505
Lockport or Riley Station	569
Highlands east of Lockport	622
County line, on the E. & I. Railway	614
Honey Creek bridge, on the Evansville road	509
Youngstown Station	578
Albin's hill, beyond Youngstown	604
Hartford or Pimento	600
County line on Evansville road	575
Farmersburg, one-half mile south of line	573
The west county line on the Vandalia	544
Point one mile west, on the plateau	581
Station at St. Mary's	555
Sandford, on the county line west	625
Morainic Hills, near Sandford	655
Yaw's Hill, northeast quarter section 18-10-8	673
Crapo's Hill, northwest quarter section 20-10-8	663

Properties of Terre Haute Oil.*—The oil from the Corniferous at Terre Haute is darker colored, more ill-smelling and of a greater weight and density than the Trenton rock oil from the main Indiana field. An examination and comparison of samples of the two were made by Dr. Noyes, who reported on them as follows:*

	Terre Haute.				Van Buren.			
	Per Cent.	Specific Gravity.	Degrees Beaumé.	Flashing Point.	Per Cent.	Specific Gravity.	Degrees Beaumé.	Flashing Point.
Original oil	......	0.879	30°	......	......	0.853	35°	......
Below 150° C.	......	......	......	......	7.2	0.719	......	Below 20° C
150°-200° C.	12.0	0.793	48°	38° C	10.2	0.759	56°	Below 20° C
200°-250° C.	14.0	0.825	41°	65° C	10.2	0.799	47°	60° C
250°-300° C.	13.6	0.847	36.5°	85° C	12.2	0.826	41°	82° C
300°-350° C.	14.8	0.867	32.5°	97° C	14.8	0.844	37°	96° C
350°-390° C.	40.6	0.879	30°	45° C	41.8	0.860	34°	38° C
Total distillate	95.0	......	......	......	96.4	......	......	......
Residue by weight	6.2 per cent.				4.5 per cent.			
Sulphur	.72 per cent.				.83 per cent.			

*The sample of Terre Haute oil was from the Phoenix well; that of Trenton rock oil was obtained at Van Buren, Grant County.

"The oils were distilled rather slowly from flasks with the thermometer in the vapor only. A thermometer filled with nitrogen and graduated to 460° C. was used.

"The oils appear to be quite similar in general character, but there is less of the low boiling products in the Terre Haute oil, and the specific gravity of the oil and of the various distillates is higher. The portion of the Terre Haute oil boiling at 350°-390° deposits considerable amounts of solid paraffines at 15° C. The low flashing point of the high boiling oil must be due to a partial 'cracking' of the oil. From the results, I calculate the following percentage of naphtha and kerosene contained in the petroleums:

	Terre Haute.	Van Buren.
Naphtha below specific gravity 0.73	None.	10%
Kerosene between specific gravity 0.73-0.83	30%	33%

There is little doubt but that a large quantity of oil occurs in the Corniferous limestone rocks beneath the city of Terre Haute and vicinity, else the yield of the Phoenix well could not have been so long continued. The porous area or reservoir containing the oil must, however, be narrow below that well, 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 Phoenix 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, the Corniferous 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. Until additional wells are completed in the vicinity of the one at Riley, no one can say what the future of that territory will be.

Jasper County Field.—In the Jasper County field the Corniferous or oil bearing limestone is found from 100 to 115 feet below the surface. On account of this shallow depth the output is small in quantity and heavy in quality, being a bluish or very dark green lubricating oil. 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.

An analysis of a sample of the Jasper County oil, made by Mariner & Hoskins, of Chicago, gave the following results:

Analysis of Crude Petroleum from the Jasper County Oil Field.

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

The oil was formerly refined by the Indian Asphalt Company, at Asphaltum, Jasper County. Its physical and chemical properties as derived from "actual runs made at the refinery upon a large scale" were as follows:

"Distillation started at 248° F. Thirty-eight gravity oil, light yellow in color. The total amount of distillates obtained when running the crude down to asphalt were 49 per cent. the loss was four per cent. and the amount of asphalt 47 per cent.

Average Gravity.	*Flash.*	*Fire.*	*Viscosity.*
26.2	272°	302°	170
25.4	292°	335°	210
24.8	312°	348°	310
24.0	338°	374°	728

"The viscosity of the crude at 90° F. is 1,274; gravity, 19.40 B.; at zero the crude will not flow through the viscosimeter, although its chill point cannot be obtained accurately, as there is no paraffine in it."

The output of the Jasper County field in 1904 was but 9,000 barrels and it has fallen off very much in the last two years, so that at present it is hardly to be considered when treating of the oil industry of the State.

Washington County.—Four bores are reported to have been sunk to the Corniferous limestone near Salem, Washington County, during the year. Two of these came in dry and the others started at about three barrels each, and are not now being pumped. No data is at hand regarding their field records.

Developments in the Vicinity of Birdseye.—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 nothing in the petroleum industry of the State.

In the vicinity of Birdseye the average bore strikes the porous rock containing the oil at 980 to 1,010 feet below the surface. This rock 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.

Fourteen bores were sunk in the Birdseye field, seven of which came in as light to fair producers, three as dry holes, one as a gas well and three 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. It never pays, when one has a fair well completed, to go a mile or two away in search of a gusher. As it was, $50,000 or more was sunk by the three companies in the field, and not a dollar's worth of oil was sold.

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

"Composition of Crude Oil from Birdseye, Indiana.

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

"Began to distill at about 45° C. Ceased to distill at about 350° C. Specific gravity, 0.850 at 16° C.

"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."

Huron Sandstone Petroleum.

Petroleum from the Huron sandstone is now produced in Indiana only in the vicinity of Princeton, Gibson County. A number of wells producing oil from this formation were pumped from 1900 to 1904 near Loogootee, Martin County, but all have been abandoned. A detailed description of the Princeton field, with accompanying map, is given in the next paper.

At Loogootee the records of the producing wells showed:

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

The results show that in this region the productive stratum is not to be relied upon. The pay streak in which the oil occurs is a fine to coarse-grained drab colored sandstone, varying in thickness from three to 14 feet. It does not appear to be continuous, but is in pockets. It varies much in closeness of texture, in some places being soft, quite porous and productive; in others hard, close-grained and barren.

TEST OR WILDCAT BORES IN WESTERN AND SOUTHERN INDIANA.

Within the past few years a number of wildcat test bores have been sunk in western and southern Indiana, all of which came in dry or as salt water producers. Those which have come to the notice of the writer were located as follows: One near Cates, Fountain County; one two miles south of Dana, Vermillion County; three near Fairbanks, Sullivan County;* one near Owensburgh, Greene County; one three miles northeast of Vincennes, Knox County; one near Bridgeport, Marion County; one near Mont Clair, Hendricks County; one near Georgetown, Brown County; one near Vevay, Switzerland County; and two near Cannelton, Perry County.

In the Brown County well the top of Trenton is said to have been struck at 1,420 feet, and that formation was penetrated 440 feet without finding a trace of oil and but a slight quantity of gas. At a depth of 1,860 feet the well was abandoned.

In the well located on the land of John Bradford, one and a half miles northwest of Bridgeport, Marion County, the strata passed through are said to have been as follows:

Record of Well near Bridgeport, Marion County.

		Feet.
1.	Drift (clay and gravel)	170
2.	Soapstone (Knobstone shale)	85
3.	Black and brown Genesee shale	125
4.	Corniferous limestone	140
5.	Niagara shale	50
6.	Niagara limestone	100
	Total depth	670

This bore was stopped before any possible oil bearing stratum except the Corniferous limestone was reached.

In the bore near Vincennes the drill reached a depth of 1,860 feet without finding either oil or gas. At this depth a bad cave was encountered in a shale, and the bore was abandoned. Its record, as furnished by T. H. Adams, of Vincennes, was as follows:

*One of these is said to have produced three barrels of oil the first day from a depth of 475 feet.

Record of Bore Northeast of Vincennes.

		Feet.	Feet.
1.	Drive pipe to bed rock	45	45
2.	Yellow sandstone	35	80
3.	Slate and shale	115	195
4.	Sandstone, limestone and shale	140	335
5.	Coal, 5-foot vein	5	340
6.	Blue limestone	10	350
7.	Light shale	10	360
8.	Soapstone	30	390
9.	Limestone	35	425
10.	Light shale	10	435
11.	Sandstone	30	465
12.	Slate and shale	20	485
13.	Fire-clay	20	505
14.	Blue shale	15	520
15.	Limestone	5	525
16.	Blue slate	20	545
17.	Black shale	20	565
18.	Sandstone	15	580
19.	Soapstone	10	590
20.	Slate	35	625
21.	Limestone and slate	15	640
22.	White sandstone and salt water	30	670
23.	Slate and shale	30	700
24.	Blue limestone	2	702
25.	Soapstone and shale	83	785
26.	White sandstone and salt water	15	800
27.	Sandstone	15	815
28.	Sandstone and shale alternately	125	940
29.	Limestone	10	950
30.	Black slate	30	980
31.	Sandstone	20	1000
32.	Slate	20	1020
33.	Streaks of slate and limestone	110	1130
34.	Sandstone	50	1180
35.	Shale (cased)	20	1200
36.	Sandstone	93	1293
37.	Shale	5	1298
38.	Gray limestone	12	1310
39.	Shale	3	1315
40.	Soapstone	10	1325
41.	Shale	10	1335
42.	Blue limestone	5	1340
43.	White sandstone	25	1365
44.	Shale	10	1375
45.	Blue limestone	10	1385
46.	Slate	15	1400
47.	Red rock	10	1410

		Feet.	Feet.
48.	Sandstone and salt water	20	1430
49.	Shale (cased)	105	1535
50.	Gray limestone	120	1655
51.	Shale	5	1660
52.	Blue limestone	5	1665
53.	Slate and shale	25	1690
54.	Sandstone and sulphur water	50	1740
55.	Slate	10	1750
56.	Shale	5	1755
57.	Gray limestone	10	1765
58.	Shale and gray limestone	55	1820
59.	Red rock	5	1825
60.	Hard gray limestone	15	1840
61.	Soapstone	5	1845
62.	Gray limestone	5	1850
63.	Soapstone	10+	1860

A record of the well located two miles east of Vevay, Switzerland County, was furnished by P. D. Pleasants, as follows:

Record of Bore near Vevay.

		Feet.	Feet.
1.	Surface, soil and clay	60	60
2.	Limestone shell and shale, 6 inches thick, alternating	105	165
3.	Limestone	75	240
4.	Layers of shale and limestone 5 feet thick, alternating	60	300
5.	Dark, hard limestone	22	322
6.	Shale, soft	1	323
7.	Limestone, very hard and full of salt water	32	355

At a depth of 165 feet shale, gas and water were encountered. In No. 4 of the section, signs of gas and oil were abundant. "A bushel of the stuff brought out by the bailer looked like yeast working." Salt water was struck at 300 feet, and at 355 feet was standing within 50 feet of the top.

One of the bores located five miles northeast of Cannelton, Perry County, was drilled to a depth of 2,533 feet. The record of the strata passed through, furnished by Wm. G. Ford, was as follows:

Record of Bore Northeast of Cannelton, Perry County.

		Feet.	Feet.
1.	Soil and loose material	47	47
2.	Shale	110	157
3.	White sandstone	63	220
4.	Shale	9	229

		Feet.	Feet.
5.	Limestone	41	270
6.	Shale	5	275
7.	Limestone, white, hard	55	330
8.	Shale	16	346
9.	Limestone with red particles	6	352
10.	White sandstone	5	357
11.	Shale	3	360
12.	Sandstone	13	373
13.	Shale	23	396
14.	Limestone, dark	10	406
15.	Gray shale	30	436
16.	Limestone, white	9	445
17.	Shale, gray	15	460
18.	White sandstone, with a little salt water	20	480
19.	Sandstone, white	31	511
20.	Shale	7	518
21.	Limestone, hard and white, with streaks of gray shale	27	545
22.	Limestone, white	103	648
23.	Hard white limestone, with alternating white and dark streaks	88	736
24.	Dark and whitish limestone	108	844
25.	Light limestone with white specks	6	850
26.	Limestone with dark and light streaks	90	940
27.	Sandy shale, hard and dark	87	1027
28.	Limestone, dark brown	81	1108
29.	Limestone, reddish brown	22	1130
30.	Limestone, dark	150	1280
31.	Limestone, lighter	10	1290
32.	Limestone, dark	52	1342
33.	Limestone, gray speckled	93	1435
34.	Limestone, Niagara, fine gray	346	1781
35.	Shale, Utica, dark brown	119	1900
36.	Limestone, Trenton	633	2533

Salt water was encountered in several places in the bore. Six and a quarter inch casing was first put in to 395 feet. After the salt water was struck at 480 feet, the hole was reamed and casing sunk to 515 feet. Mineral water was struck at 634 feet. The hole was again reamed out and cased down to 648 feet. Salt water was found again at 733 feet, necessitating another reaming and lowering of the casing to 736 feet. A small amount of water was had at 774 feet (about 40 gallons per hour and diminishing), but not enough to interfere, the bailer taking care of it easily.

An analysis of the mineral water found in this well at 634 feet was made by Dr. J. N. Hurty, of Indianapolis, who reported on it as follows:

Analysis of Water from Well near Cannelton.

	Grains per U.S. Gallon.
Calcium carbonate ($CaCO_3$)	18.20
Calcium sulphate ($CaSO_4$)	22.66
Calcium chloride ($CaCl_2$)	130.20
Magnesium sulphate ($MgSo_4$)	147.37
Magnesium chloride ($MgCl_2$)	75.00
Sodium chloride (NaCl)	2681.03
Silica (SiO_2)	2.07
Hydrogen sulfid (H_2S)	Abundant

"This is a valuable medicinal water. It belongs to the class known as 'saline-sulphuretted waters.' It will be found cathartic and alterative. For bathing it is excellent. It will also act excellently in rheumatism, stomach troubles and like disorders."—*Hurty.*

One of the deepest wells drilled in Indiana was the one in the court house yard at Bloomington, Monroe County, which was put down about 1885 in search of artesian water. It was sunk to a depth of 2,730 feet and is said to have passed through the following formations without finding more than a trace of oil or gas:

General Record of Well at Bloomington.

	Feet.
Drift	6
Sub-carboniferous limestone	749
Devonian shales and limestones	170
Niagara limestone	240
Hudson River limestone	485
Utica shale	180
Trenton limestone	626
Potsdam sandstone	274
Total	2730

No oil or gas has been found in Indiana or adjoining states below the Trenton limestone, though a half dozen or more bores have passed entirely through that formation.

A bore was put down near the gas works on the east bank of the Wabash River at Terre Haute about 1890, which stopped at a depth of 2,940 feet. In it the top of Trenton was found at 2,890 feet. This was the deepest bore in western Indiana, and probably in the State.

* * *

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 Princeton, we find the total production and value of petroleum in Indiana for the last three years to be as follows:

Total Production and Value of Crude Petroleum Produced in Indiana in the Years 1904, 1905 and 1906.

	1904.		1905.		1906.	
	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
Trenton Rock Petroleum.	11,281,030	$12,127,107	10,892,438	$9,236,788	7,762,825	$6,877,863
Corniferous Rock Petroleum	18,103	21,040	12,064	13,270	7,269	8,456
Huron Rock Petroleum	32,405	28,951	64,806	55,413	103,843	81,770
Total	11,331,538	$12,177,098	10,969,308	$9,305,473	7,873,937	$6,968,089

As one travels through the oil district of the State a sense of the greatness of the industry grows rapidly upon him. One might study it for years and yet not master its every intricacy. He 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 in 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 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 Messrs. George Davids and John Sidey, of Montpelier; W. H. Mandeville, W. A. Kunkle, R. K. Souder and Mike Long, of Bluffton; Jas. E. Hardison, of Geneva; Benjamin Fulton of Portland; H. C. Zeigler, H. A. Wheeler and Geo. E. Scott, of Muncie; B. A. Kinney, A. W. Nickle, A. S. Warren, R. B. Moran and L. A. Von Berin, of Marion, I am under special obligation for services rendered both in the field and since my return therefrom.

THE PRINCETON PETROLEUM FIELD OF INDIANA.

By Raymond S. Blatchley.

Topography.—Gibson County, of which Princeton is the county seat, lies in the southwestern point or "pocket" of Indiana, adjoining Illinois on the west and separated from that state by the Wabash River. On the north, with White River between, is Knox County; on the east Pike, and on the south, Posey, Vanderburgh and Warrick counties. It comprises an area of 490 square miles, with 305,114 acres of farm land, the surface of which is, for the most part, rolling, with the exception of the flat-bottom lands of the Wabash River valley.

The county is divided topographically into three sections, viz.: the river flats, upland plains or terraces and rolling uplands. The soils of these are of drift origin, and are for the most part very fertile. The land west of Patoka, between the Patoka and White rivers, is of the lower flood plain deposits, and is subject to an annual overflow. Its soil is composed of alluvial silts and sands, except in one place in the southwestern point of White River township, where are a few compact and isolated knobs, called the Gordon Hills. They cover an area of one and a half square miles and rise to an elevation of 500 feet above sea level. In the lower flood plain to the east of the Gordon Hills heavy deposits of gravel occur, ranging from 20 to 114 feet in thickness.

South of the Patoka River and adjoining the Wabash River, lie the terraces or second bottoms, which are rarely overflowed. Along the Wabash River are several abandoned channels, and in these are found the low swamp land and river flats, which are drained by ditches.

Bordering the upper plain or terrace deposits, on a line drawn from the village of Patoka to the southeastern corner of Wabash township are the first sand hills or dunes, composed of coarse sands resting on the upper flood plain deposits. These range from one-half mile to two miles in width. Back of the sand hills and covering an area to the eastern border of the county, are the drift ridges of the rolling uplands. This is all tillable land underlain with stratified gravels and sands. The only loess of any consequence lies through the center of Montgomery township between townships 2 and 4 south and bordering the southern edge of Princeton in a strip covering two square miles.

The county is thus one of the richest farming districts in southern Indiana, the most stable crops being corn, wheat and hay on the ridges and lowlands, and watermelons on the sand ridges.

In the drilling of oil wells many clays and shales are encountered which form a part of the Coal Measure rocks. They are first found east of the Wabash three or four miles, and are heaviest in the vicinity of Princeton and the present oil field. Near the surface they are brown and almost black in color, but at a depth of 200 feet become gray. The shales are found in greater abundance, and their thicker layers are often separated by thin layers of limestone shell. At a depth of 100 to 125 feet, about 200 feet of a tough, soft shale gradually merging into a hard shale and limestone is encountered. At a depth of about 420 feet occurs a heavy vein (6 to 7 feet) of coal. This is mined just north of the corporate limits of Princetion. This vein is found over all the territory in the vicinity of Princeton and is everywhere a workable deposit. Just beneath this coal vein in the present oil field, alternate strata of shale and sandstone are gotten.

A record of the coal veins which occur in and about Princeton is given in the Patoka Folio of the United States Geological Survey as follows:

COAL VEINS IN VICINITY OF PRINCETON.

Nearest Town.	Location.	Source of Information.	Depth. Feet.	Thickness, Feet.	Coal.
Patoka......	Bluff South of river..............	Outcrop................	....	1	Parker.
Princeton....	Indian Creek, N. E. of town......	Outcrop................	....	2	
Princeton....	N. E. ¼ Sec. 5, T. 2 S., R. 10 W...	Kurtz deep bore.........	146	1	
Princeton....	Sec. 5, T. 2 S., R. 10 W..........	Kurtz shallow bore......	258	2½	Millersburg.
			90	4½	
Princeton....	Sec. 33, T. 1 S., R. 10 W.........	Shannon well...........	76	1½	
Princeton....	S. E. ¼ Sec. 12, T. 2 S., R. 11 W...	Oswald shaft............	430	6	Petersburg.
Princeton....	North edge of town..............	Interstate Gas & Oil Co..	380	7	Petersburg.
			460	4	
			615	5	
Princeton....	N. W. ¼ Sec. 8, T. 2 S., R. 10 W..	Evans well.............	62	1½	
			281	½	Millersburg
			402	6	Petersburg.
			514	6	
Princeton....	Near preceding..................	Deep well..............	80	1½	
			283	3	Millersburg.
			422	7	Petersburg.
			471	7	
			593	4	
			628	3½	
			670	4	
Princeton....	S. W. ¼ Sec. 7, T. 2 S., R. 10 W...	Hall well..............	355	6	Petersburg.
			470	6	
			670	6	
			130	7	
			1,020	3	
Princeton....	S. E. ¼ Sec. 7, T. 2 S., R. 10 W....	Thompson well..........	82	1	
			281	2	Millersburg.
			396	6	Petersburg
			462	5	
			604	6	
			723	6	
Princeton....	N. E. ¼ Sec. 18, T 2 S., R. 10 W..	Southern R. R. shops well	199	2	Millersburg.
			346	7	
			451	2	
Fort Branch..	Peter Hoffman place............	Well..................	56	1	
			178	5	
			250	3½	Millersburg.
			301	5	Millersburg.

Drainage.—The Patoka River enters the county at the northeastern corner of Columbia township and has its mouth at the southwestern corner of White River township, cutting the country in a zig-zag fashion. The Patoka valley, before it merges into the more extensive Wabash valley, averages two miles in width, and many hills, of which Yeagers Hill is the highest, border the river throughout its course.

Above the Wabash bottoms the county is drained principally by the Patoka River, Pigeon Creek and Indian Creek. The Wabash, White and Patoka rivers are the only streams maintaining any notable flow throughout the seasons, while in the wet months the Indian, Pigeon and Indian Camp creeks flow merely enough to drain. The lesser streams have their sources in numerous springs found on the upland ridges.

In the lowlands a ditching system has converted the low marsh lands and bayous into rich black soil. The Blair, Summers, Stunkle and McCarty ditches are the largest, and the latter affords practically the only drainage for the southwestern end of the present oil field.

Transportation, population and elevations.—The transportation facilities of the county are fair, the Evansville & Terre Haute Division of the Frisco System, and the St. Louis & Louisville Division of the Southern Railroad pass entirely through the county and have their junction at Princeton. The latter railroad has its central shops at Princeton, and gives extensive employment to many people.

Besides these, the Evansville & Indianapolis Railroad passes north and south through Columbia and Barton townships on the east; the Evansville, Princeton & Vincennes Traction Company operates between Evansville and Princeton; and the Evansville & Terre Haute Railway has a branch road running from Ft. Branch through Owensville in Montgomery township and thence to Mt. Vernon, Posey County.

Within the last two or three years the improvement of roads has received much attention in the county, with the result that all the main roads are being converted into macadamized pikes. This has been of especial advantage to the region west of Princeton through the oil fields, where previously the only roads leading into the bottom lands of the Wabash River were of sand.

The population of the county in 1900 was 30,099, and at the present time is about 34,500, while that of Princeton was 6,041 as against 8,500 now. Owensville has a population of about 1,250 and Patoka about 900.

The elevations in feet above sea level of the towns and principal points in the county are: Yeagers Hill, 642; Bald Hill, 634; Francisco, 430; Fort Branch, 440; Gordon Hills, 500; Haubstadt, 473; Hazelton, 422; Kings Station, 463; Lyles, 400; Owensville, 507; Patoka, 429; Princeton, E. & T. H. Ry. Station, 478; Southern Ry. Station, 461; Crossing of E. & T. H. and Southern railways, 429; Court House, 501; Mt. Carmel, Ill., Southern Ry., 390, Court House, 424.

THE PRINCETON OIL FIELD.

Since May, 1903, petroleum has been found in Gibson County in commercial quantities in a sandstone which varies from 820 to 920 feet below the surface. From the record of the bores and the appearance and structure of the oil bearing sand, which changes from a coarse gray on top to a finer grayish-yellow sand in the pay stratum, 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. The Huron comprises the surface rock over a strip two 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 Footes 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:

Section near Footes Spring, Orange County.

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

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 limestones, 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."

The Princeton field at present covers an area of twelve square miles, and lies in sections 35 (1 S., 11 W.) and 2, 3, 10 and 11 (2 S., 11 W.) of Patoka township. The eastern limit of the field is about one and a half miles from the northwestern corner of the corporate limits of Princeton. The field is easy of access and is cut by the old Sand and Mt. Carmel roads and by the Southern Railway.

Early History of the Field.—The early history of the Princeton oil field dates back to 1891, at the time when a subsidy was voted by Patoka township to the Southern Railway Company, inducing that company to locate their central shops at Princeton. A little previous to this time Wm. R. Wright of Princeton, while in search of coal and gas, had completed a well known as the Evans well, on the eastern edge of the city. A considerable pressure of gas was found, which induced him to pipe it to the courthouse yard and burn it, so attracting public interest to his well. This event, along with the voting of the subsidy, created some excitement and in a short time afterward four more wells were completed. However, they were unsuccessful in producing any quantity of gas, although the presence of heavy strata of coal and shale was shown.

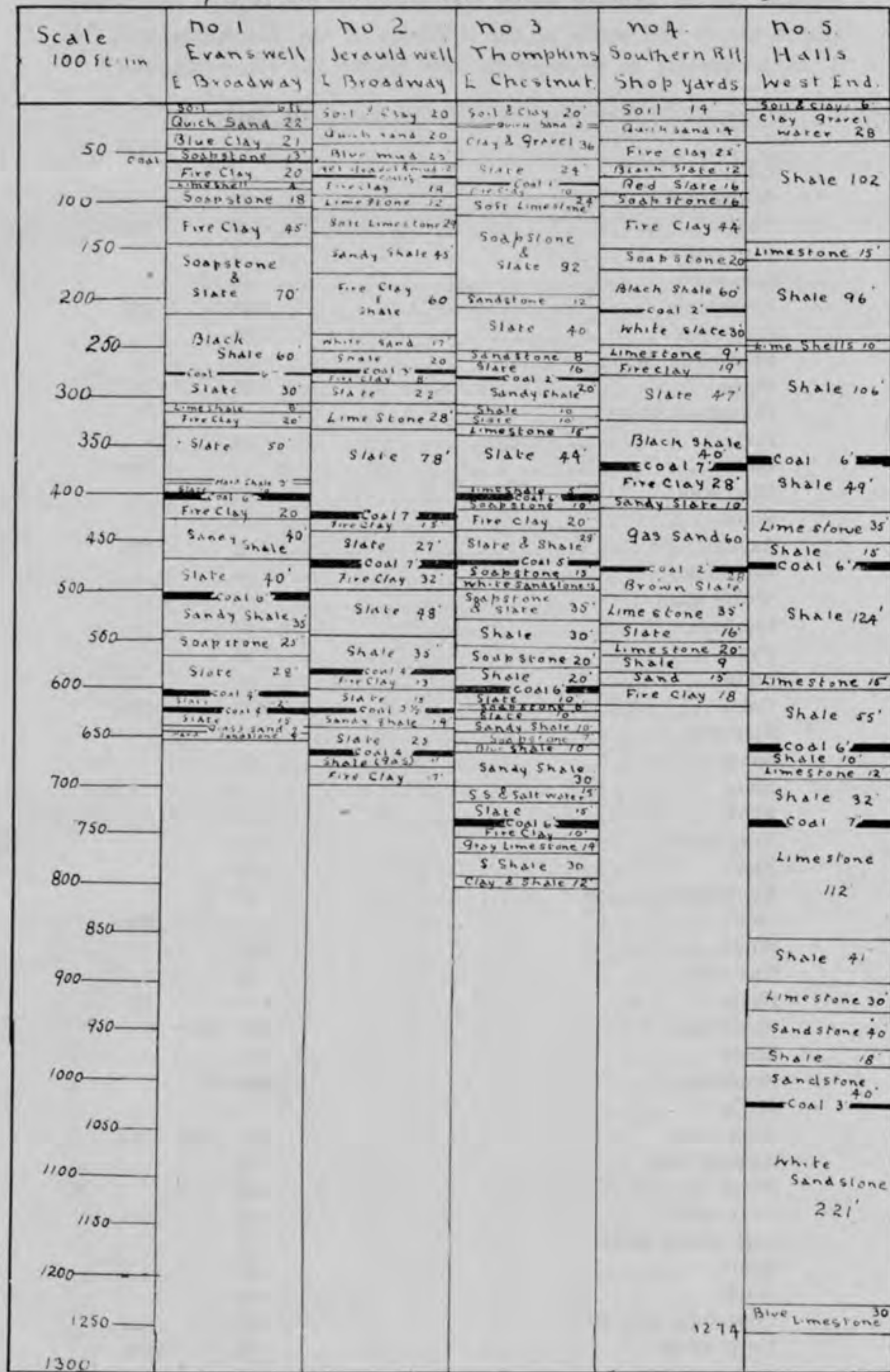
Three of these wells were near the Evans well, while the fourth was located in the Southern shops yard. The latter well was notable as indicating the presence of workable coal strata. At a depth of 199 feet two feet of Millersburg coal was found, and at 346 feet a heavy vein of seven feet was located. At 451 feet a small vein of two feet was gone through, and in the neighborhood of 600 feet a small quantity of gas was encountered.

A sixth well was located on the J. B. Hall tract on the western edge of Princeton, west half of the southwest quarter of section 7, directly south of the E. & T. H. depot. A distinctive feature of this well was the depth and number of coal strata passed through. It was carried to a depth of 1,274 feet, and at 355 feet a vein six feet in thickness was passed through. At 470 feet another vein of six feet was located and another of the same thickness at 670 feet. The largest vein was struck at 730 feet, being seven feet through, and finally, at a depth of 1,020 feet, three feet of coal was encountered, showing five strata of coal in this one location. This location has not, as yet, been operated for coal and the opening has been standing as a water well. Recently a small quantity of gas was found issuing from the hole, but merely enough to make a temporary blaze.

Gas has not been found in sufficient quantity to be of any commercial value in any of the wells located in 1891, but all were comparatively rich in coal strata. A full record of the wells as they were drilled is shown on the opposite page, the data being secured from E. Criswell, of Princeton.

Some time elapsed before prospecting for gas and coal was again begun. During the following ten years small deposits of jet-black asphaltum were from time to time encountered in several entries in the deep coal mine operated north of Princeton, near West Junction, the crossing of the E. & T. H. and Southern railways. This discovery led to the belief that petroleum would eventually be found, and finally, on January 16, 1902, a company composed of business men of Princeton was organized, and incorporated as the "Interstate Oil and Gas Company." These men were the pioneers of the Princeton oil field and were, namely: Seth Ward, Sr., S. T. Heston, Eugene Criswell, G. E. Bryant, Harry Kurtz and J. W. Archer. The capital stock was $500,000, in $1.00 shares. They leased 3,000 acres of land in the vicinity of Princeton, and early in the spring of 1902, let a contract to drill 2,000 feet, with the understanding that Trenton rock was to be reached. A bore was put down on the Chas. Brownlee farm, south half of the southwest quarter of section 6 (2 S., 11 W.), one-half mile north of the corporate limits of Princeton. The drill passed through alternating strata of shale, coal, fire-clay, limestone, sandstone, etc., and, after reaching a depth of 1,453 feet, the bore was abandoned on account of frequent cavings of the shale passed through. A deposit of asphaltum, estimated to be six feet in thickness was struck at a denpth of 450 feet. At a depth of 869 feet a showing of oil was found, but the quantity was so small as not to warrant the shooting of the well. At a depth of 1,026 feet another showing of oil was encountered, but like the first, was passed in the hope of reaching Trenton rock. The abandonment of the well in February, 1903, after the expenditure of $5,000, discouraged the operators, so that some time

Princeton Wells Drilled in 1891 Fig 1



elapsed before another entry was made in the field. The following is the record made of the drillings of the Interstate well, No. 1, as accurately as it could be kept under the circumstances:

Record of Bore No. 1 Sunk by Interstate Oil and Gas Co.

	Feet.		Feet.
Drift	40		
Soapstone	75		
Coal	3		118
Fire-clay	4		
Limestone	10		
Soapstone	148		280
Limestone	35		
Shale and mud	35		
Slate	20		
Limestone shale	1		
Slate	14		
Coal	7		392
Blue mud	43		
Slate	15		
Asphalt (?)	6		456
Limestone	30		
White sand	6		
Limestone	35		
Shale	45		
Slate	15		
Coal	5		592
Fire-clay	5		
Sand	15		
Slate	6		
Shale	5		
Gray sand	20		
Shale	36		
Limestone	13		
Coal	7		699
Shale	40		
Gas sand	12		
Shale	18		769
Sandstone	100	(oil)	869
Shale	25		
Sandstone	100		
Shale	5		
Gray sand	30	(oil)	1029
Asphalt base	25		
Shale	125		
Gray sand	20		1199
Salt water sand	15		
Shale	45		
Sand	40		
Limestone and shale	20		1319
Hard stone	84		1403

After the abandonment of the Interstate well a new company, known as the Hoosier Prospecting Company, was organized and, being stimulated by the reports of asphaltum in the vicinity, incorporated April 20, 1903, and recorded June 11, 1903, with $5,000 stock in shares of $10 each. They secured leases upon 700 acres of land northwest of Princeton and started a bore on the L. M. Miller farm, north half of the west half of the southeast quarter of section 2 (2 S., 11 W.), which was finished May 25, 1903, and developed into the first productive oil well in the Princeton field. The strata passed through were alternating layers of sandstone, limestone, shale and coal, varying in thickness from one 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 field record of the well was:

	Feet.
Drive pipe	60
Casing	802
Top of oil sand	871
Bottom of sand	893
Total depth	907

When finished the oil rose nearly to the top of the bore, but was not pumped for several months. On July 15, 1906, it was producing about three barrels per day.

A second well, 100 feet south, was drilled soon after the completion of the first and was finished in August, 1903. Its record showed:

	Feet.
Drive pipe (10 in.)	60
Casing (8 in.)	60
Casing (6¼ in.)	384
Casing (4⅝ in.)	800
Top of sand	871
Bottom of sand	895

The shale immediately overlying the oil pay in No. 1 on the Miller lease was continuous, and 62 feet in thickness, but in No. 2 there were two strata of non-productive sandstone intercalated with this shale before the oil pay was reached. This sandstone yielded slight quantities of gas. In several wells in the field these two strata of sand produced considerable pressure of gas, and in one instance, on the Kendle lease, the driller was badly burned by the rush of gas which ignited from the fire of a blacksmith's forge.

In the Hoosier Oil well No. 2, one of these gas veins ten feet in thickness was found 20 feet in the shale. The second, five feet thick, was 35 feet below the top of the shale. The third layer of sandstone, or oil sand, had the upper 12 feet barren, but the lower six feet proved to be rich in oil. The gas present was of sufficient pressure to spray the oil above the top of the derrick. A shot of 80 quarts of nitroglycerine was used and the initial production was 25 barrels per day. The well was put to pumping steadily September 15th, and on October 13th the two wells on the lease were producing about nine barrels of oil per day, and on July 15, 1906, averaged four barrels each.

The advent of a second successful well was reported far and wide and soon caused an influx of oil operators from every direction. A rush for leases took place and by the middle of October, 1903, sixteen companies had organized and half a dozen derricks were up. The new turn of affairs renewed the interest of the Interstate Company and, in September, 1903, they started their second bore. It was located on the S. Warnock tract, southwest quarter of the southwest quarter of the northwest quarter of section 6 (2 S., 10 W.), Patoka township, and was drilled to a depth of 950 feet, but proved to be dry with only a small showing of gas.

From this time the drilling of wells went steadily on and the field branched out to the southwest and northwest of Princeton, with considerable wild-catting on the outskirts of the present field. A number of these wild-cat bores resulted in dry holes, which restricted this territory to the area of 12 square miles of the present field.

The Outer Field.—The wild-cat wells of the Princeton field cover an area of about 120 square miles, with Princeton as a central point. The wells placed in the outskirts of the present field were put down rapidly and, in many cases, with but little knowledge as to the nature of the oil bearing stratum. As a result, practically all of the wells came in as dry holes; but this does not necessarily mean that the outer field is barren territory. In fact, the present advance is moving directly into the wild-cat country. Records of these wells were kept only in a few cases, and only in the terms used by the drillers.

Near Owensville in Montgomery township two wells were put down by the "Eagle Oil & Gas Company." Of these well No. 1 was placed on the C. W. Jones tract of 20 acres, southwest quarter of section 30 (2 S., 11 W.). A contract was let to drill 1,000 feet and the driller carried it to 1,030 feet. Through the drift, a large amount of water was met, necessitating 100 feet of 10-inch drive pipe. At a depth of about 150 feet, three feet of coal was found, and at a depth of 230 feet a vein of three and a half feet was met. The largest vein of coal was struck at 425 feet and was eight and one-half feet in thickness. At a depth of 500 feet a trace of gas was encountered. The bore was carried 40 feet into the sand and proved to be barren. After the drift was passed and the water cased off, the remaining depth was found to be entirely free from water, which marked it as one of the driest holes in the field.

No. 2 of this company was located on the W. Garret tract of 80 acres in the east half of the southeast quarter of section 4 (3 S., 12 W.). There was hardly any evidence of coal in this bore but a strong flow of gas was secured. A large volume of fresh water interfered with utilizing the gas, with the result that the bore was abandoned. The well was completed in October, 1904, and was reported barren.

A third well in the vicinity of Owensville was sunk by the Indian Camp Oil Company, on the H. A. Mauck lease of 15 acres in the southwest quarter of section 19 (2 S., 11 W.). At a depth of 430 feet, eight feet of coal was struck, and at 360 feet four feet was passed through. The field record of the well shows:

	Feet.
Drive pipe, 10 in.	95
Casing, 8 in.	130
Casing, 6¼ in.	785
Top of sand.	918
Depth into sand.	28
Total depth	946

This well was drilled in eight days and came in without a showing of either oil or gas.

The fourth well in this vicinity was on the J. Meaders lease, southwest quarter of the northeast quarter of section 28 (3 S., 12 W.), Montgomery township. It was drilled by the Posey, Vanderburgh and Gibson County Gas and Oil Company, and was reported a dry hole.

South of Fort Branch, in Johnson township, a well was drilled on the H. Solloman tract, west half of the west half of section 5. It was drilled to a depth of 1,550 feet without a showing of oil. A large volume of salt water was, however, encountered.

The second well in the vicinity of Ft. Branch was drilled on the J. E. Toops farm. It was put down over 1,000 feet without showing of oil or gas, but coming in contact with another large volume of salt water. An interesting fact concerning this well was the thickness of coal strata passed through. At a depth of 260 feet, five feet of coal was met and at 366 feet eight feet of coal was encountered. The thickest vein recorded in the county was struck at 591 feet, it being said to be twelve feet through, though part of it was doubtless black shale. Several smaller veins were also drilled through. In all, 25 feet of coal was passed through. This well was completed July 25, 1906, and was drilled to 925 feet before sand was gotten. At 935 feet a strong vein of salt water was encountered, and at 1,020 feet the drilling stopped.

A dry hole on the John S. Brown tract of 160 acres, southeast quarter of the northeast quarter of section 28 (2 S., 11 W.), Montgomery township, had the following record:

	Feet.
Drive pipe, 10 in.	120
Casing, 8 in.	210
Casing, 6¼ in.	850
Top of sand	750
Total depth	1200

Northeast of Princeton a dry hole was drilled on the James Carithers tract of 100 acres, southwest quarter of the southeast quarter of section 27 (1 S., 10 W.), Patoka township. As there was no record kept of this well, but little is known about it, except that it had a showing of gas and was over 900 feet in depth.

About a mile west of the Carithers well, on the J. Glaze tract, south half of the northwest quarter of section 28 (1 S., 10 W.), White River township, the Ohio Oil Company drilled a dry hole in September, 1903. The well was plugged immediately after it was drilled, and doubt has been expressed as to whether it was barren or not. The record as given by the company is:

	Feet.
Top of sand	790
Water	853
Total depth	863

The same company drilled a test well on the R. Smiley tract, south half of the southeast quarter of section 21 (1 S., 11 W.). White River township. The intention of the company was to drill 2,500 feet into Trenton rock, but they only reached a depth of 1,735 feet when they had to abandon the well on account of cavings in the shale strata. This well is notable in that 14 feet from the surface a heavy stratum of water gravel was struck which was 114 feet in thickness. At a depth of 1,400 feet a pool of salt water was struck which has been running out of the top of the bore for a year and a half. A mere showing of Huron sandstone was found. The record of the well showed:

	Feet.
Drive pipe, 15 in.	106
Drive pipe, 12 in.	166
Drive pipe, 10 in.	741
Casing, 8 in.	1060
Casing, 6¼ in.	1735
Total depth	1735

The well came in dry and without a showing of gas.

A bore on the J. Kelch lease, southeast quarter of the southwest quarter of section 26 (1 S., 12 W.), White River township, was put down by W. J. Rogers of Mt. Carmel, Illinois, as a private enterprise. It was carried to a depth of 1,010 feet into salt water and came in as a dry hole, with a showing of gas. At a depth of 320 feet, four feet of coal was passed through; at 360 feet, 14 inches was found; at 400 feet, eight inches, and at 420 feet, six feet was struck. The field record of the well shows:

	Feet.
Drive pipe, 10 in.	60
Casing, 8 in.	110
Casing, 6¼ in.	700
Top of sand	960
Thickness of sand	8
Total depth	1010

A well reported as dry was drilled on the Emma D. Pickeral tract, east half of the northwest quarter of section 19 (1 S., 11 W.), White River township.

A well located on the C. and E. Hitch tract, northwest quarter of the southeast quarter of section 33 (1 S., 11 W.), White River township, was put down by the Butler Oil Company and was also reported as a dry hole. The well was drilled over 1,000 feet and the Huron sandstone was gotten close to 900 feet.

In the southwest quarter of section 26, White River township, a bore was sunk by a private company which proved barren. It was immediately south of the southern wing of the field and placed a check on the movement toward the town of Patoka.

The Princeton Oil & Gas Company, of Princeton, sunk two bores in the outskirts of the present field. The first was on the E. D. Miller tract, west half of the southeast quarter of the southeast quarter of section 5 (2 S., 11 W.), Patoka township. It came in a dry hole, but immediately under a six-foot vein of coal, at 460 feet, a small volume of gas was encountered, and just above the top of Huron sandstone, which was found at 935 feet, a heavy volume of gas was gotten, which flowed for a long period. A large quantity of water filled the bore and restricted the flow of gas which, at present, escapes from the bore only in sufficient quantity to make a small blaze when lighted. The drill was sunk 40 feet into the sand, making the total depth 975 feet. The well when completed was held to condemn the territory on the west of the present field, but in September, 1906, the active field was making progress in this direction.

A second bore by this company was completed in May, 1904, on the W. L. Watkins lease, northeast quarter of the southeast quarter of section 9 (2 S., 11 W.), Patoka township. It came in as a dry hole, and was drilled to a depth of 955 feet, the sand being found at 910 feet. This well placed a permanent check on the movement southwest of the active field.

In the southwest quarter of the southwest quarter of section 36 (1 S., 11 W.), Patoka township, on the Robert Mitchell tract, the Hoosier Oil Company drilled a dry hole. It was carried to a depth of 856 feet and had the following record:

	Feet.
Casing, 6¼ in.	680
Top of sand	816
Depth into sand	40
Total depth	856

The Ohio Oil Company drilled a well on the Robert Howe tract, southeast quarter of the northwest quarter section 1 (2 S., 11 W.), Patoka township, close to the E. & T. H. Railroad, which showed a quantity of oil at 892 feet, but the well was never shot and is reported as a dry hole. It has since been plugged and abandoned. Its field record shows:

	Feet.
Drive pipe, 10 in.	63
Casing, 6¼ in.	165
Casing, 4⅞ in.	705
Top of sand	871
Oil at	892
Total depth	912

The Gibson County Oil & Gas Company drilled one well, which proved to be dry. It was located in the northwest quarter of the northeast quarter of section 13 (2 S., 11 W.), Patoka township, on the J. McCarty tract.

In the northwest quarter of the southeast quarter of section 11 (2 S., 11 W.), Patoka township, on the R. H. McCurdy lease, the Interstate Oil and Gas Company drilled their third and last well. It was finished in January, 1904, and proved to be a dry hole.

The Crawford & Trenton Rock Oil Company drilled a dry hole on the Westfall tract, northeast quarter of the southwest quarter of section 14 (2 S., 11 W.), Patoka township. The same company drilled four wells on the W. W. Blair tract, southeast quarter of the northwest quarter of section 4 (2 S., 11 W.), Patoka township, of which two were dry holes and two were light pay wells, averaging about one and a half barrels per day. This was so light that they were abandoned. Several large veins of coal were passed through in these wells. At a depth of 430 feet the first vein was found, which measured seven feet through. At 555 feet a second vein, six feet in thickness, was struck. Also one of the same depth was found at 665 feet. The largest vein was encountered at 789 feet, and was nine feet through, making four thick strata in this territory. The four wells were about 350 feet apart, forming a square. The record of well No. 1 shows:

	Feet.
Drive pipe, 10 in.	100
Casing, 8 in.	120
Casing, 6¼ in.	690
Top of sand	826
Total depth	850

A well on the L. Binkley farm, southwest quarter of the southeast quarter of section 10 (2 S., 11 W.), Patoka township, was drilled by the Ohio Oil Company and was carried to a depth of 1,040 feet. In it the Huron sand was gotten at 1,035 feet. This is due to an elevation in the surface of the land, one-half a mile from the active field. This well borders the present pay wells and came in as barren, which, along with the Interstate Oil Company's well No. 3 on the McCarty lease, placed a check on the field south and southeast of the old Sand road. Its record shows:

	Feet.
Casing, 8 in.	69
Casing, 6¼ in.	691
Top of sand	1035
Total depth	1040

The Ohio Oil Company also drilled two wells on the J. A. Mauck tract, of which No. 2, offsetting No. 2 on the W. W. Blair farm, came in with a fair showing of oil, but not of sufficient quantity to justify shooting. It was located in the southwest quarter of the northeast quarter of section 4.

About one mile northeast of No. 2, just south of the Patoka River in the southeast quarter of the northeast quarter of section 33 (1 S., 11 W.), Patoka township, was located No. 1, which was completely barren of gas or oil. The field records of the two wells show:

	No. 1. *Feet.*	*No. 2.* *Feet.*
Drive pipe, 10 in.	103	93
Casing, 8 in.	147	128
Casing, 6¼ in.	748	700
Top of sand	875	864
Total depth	936	920

On the P. F. Mauck lease, the same company drilled a dry hole in the southeast quarter of the northwest quarter of section 3, the record of which showed:

	Feet.
Drive pipe, 10 in.	36
Casing, 8 in.	106
Casing, 6¼ in.	759
Top of sand	878
Total depth	930

Northeast of this well, on the McConaha lease, the Ohio Oil Company drilled a dry hole, which showed:

	Feet.
Drive pipe, 10 in.	84
Top of sand	827
Total depth	898

An important wildcat well in the northeast quarter of the southeast quarter of section 9, Patoka township, was put down on the W. L. Watkins' heirs farm. It was 1,000 feet southwest of No. 11 on the Kendle lease and 600 feet northwest of another dry hole on the Watkins' lease. This No. 2 Watkins showed a trace of oil, and was drilled to a depth of 877 feet. It practically placed the limit of the Princeton pool at that point, changing the direction from southwest to northwest. A cross section of the well is given, showing depth and thickness of strata passed through.

The Active Princeton Field (Section 35).—The north wing of the active field terminates in section 35 of Patoka township. It continues south to the middle of section 11 and from thence veers in a southwest direction to the lower half of section 10. Section 35 is controlled by the Ohio Oil Company and the wells are all constant in their production of oil, averaging for the section eight barrels each per day in August, 1906. There is a total of 20 producing wells on the two leases operated on the section.

In the northeast quarter of the northeast quarter of this section, on the M. E. Hull tract, a dry hole was put down. This checked the movement of the field in the extreme northwestern direction.

The west 300 acres of the section is owned by R. Stormont. Fif-

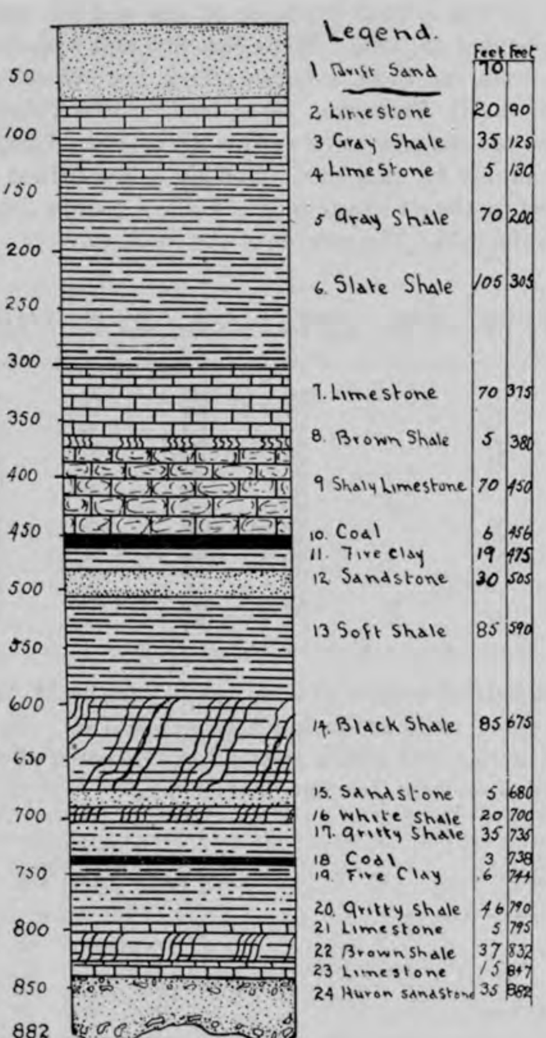


Fig 2

Farmers Oil Co

(Watkins) No 1

teen wells have been drilled on his land, all of which, with the exception of Nos. 11, 13 and 15 are good producers both of gas and oil. No. 11 was drilled on July 15, 1906, and only produced a small quantity of oil until salt water broke into the well, causing it to be abandoned temporarily. Wells Nos. 13 and 15 were dry holes, and were finished on September 17 and November 26, 1906, respectively, while No. 14 was a good producer of gas and oil, and was completed September 14, 1906. Wells Nos. 8, 9 and 4 produce the most gas on the lease and these, with the others, are connected to a main gas line on the G. Emmerson farm, leading into Princeton. Outside of fuel for the powers on section 35, this line furnishes a part of the gas supply for that city. Well No. 4 was drilled 35 feet into the sand before the oil was found. This is a greater depth than the average in the field. The records of the wells show:

Number of Well.	Drive Pipe, 10-in., Feet.	Casing, 8-in., Feet.	Casing, 6¼-in., Feet.	Top of Sand, Feet.	Depth into Sand, Feet.	Total Depth, Feet.	Initial Production, Bbls
1..........	54	....	840	840	52	892	15 bbls.
2..........	67	....	830	847	47	894	12 "
3..........	53	....	832	852	46	898	40 "
4..........	70	....	685	869	48	917	42 "
5..........	54	....	692	861	46	907	55 "
6..........	....	51	680	853	46	899	40 "
7..........	....	75	730	903	42	945	20 "
8..........	....	87	700	822	43	865	12 "
9..........	95	....	895	897	44	941	20 "
10..........	88	....	822	825	47	872	12 "
11..........	85	....	800	839	39	878	6 "
12..........	82	....	806	829	42	871	12 "
13..........	60	....	....	848	44	892	Dry.
14..........	....	88	620	845	31	876	18 "
15..........	65	....	800	865	40	935	Dry.

The east half of section 35 is owned in part by M. Howard, and on it are seven wells producing both gas and oil. In well No. 6 eight feet of coal was gotten at 460 feet. Records of wells Nos. 1 and 2 were never kept, but the others show:

	No. 3, Feet.	No. 4, Feet.	No. 5, Feet.	No. 6, Feet.	No. 7, Feet.
Drive pipe..........	66	42	55	44	59
Casing, 6¼-inch..........	870	830	795	800	798
Top of sand..........	830	860	840	834	840
Total Depth..........	871	901	878	875	881
Initial production, barrels..........	12	10	20	15	40

No. 7 on this lease came in as one of the best wells in the field, producing a heavy flow of both oil and gas. It was shot August 4, 1906.

Section 2.—Section 2 has three companies operating on it, with a total of 44 bores drilled. Of these 38 are active pay wells, three have been abandoned and three were dry holes. The northeast quarter was leased by the Ohio Oil Company in two leases, the R. M. Mumford and the Mumford Heirs tracts. The R. M. Mumford tract occupies the east half of the northeast quarter, and has three pay wells upon it. Records of these wells show:

	No. 1, Feet.	*No. 2, Feet.*	*No. 3, Feet.*
Drive pipe, 8 in.	70	62	40
Casing, 6¼ in.	715	700	700
Top of sand	904	904	918
Depth into sand	78	38	34
Total depth	982	942	952

The west half of the northeast quarter of this section is owned by the Mumford Heirs and was the first lease operated by the Ohio Oil Company in the Princeton field. There are eight wells on the lease, seven of which are productive of both gas and oil. No. 1 started at a production of 25 barrels per day 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 standstone 48 feet thick. At a depth of 1,088 feet a strong vein of salt water was encountered and the drilling was stopped. No. 2, a quarter of a mile west, was a light producer of about eight barrels. Oil was gotten at 881 feet and gas at 875 feet. In No. 7 only a showing of oil was found. As a consequence the well was never shot and is left as a dry hole. In well No. 5 but little water was found, while in No. 7, 500 feet distant, 335 feet of water stood in the bore. In No. 5 the pay was the deepest in the field, being found at a depth of 903 feet. The records of the wells show:

	No. 1, Feet.	No. 2, Feet.	No. 3, Feet.	No. 4, Feet.	No. 5, Feet.	No. 6, Feet.	No. 7, Feet.	No. 8, Feet.
Drive pipe, 10-inch	....	67	58	42	33	42	40	42
Casing, 8-inch	....	....	154	....	....	145	140	150
Casing, 6¼-inch	....	725	702	715	715	700	733	714
Top of sand	913	860	862	895	903	858	854	870
Depth into sand	48	68	62	72	67	59	53	41
Total Depth	1,088	928	924	967	965	917	909	911
Initial production, barrels	25	10	10	20	22	5	showing	5

The east half of the southwest quarter and the southeast quarter of section 2 are leased by the Hoosier Prospecting Oil Company. This pioneer company, which has been previously mentioned, holds leases on two tracts; the L. M. Miller tract, east half of the southwest quarter and the west half of the southeast quarter, and the G. Woods tract, east half of the southeast quarter. The Miller tract has eight wells on it, all of which are pay wells, and four of them only producing gas enough for use in the power. The Woods tract has one well upon it connected to the power on the Miller tract. The wells average a total of 20 barrels of oil per day.

In most of the Hoosier wells on the Miller lease five veins of coal were struck, the depths being approximately the same for all the wells. The first vein was gotten at 120 feet, and was two and a half feet thick, while the second vein was about six feet through and was 450 feet deep. Two other veins of six feet each were gotten at depths of 560 feet and 670 feet respectively. The largest vein was gotten at 789 feet. Between lines drawn west of Princeton along the old Sand road and northeast to the Patoka River there occur these five thick strata of coal at approximately the same depths, the variation not exceeding eight feet at the most. The field records of part of the Hoosier wells show:

MILLER LEASE.

	No. 1, Feet.	No. 2, Feet.	No. 3, Feet.	No. 4, Feet.	No. 5, Feet.
Drive pipe, 10-inch	....	60	100	78	98
Casing, 8-inch	60	....	....	160	140
Casing, 6¼-inch	802	....	715	708	690
Casing, 4⅝-inch	....	800	220	210	855
Top of sand	871	871	864	864	843
Depth into sand	22	24	64	40	12
Total Depth	893	895	928	904	855

WOODS LEASE.

	No. 1, Feet.
Drive pipe, 10-inch	....
Casing, 8-inch	73
Casing, 6¼-inch	720
Casing, 4⅝-inch	853
Top of sand	903
Depth into sand	62
Total Depth	965

Of the northwest quarter of section 2, all but the northwest 40 acres is leased by the Patoka Valley Oil Company. This company was previously controlled by the Hoosier Prospecting Oil Company, which at the time of the transfer, in March, 1905, was operating wells Nos. 1 and 2. The Patoka Company has seven wells on the E. P. Downey lease, of which six are producing. No. 1 was plugged and abandoned in the fall of 1904, on account of fresh water breaking into the well. Wells Nos. 5, 6 and 7 are gas wells and yield the fuel for the power on the lease. All six wells average a total of 30 barrels of oil per day. The records show:

	No. 1, Feet.	No. 2, Feet.	No. 3, Feet.	No. 4, Feet.	No. 5, Feet.	No. 6, Feet
Drive pipe, 10-inch	100	80	83	80	80	80
Casing, 8-inch	120	....	....	....	....	130
Casing, 6¼-inch	710	695	685	700	690	730
Casing, 4⅝-inch	846	229	250	....	....	....
Top of sand	846	868	860	858	853	850
Depth into sand	41	39	33	41	39	45
Total depth	887	907	893	899	892	895
Initial production, barrels	4	6	12	10	2	10
Production, August, 1906, barrels	....	3	8	7	3	6

The R. Conant lease, on the southwest quarter of the northwest quarter of section 2, was absorbed in October, 1904, by the Patoka Oil Company from the Crescent Oil Company. The latter company, at the time of the transfer, was operating three wells, two of which have since been plugged while No. 1 is yet being operated by the Patoka Company. The records of the wells show in part:

	No. 1, Feet.	*No. 2, Feet.*	*No. 3, Feet.*
Drive pipe, 10 in	60	70	...
Casing, 6¼ in	760	175	...
Tubing	900	...	...
Top of sand	867	860	872
Depth into sand	47	40	42
Total depth	914	900	914

The northwest quarter of the northwest quarter of section 2 has two bores upon it one of which is dry, though at one time it produced considerable gas. The other is a pay well operated by the power on the R. Stormont lease in section 35. The field records show:

	No. 1. *Feet.*	*No. 2.* *Feet.*
Casing, 8 in.	65	65
Casing, 6¼ in.	730	...
Top of sand	861	864
Total depth	904	916
Initial production, barrels	15	dry

The west half of the southwest quarter of section 2 comprises the Dixon lease, west half of the north half; Geiser lease, east half of the north half; and the Knight lease, south half of the above location. The Dixon lease has four wells upon it, producing both gas and oil, and the Geiser lease two, which have been constant pay wells since January 1, 1904, at which time they yielded 75 barrels per day, but settled later to 20 barrels. Well No. 2 on the lease was drilled 35 feet into the sand before pay oil was struck. Well No. 3 on the Dixon lease pumps a large quantity of water and makes but two barrels of oil per day.

On the W. F. Knight lease there are four wells, No. 1 being a dry hole, while the other three are pay wells and make a total of nine barrels of oil per day. The C. E. Knight tract, included in the W. F. Knight lease, has one pay well averaging three barrels of oil per day. The L. E. Knight lease, adjoining the W. F. Knight tract in section 3, southeast quarter, has two pay wells making six barrels per day. The twelve pay wells are run on one power, operated on the W. F. Knight lease, and all of the wells make gas which is piped to the leading main on the G. Emmerson farm and from thence to Princeton. The records of the wells show:

Number of Well.	Drive Pipe, 10-in., Feet.	Casing, 8-in., Feet.	Casing, 6¼-in., Feet.	Top of Sand, Feet	Depth into Sand, Feet.	Total Depth, Feet.	Initial Production, Barrels.	Production in August, 1906, Barrels.	Lease.
1	92	165	700	860	50	910	20	3	Dickson.
2	104	136	715	887	42	931	30	3	Dickson.
3	80	160	700	868	41	909	25	2	Dickson.
4	92	147	....	862	55	917	10	3	Dickson.
1	86	138	691	856	56	912	25	3	C. Knight.
1	60	80	600	900	60	978	75	20	Geiser.
2	75	67	772	868	45	913	40	12	Geiser.
1	90	....	690	840	62	902	Gas.	Dry.	W. Knight.
2	94	161	710	864	38	902	15	3	W. Knight.
3	....	116	690	863	40	930	15	3	W. Knight.
4	....	105	682	844	58	902	12	3	W. Knight.
1	95	135	685	858	32	890	5	3	L. E. Knight.
2	90	....	650	869	35	904	3	3	L. E. Knight.

Section 3.—The northeast quarter of section 3 has but two wells upon it in addition to those already mentioned. On the Mum-

ford Heirs' tract the Ohio Oil Company put down a dry hole which had the following record:

	Feet.
Drive pipe, 10 in	55
Casing, 8 in	160
Casing, 6 in	712
Top of sand	884
Total depth	914

On the Bradley lease in the southeast quarter of the northeast quarter the Hoosier Oil Company sunk a bore which had an initial production of seven barrels per day. Later the pay declined and the well was plugged and abandoned.

In the northeast quarter of the southeast quarter of section 3 there are three wells, one on the Smith lease, west half, and the other two on the McCurdy lease, east half, one of which was finished April 1, 1904, but has since been abandoned, and the other was brought in October 9, 1906, producing both gas and oil. The records of the three wells show:

	McCurdy No. 1. Feet.	McCurdy No. 2. Feet.	Smith. Feet.
Drive pipe, 10 in	90	102	106
Casing, 8 in	165	...	167
Casing, 6¼ in	600	820	707
Top of sand	874	864	874
Total depth	925	926	933
Initial production, barrels	10	30	24
Present production	Not operated	20	4

The north half of the southeast quarter of the southeast quarter of section 3 is owned by F. Jones. On it the Ohio Oil Company drilled a well 700 feet east from the power on the W. F. Knight lease and brought in a dry hole, with a heavy showing of gas. The record shows:

	Feet.
Drive pipe, 10 in	74
Casing, 8 in	160
Casing, 6¼ in	715
Top of sand	854
Total depth	888

The other well, 800 feet west, gave only a showing of oil, and a third one 600 feet away produced a good flow of oil, with the following record:

	Feet.
Drive pipe	112
Casing, 6¼ in	680
Depth to sand	856
Total depth	904
Initial production, barrels	40

In the northwest quarter of the southeast quarter the Ohio Oil Company sunk two bores, one on the Sam. Embree lease, which proved to be a dry hole with a very light showing of oil, and one on the N. E. Embree lease, which is a light well. The records show:

	S. Embree. *Feet.*	*N. Embree.* *Feet.*
Drive pipe, 10 in.	74	62
Casing, 8 in.	142	150
Casing, 6¼ in.	720	...
Top of sand	896	888
Total depth	933	919
Initial production, barrels	dry	5

On the H. E. Sweppy tract, north half of the southwest quarter, are two wells, completed in February and April, 1904, which gave merely a showing of oil and were later abandoned and plugged. The records show:

	No. 1. *Feet.*	*No. 2.* *Feet.*
Drive pipe, 10 in.	36	40
Casing, 8 in.	85	100
Casing, 6¼ in.	706	710
Top of sand	865	875
Into sand	31	30
Total depth	896	905

Section 11.—There are in this section a total of 18 bores, 15 of which are pay wells, while two are dry holes. One, after a good showing of oil was gotten, was abandoned because of lost tools.

The west half of the northeast quarter is owned by J. Woodburn, and on it three light wells were put down, which produce a total of about six barrels of oil per day. The records show:

	No. 1, *Feet.*	*No. 2,* *Feet.*	*No. 3,* *Feet.*
Drive pipe, 10 in.	77	73	72
Casing	135	154	122
Casing, 6¼ in.	...	705	692
Top of sand	842	853	841
Total depth	936	910	883
Initial production, barrels	light	30	20

On the east half of the northwest quarter of section 11, owned by H. and A. M. Embree, there are eight bores, all of which are pay wells making 500 barrels of oil per month. Five of the wells produce gas for power use only. The partial records of five of the wells show:

	No. 1. Feet.	No. 5. Feet.	No. 6. Feet.	No. 7. Feet.	No. 8. Feet.
Top of sand	841	839	845	842	839
Depth into sand	30	39	48	46	40
Total depth	901	878	893	888	879

The west half of the northwest quarter of section 11 is owned by G. Emmerson. The first well on the lease, finished September 15, 1905, produced an excellent show of oil, but unfortunately the drilling tools were lost in the well, which caused it to be abandoned. Four pay wells were afterwards gotten in Nos. 2, 5, 6 and 7, while Nos. 3 and 4 came in as dry holes. The records of four of these wells show:

	No. 1. Feet.	No. 3. Feet.	No. 5. Feet.	No. 7. Feet.
Drive pipe, 10 in	96	18	84	20
Casing, 8 in	140	110	135	...
Casing, 6¼ in	700	640	680	624
Casing, 4⅝ in	210	700	...	...
Top of sand	838	832	835	820
Total depth	890	870	885	864.5
Initial production, barrels	10	dry	8	10

Section 10.—The most productive area in the active field lies in this section, in which four companies are operating. There are on the section 39 wells, 36 of which produce oil and gas, while two came in as dry holes. The gas pressure has been quite high and afforded the greater part of the supply for Princeton.

The northeast quarter of the northeast quarter of section 10 is owned by F. M. Smith and has on it five active wells, producing 150 barrels per week. Four hundred feet southwest from No. 4 on the Smith lease, is a sixth well on the Drake tract of one acre. This well was brought in June 10, 1904, and offsets No. 1 on the Farmers lease 400 feet north. Both are large gas producers. The pressure in No. 1, on the Smith lease, was so great that it blew out pieces of slate a pound or more in weight, and prevented the immediate shooting of the well. It was capped and furnished a gas supply for one year; and in March, 1905, was drilled deeper and shot for oil. A heavy flow was secured and at the present time it produces eight barrels per day. A record of the bore shows:

	Feet.
Drive pipe, 10 in	104
Casing, 8 in	...
Casing, 6¼ in	725
Top of sand	873
Depth into sand	61
Total depth	934
Initial production, barrels	10

On the quarter section directly south of the Smith lease is the J. Woods tract of 20 acres on which are two wells, and there are also two wells on the M. Woods lease of 20 acres. These four wells make a total of 15 barrels of oil per day, and have the following records:

	J. B. Woods.		*M. K. Woods.*	
	No. 1.	*No.* 2.	*No.* 1.	*No.* 2.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Drive pipe, 10 in.	92	80	70	50
Casing, 8 in.	157	190	160	...
Casing, 6¼ in.	750	700	718	810
Casing, 4⅝ in.	157	156	144	...
Top of sand.	815	818	835	814
Total depth	872	867	883	872
Initial production	...	...	...	27

The west half of the northwest quarter and the east half of the northeast quarter of section 10 contains 12 pay wells which average 2,700 barrels per month. This is the best producing lease in the field, both in gas and oil and is owned by C. Emmerson. The field records of the wells show:

Number of Well.	Drive Pipe, 10-in., Feet.	Casing, 8-in., Feet.	Casing, 6¼-in., Feet.	Casing, 4⅝-in., Feet.	Top of Sand, Feet.	Total Depth, Feet.	Initial Production, Bbls.
1.	88	...	680	230	840	895	50
2.	...	86	675	225	838	855	6
3.	...	89	680	225	837	875	12
4.	...	90	675	230	835	868	10
5.	...	88	680	215	840	875	12
6.	...	96	689	210	870	890	75
7.	...	97	685	225	839	886	15
8.	85	110	680	220	860	895	15
9.	70	106	675	225	845	880	10
10.	68	115	670	230	843	884	15
11.	70	108	680	225	846	880	15
12.	70	96	650	235	849	885	15

The west half of the northwest quarter and the northwest quarter of the southwest quarter of section 10, and the west half of the northeast quarter of section 9, are owned by the J. W. Kendle heirs, and the wells on them are also good producers of both oil and gas, the surplus supply of the latter being sent to Princeton by a direct pipe line along the old Sand road. The Kendle lease lies in the head of the lowlands, the surface being flat. The lease has 16 wells upon it, of which 14 produce oil and 10 gas, while two, Nos. 4 and 5, are dry holes. The records of 15 of the wells show:

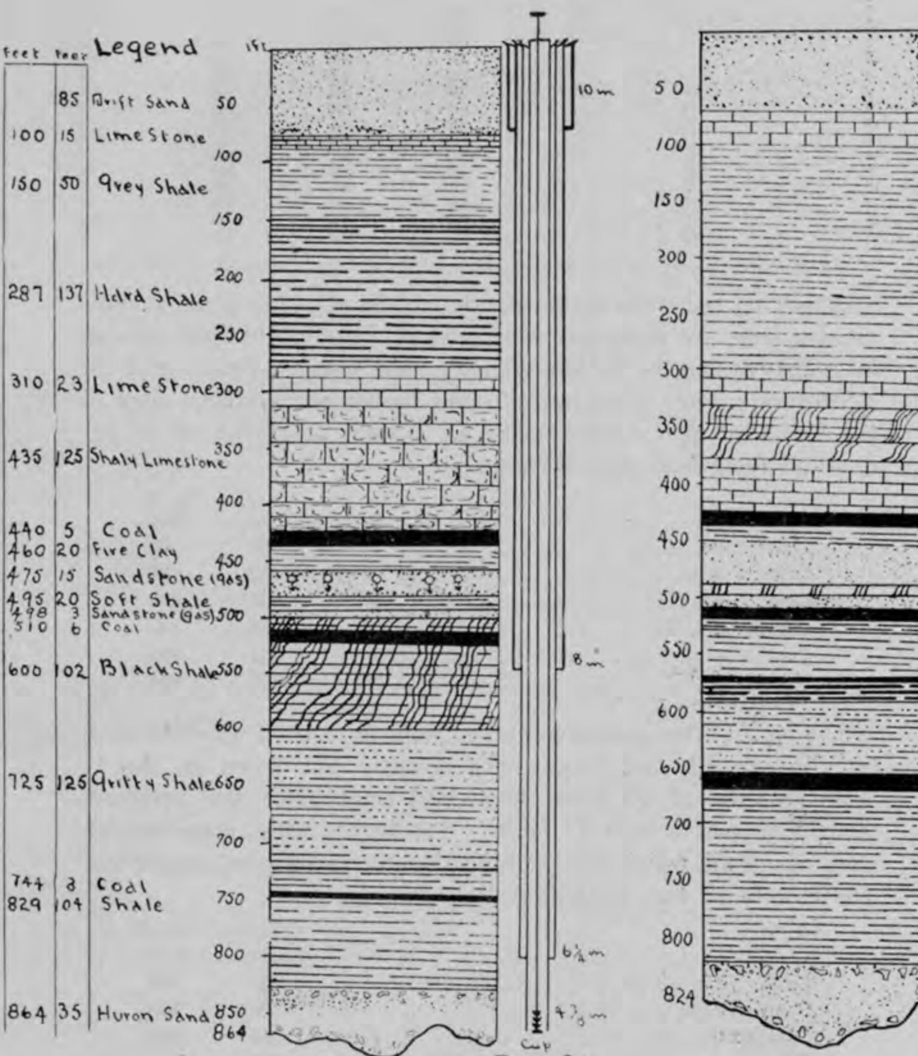


Fig 3.
Ohio Oil Co.
(Kendle) No 10

Fig 4
Ohio Oil Co
(Kendle) No 9)

From the above records, which are practically the only ones kept in the fields, it will be seen that operations in the Princeton oil field to the close of the year 1906, resulted in 122 producing wells, 44 dry holes, 11 abandoned pay wells and one well drilling, making a total of 176 wells, 82 of which yield gas. The field is gradually extending north in section 35 and west of the southwest wing into sections 9 and 4.

The Production of Oil in the Princeton Field.

The oil of the Princeton field is found in a bluish-gray, sharp and coarse-grained sandstone. This formation, which is the Huron sandstone, immediately underlying the Mansfield sandstone or Millstone Grit, is the same as that in which the Loogootee oil occurred, 45 miles to the northeast, and somewhat similar to the Casey and Robinson sands 60 miles to the northwest. The latter sands, however, belong to the Upper Carboniferous rocks.

The records of the wells in the vicinity of Princeton show a change in the depth from the surface to the top of the Huron sandstone of a little over 30 feet to the mile and a local dip in the sand from the J. Glaze farm in section 28, White River township, to the Kendle tract in the southwest quarter of section 10, Patoka township, of a little more than three feet to the mile. The elevations of the two locations are the same and the difference in the depths running in a southwesterly direction, is 20 feet in six miles. From the Kendle tract in section 10 to the R. Stormont tract in section 35, the dip in the oil bearing sand is a little over five feet to the mile. The average depth to the oil sandstone in the north wing of the field is 856 feet; that of the central portion, 861 feet; and in the south wing, 836 feet, while the pay oil is gotten at the respective average depths of 25, 20 and 15 feet below the top of the sand.

Much trouble is experienced with numerous shales passed through, as all of them are comparatively soft and friable, and are very likely to cave. For this reason most of the wells have to be cased nearly to the top of the productive sand. The drift in the field varies from 100 to 70 feet in thickness, and a ten-inch drive pipe is driven through this. Eight-inch casing is driven to an average depth of 150 feet and in several cases to 500 feet. This is to protect the bore from the cavings of the upper shale deposits, and the vast amounts of fresh water found in them. Six and a quarter inch casing is driven to the gritty shales lying above the productive sand to insure free drilling. The above sizes of pipe and casing are used in nearly all the Princeton wells, and the number of feet used varies but little.

The drilling of a well, including the building of a derrick and setting up of the machinery; also the necessary delays in drilling, etc., occupies about ten or twelve days. After pay oil has been struck the wells are immediately shot, a nitro-glycerine plant operated by the Hercules Torpedo Company, being located on the McConaha farm near the north wing of the field. The average shot for a Princeton well is 100 quarts, used in 20-quart torpedoes. The cost of the shot is $1.00 per quart.

Difficulty in pumping often arises in a new well on account of trouble with the suction cups, due to the grinding of the loose sand torn from its compact state by the shot. The sand grains are sharp and rather coarse and cut away the packing in the cups, which necessitates their being taken up and replaced. After a well has been in use some time the sand is cleaned away and the wearing is lessened. The cups are made of leather or canvas, the latter being best adapted to this field. Companies often have so much trouble in this respect that they employ men constantly to keep the rods clean. A portable derrick is used by the Ohio Oil Company, while the others use a block and pulley.

The oil of the Princeton field seems to be in a pool or body of porous sandstone at a level of about 850 feet below the surface. The formation of a deep cavity in the oil producing sand by shooting with nitro-glycerine causes a flow of oil to it, the oil coming from a common level in the field. The inflow of the oil through seepage from the surrounding sandstone fills up the hole and part of the casing. This is pumped down until the seepage, after two or three weeks, assumes a constant flow, producing in the average well seven and a half barrels of oil per day. For example, in the northern wing of the field on the Mumford Heirs' lease, the periods of pumping off the wells are shown in the fact that No. 6 and No. 1 are pumped off in three and a half hours, Nos. 2, 3, 7 and 8 in two hours and No. 5 in three hours. This is generally done in the forenoon and the wells are then left to stand and collect oil until the following morning. If pumped over the above time, the cups are likely to become sanded, causing an additional expense; and also the oil will roil and turn yellow. This is no doubt due to the sulphur compounds in the oil, as the higher the per cent. of sulphur, the more it seems to roil. In most places in this field the oil is steamed to reduce the impurities and sediment to a minimum. This is done by connecting pipes from the boiler of the engine with the bottom of the tank and forcing steam through the oil, which precipitates the sulphur and impurities. After standing quite a while the sediment is drawn off from the bottom of the tank, along with any water that is present. For a year and a half about 70 wells in the field have been constant and steady producers and have added wealth to the pockets of the operators.

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 for a long time the Indiana Pipe Line Company paid 35 cents less per barrel for it than for the Trenton limestone product. On August 16, 1904, the price was advanced to the same figure as the Trenton rock oil, and until April 27, 1906, it sold for the same. On that date the price was lowered to 83 cents, or ten cents lower than Trenton rock oil. On July 25th it again fell to 81 cents, and on August 1st to 79 cents. From that figure it was lowered to 74 cents on August 9th; to 69 cents on August 15th and to 64 cents on August 25th, which price it held to the close of the year. This was 21 cents less than was being paid for the Trenton rock product. Taking both the amount received and time into consideration, the average price for the year was 77½ cents per barrel, as against 88 3-5 cents for the Trenton rock oil. The Indiana Pipe Line Company, operated by the Standard Oil Company, controls the output of the field, and bought all the oil produced in 1906 except 6,036 barrels. They have constructed a loading rack for tank cars on the Miller lease in section 2, and from this point lead lines are connected to all lease tanks, which, in turn, are connected to the producing wells as fast as they are finished.

The output of the field by months for the years 1904, 1905 and 1906 is shown in the following table;

Number of Barrels of Huron Sandstone Oil Piped or Shipped from the Princeton Field in 1904, 1905 *and* 1906, *by Months.*

	1904.	1905.	1906.
January	1,412	4,043	8,026
February	1,399	3,637	6,127
March	2,920	5,400	7,322
April	1,319	5,262	9,033
May	2,047	5,559	8,463
June	2,315	4,523	10,201
July	2,971	5,569	9,498
August	2,991	6,296	9,429
September	3,345	6,141	9,469
October	3,093	6,865	9,312
November	4,554	6,116	8,294
December	3,841	5,395	8,382
Totals	32,207	64,806	103,843

By subtraction the gain in the field for the year 1905 is shown to be 32,599 barrels, or a little over 100 per cent.; while the gain in 1906 was 39,037 barrels or 60.2 per cent.

Cost of a Producing Well in the Princeton Field.

An estimate of the average cost of drilling and fitting up a new well in the Princeton field, based on the cost of No. 12 well of the Farmers' Oil Company on the C. Emmerson lease, is as follows:

Rig or derrick	$300
Drilling at 65c. per foot	575
70 feet drive pipe (10 in.) at $1.10	77
96 feet casing (8 in.) at 73c	73
650 feet casing (6¼ in.) at 41c	266
235 feet casing (4⅞ in.) at 30c	60
1,500 feet pull rod	43
850 feet tubing at 12½c	106
860 feet sucker rod at 3½c	30
1,500 feet lead pipe at 8¼c	124
Pumping outfit	12
Power	210
Engine	600
Two 200-barrel tanks	224
Incidentals	100
Total	$2,800

The incidentals include the cost of necessary teaming and minor supplies. The second well on the lease will cost about $1,300 less, as the tanks, power house and power are in place, and in many cases the casing is pulled and re-used.

The same rig or derrick can also be used, though there will be a loss of $125 in tearing it down and rebuilding. 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 about $350.00. In one case in the Princeton field the Monarch Company have in use an eccentric power (the Mascot) designed for the pumping of 47 wells. The cost of such a power is about $2,500. At the present time the average well on a 12-well lease in this field costs about $1,500 which is very near the cost of an oil well in the Indiana Trenton rock field.

The Cost of Operating a Lease.

The cost of operating an oil lease in the Princeton field after the production has been established need not be more than $110 per month, the salary of the pumper being $60; the cost of the fuel, where gas is lacking, about $30 and the cleaning and repairing the suction cups, $20. On most leases in the field one or more wells at the least have been found to yield sufficient gas to run the power. A dozen wells or more can be operated almost as cheaply as one, after they have been connected with the power.

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

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

Income per month:		
225 barrels of oil at 79c. (price in 1906)		$177 75
Salary of pumper	$60 00	
Cost of cleaning cups	20 00	
		80 00
Profit		$97 75

With six three-barrel wells on the lease the income would be $355.50 and the expense $80.00, a net gain of $275.50 per month.

From the above statements it will be seen that the cost of drilling and operating a lease in the Huron sandstone field is as low as that of the Indiana Trenton rock field.

According to the statements of several of the operators in the field, it cost 45 cents per barrel to produce oil on the average lease in the Princeton field. Whatever is received above that sum is net profit. If the lease is small, the cost is greater in proportion.

After the well has been pumped off, to use the terms of the operator, the pumping on that well should cease, as it would be an economic loss to the machinery to continue. One should be on the lookout for overflow of oil, and also guard against the waste of the volatile part of the petroleum, the natural gas. This has in the past ten years been wasted to such an enormous extent that the supply is very nearly exhausted in the Indiana fields. Its loss as a fuel both in the field and home is greatly felt, and a willful waste of it is deplored. The Princeton field produces a constant flow of gas and on six of the leases the supply beyond the need of fuel for the power, is of sufficient quantity to furnish Princeton with an abundance. The remaining leases have only enough to pump their wells. A State law insists upon the capping and plugging of the casing in a well, whether it produces gas or not, and any negligence of this should be avoided.

Relations of the Princeton Field to the Trenton Rock and Other Producing Fields.

In another part of this volume it is shown that while so-called pools exist in the Trenton rock formations, they are not necessarily connected. The same fact may be noted in the Huron sandstone and neighboring formations. The Princeton, Robinson and Casey fields are not in any way connected. The Robinson oil is found in a sandstone of the Lower Coal Measures, while the Casey oil is found in a still higher formation. Neither does the oil at Princeton have anything to do with the Trenton rock oil. The top of Trenton in Gibson County will be found at approximately 1,600 feet below sea level, which will make it about 2,100 feet below the surface. The oil at Princeton does not come from the Trenton rock but from a shale or limestone either above or below the sandstone in which it is found. The Huron sandstone forms a porous bed or reservoir for the oil from the nearby producing strata, and this field, like those of Robinson and Casey, is merely a pool with limits yet to be found.

The Oil Map.

The accompanying map of the Princeton oil field embraces 72 square miles of portions of Patoka, White River, Montgomery and Washington townships. It is made on a large scale in order that leases and tracts may be located in the vicinity of the active field.

Future Drilling.

Several attempts have been made to drill to Trenton rock, but all have been failures, due to the expense attached and the caving of the strata passed through. This fact, along with the narrow limits of the field indicate its infancy, and a great deal may be brought to light by a more thorough and systematic search for oil in this territory. The fact that wells reach a depth of 1,000 feet and more in this territory does not indicate a lack of oil. While there is nothing to indicate oil in Trenton rock, there is nothing to show that it is absent, and it is not impossible that oil in commercial quantities may be found present in pockets in that formation.

Attempts north and south of the present field have resulted in a failure to locate oil, while east and west the territory is practically untried. The trend of the field would indicate a northwestern course from Princeton and but two bores oppose a southeasterly course, both of which were put down at a time when but little was known of the nature of the oil bearing strata. This, along with the territory east of Princeton, is unproven, and there exists a chance of development that may prove a valuabe addition to the present narrow limits of the field.

Acknowledgments.

In performing the field work embodied in the foregoing report, acknowledgments for assistance are gratefully accorded to Mr. Harry Embree, County Auditor of Gibson County; Mr. Garret Emmerson, Mr. Fred Ward, Mr. H. E. Agar, Mr. I. E. Criswell, Mr. Will Ennes, Mr. Arthur Mauch and Mr. Harry Kurtz.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

OFFICE OF THE STATE GAS SUPERVISOR,
MARION, INDIANA, FEB. 1, 1907.

Prof. W. S. Blatchley, State Geologist:

SIR—I have the honor to submit to you herewith my fourth annual report as State Gas Supervisor for the year 1906, the same being the fifteenth report from this department. In former reports I have endeavored to call your attention to certain conditions which were sure to result in injury to the gas field. This report must necessarily be along the same line as the others. However, I will endeavor to eliminate such matter as may be considered of little or no importance at this time.

I trust that this report will receive your approval and the approval of those who, from their interest and experience in the gas field, are in a position to judge the same.

BRYCE A. KINNEY,
State Natural Gas Supervisor.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

The interest of the public and of the men who produce the natural gas in the State of Indiana has been centered in that part of the existing law which governs the plugging of abandoned wells and the pumping of gas from wells that continue to produce. To one who has made a study of conditions as they exist at the present time it is no surprise that such is the case. I have attempted in former reports to set out the dangers that confront the producers of gas in this State, and also the dangers that confront those who look upon it as a luxury and have reason to desire that our resources be husbanded to the greatest possible extent. I have been actuated in this by a desire to protect this industry for the benefit of the people of the State.

Corporate wealth at times pays little heed to the future welfare of this industry and seems to be only interested in an increase of dividends for the present, relying upon other fields to furnish equal opportunities for investment, in the event that our field should be rendered non-productive. Individuals who are interested in the drilling of wells only as a speculative proposition, and who, except in the event they should be successful in their search that they are prosecuting for the discovery of gas, pay little attention to the wells that they have drilled in the event that such wells are failures. Hence this office is compelled to keep continually on the lookout for abandoned wells that have not been properly plugged. It is not my desire to lodge a general complaint against all of the producers in the State of Indiana because such a complaint would be most unfair. Many of the producers have assisted me in the discharge of my duties in every possible way, but there are others who have sought to raise such obstructions as they could, and have even gone so far as to attempt to create a sentiment against the office, doubtless hoping that such sentiment would result in its abolition.

Without any regard for the individual welfare of anyone connected with the office, I wish to say that its importance will cease to exist only when the gas industry is a thing of the past. And even at that period this office is the only source through which the people may be reached who are trying to avoid the law in regard to plugging abandoned wells. The object of some who have manifested a willingness to abolish the office has been, doubtless, a desire on their part to have our State observe, as far as possible, rules of economy in its disbursements. Such an object is doubtless most praiseworthy in the event that this office is of no benefit to the people of our State. Others, however, have doubtless been controlled solely by a desire on their part to remove all obstacles from their way, that they may quickly drain this product from our State and thereafter leave its citizens to substitute in the place of gas such fuel as they may be able to secure. For those who have an honest desire to do all they can for the interests of the people and have opposed this office, I have no word of censure. An investigation will doubtless reveal to them the error under which they have been laboring; but for those whose motive is a desire for personal gain without any regard for the interests of the people of the State, we desire to say that the efforts of this office will be directed against them when their practices are such as to threaten an industry of such importance to the people of this State.

In one of the former reports from this office it was prophesied that the existence of gas in this State would be of short duration. Such a prophecy was perhaps well founded, being based upon conditions that existed at that time. A dozen pumping stations were in operation, sixty million feet of gas being transported from the State daily. This practice was continued until the supply was exhausted to such an extent that it was necessary to apply a strong suction to these wells in order to make them productive. For a time we had laws in force in this State prohibiting the employment of any artificial means for the purpose of increasing the flow of gas from the wells. This, of course, prohibited the corporations that had installed pumping stations from using the power of suction to increase their production. About four years ago this law was repealed. The agricultural interests of this State in convention assembled have unanimously protested against the use of pumps and have manifested dissatisfaction with the repeal of the pumping law by drafting resolutions asking that a similar law be re-enacted.

In a similar manner the agricultural interests have asked that a plugging law be enacted whereby the inspector will be able to personally superintend the plugging of all wells throughout the State. The law in force at the present time is not effective for the reason that the supervisor has no means of ascertaining when abandoned wells are to be plugged. Junk dealers operating throughout the State have purchased the old iron in abandoned wells, and upon drawing the material from these wells they are left without any attention whatever. They pay a stipulated amount for these abandoned wells and the former owners of the wells take the position that they are relieved from all responsibility, and as soon as the drive pipe is pulled from the well the supervisor has no means of ascertaining whether or not the well has been properly plugged or plugged at all. This practice and the practice of using pumps has resulted in the conditions that now exist in the gas field. Where pumping stations have been abandoned for two years and where the territory has not materially suffered from the introduction of fresh water, the pressure is returning, also the volume, proving conclusively that with proper attention the Trenton rock field will produce gas for some time to come.

Many people who have discredited the necessity for a supervisor in this State have cited the Pennsylvania and West Virginia fields, giving the same as a precedent to be followed in our State, claiming that both of these fields continue to produce gas, yet neither state has a supervisor. Such an argument is fallacious for the reason that the formation here productive is altogether different from the formation of either of those fields. They have what is called a pocket formation, with no connection whatever between the various pockets. These pockets being distinct and isolated, are not effected by the introduction of fresh water into the adjoining pockets. In this State, while the formation may differ in porosity, yet there is an established connection throughout the entire field, as demonstrated by our development, and the damage done by the introduction of fresh water into the gas bearing rock at one locality can only be measured after the destruction has been most complete. The experience of this office has taught us that producing wells are effected by the abandoned wells that have been improperly plugged or not plugged at all, which are located several miles away. With all the foregoing facts at our command we fail to see why the people should not be warned and take such action as will materially assist this office, as experience has taught the people living in different localities where pumping stations have existed, where wells have not been properly plugged, and where the law could not lay its hands on such violators, that the volume of gas has steadily decreased. Such steps should be taken to preserve this fuel and to empower the supervisor to see that it is done according to law.

One great difficulty is that pipes that were used in the first wells were new, also the pipe lines. Now, of course, constant use has worn them out. Especially in old fields the supervisor finds this to be the case. Throughout the field and in cities and towns they are now and always have been very careful that the lines are kept in the best possible condition, and the loss of life and property is light in comparison to the number of people using gas.

This office has received numerous requests for information as to how gas and oil wells were drilled. I am pleased to state that for twenty years I have been in close touch with the oil and gas fields in the United States and have had practical experience which is, without a doubt, the best teacher. Such experience is a great advantage to me in my present position, as knowing the practice of the gas and oil men, it is not hard to locate the trouble.

The gas or oil man when he starts in the business leases his land where he thinks it most profitable to himself. It is customary to give the farmer $100 per year for each gas well drilled on his farm, if gas is found in paying quantities, and also gas for the tenants on the farm, which is equal to $200 per year. If he fails to find gas and gets oil, the farmer receives one-eighth of the gross production of oil produced from his farm. Sometimes he gets one-sixth and rarely one-fourth, but this is not the rule, as the oil men take all the chances.

In the gas belt the well will cost him $1,200.00 at least, and from that to $3,500.00 per well, owing to the amount of pipe and labor required. In this belt the amount of pipe used is not so great as in Southern Indiana.

When the derrick is completed and the drilling tools ready to work there are two men on the shift or tower, as termed in the oil country. These men are the driller and tool dresser. The driller drills the hole and is supposed to be at his post at all times, as any little accident in his absence would result in possibly plugging and abandoning the well. A man has to have experience to be a successful driller. The tool dresser works with the driller as does the fireman with the engineer. He keeps the boiler steamed, the drilling tools in drilling condition and is a general roustabout.

As soon as the hole is started the eight-inch pipe is started and forced by driving with the drilling stem, which weighs a ton. They drill and break the way and then drive until the limestone is reached, which means four hundred feet at times. The most difficult task the driller has is in landing this string of pipe on this rock for if he drives this pipe into the rock the bottom will collapse and the pipe must be pulled and put in new in its place.

He has next to go through this limestone, which is full of fresh water and is very hard drilling. About fifty feet in one tower of twelve hours is considered good progress. When this limestone is finished the casing that shuts off all fresh water from it is set in, not driven, and the large eight-inch tools are changed to smaller ones, $6\frac{1}{4}$ being the regular size. They then drill through what the oil men term the shale, which is quite soft, and they can often drill 150 feet in twelve hours. This part of the bore is dry, so that the driller pours water in the hole to mix his drillings so the drill will work. As he reaches the bottom of this so-called shale he penetrates the Trenton limestone, or oil and gas-bearing rock. He measures the length of the hole from the top to the Trenton, so as to keep a record of the well, as it materially helps in future work. Then he proceeds to feel his way into the Trenton. If he is after gas, when he thinks he has gone into the rock far enough and is afraid of salt water, he stops and if the well needs to be torpedoed it is done with such an amount of nitro-glycerine as is necessary. If not, it is allowed to flow naturally through the tubing or casing, and if the pressure is so great as to endanger the pipe being blown out of the earth, anchors are used to prevent it.

There are hundreds of men working daily at drilling in this State. They are paid good wages, the drillers receiving $4.00 per day and the tool dresser $3.00. One crew goes to work at twelve midnight and the other at noon. This custom was begun in the early days and has never been changed. If a man gets into the oil or gas business it is seldom he cares for any other life. It is a big gamble; if he wins he is independent and if he fails he lives in hope of finding the "golden fluid" next time.

THE NEW FIELD.

The condition of the gas field is constantly changing. They are drilling in the heart of old territory and finding fair wells. In Jay County especially the gas pressure has increased from 70 to 145 pounds, and 145 pounds is the average rock pressure of the field. In that county there are wells that are running as high as three hundred pounds, but there are not many of these.

In Madison County, where the field was considered exhausted three years ago, the gas in some localities is better now than it was last year, and it was better last year than the year previous, so it is steadily increasing.

In Delaware County they are pumping a number of old gas wells now, after getting the water from them, and the results are very profitable. The gas there in places is now better than it has been for several years.

In Grant County there are two pumping stations, one north of Upland and one east of Fairmount. These stations have held the output down in Grant County more than anything else. The gas supply in Marion in summer and fall was better this year than last for the reason that the people are taking better care of the wells and not using it so extravagantly as they did when gas was so plentiful.

Since last year's report gas has been found in small quantities in Vigo and Sullivan counties. Only a few test wells were drilled in each county, but gas was found in each well and at the present time there are at least a dozen wells being drilled between Petersburg and Terre Haute for gas, and the older gas and oil men feel certain that they are going to strike a good field in Southern Indiana. As Petersburg for a few years had the greatest rock pressure in the State and Terre Haute had the greatest oil well, gas men presume that there must be gas somewhere between these two points. Princeton, in Gibson County, still has gas sufficient to run their oil wells, and it is still being used to some extent in the town.

A very good gas field has been struck just across the Wabash River from Vincennes and Sullivan in Illinois, and oil and gas men are leasing everything on the Indiana side in the hope of finding gas, which in all probabality they will. In the last six months the oil and gas men have leased two hundred thousand acres between Petersburg and the Ohio River in the hope of finding gas, but no drilling has yet been done. One well was drilled near Salem, Indiana, in which gas in small quantity was found, and there was also a well drilled near Cannelton on the Ohio River.

There are several pumping stations in Indiana used for transporting gas. These stations are located east of Fairmount, north of Upland, north of Perkinsville, and near Hartford City, Richmond, Shelbyville and Greentown. The Chicago Gas Co. is operating the Fairmount station, also the Greentown station; and the Huntington Light & Fuel Co., the one at Upland. The Perkinsville station is operated by the Ft. Wayne Gas Co., the one at Richmond by the Richmond Valley Gas. Co. Many wells have been drilled in the immediate vicinity of these pumping stations with fair results. At Greentown all the gas wells are being pumped for the purpose of getting the water out of these wells and securing the gas. This gas goes to different points in the State and to Chicago. The

Huntington Light & Fuel Co. has a line reaching from Upland to Huntington, and it supplies different towns along the line with gas.

Marion is using gas from the Marion Gas Company's lines, but it is natural pressure, there being no pumping stations to help the supply. Montpelier, Muncie and Hartford City are having the same experience as Marion, there being no pumping stations connected with the mains, and the people are now beginning to believe that the life of the gas and oil field will be much longer if every pumping station were dismantled. As said last year in our report, it not only increases the flow from the well but it draws the water up through the oil and gas-bearing rock and injures the rock, thus lessening the life of the field.

Since last year's report the Lafayette Gas Co. has practically gone out of business. The Indiana & Ohio Consolidated Natural Gas Co., which had a big pumping station at Red Key for transporting gas to Ohio towns has also ceased operations. The Ft. Wayne Gas Co. is doing very little business at the present time and will probably be out of business this year. Since the gas has become so low that there is not sufficient amount to pump to larger cities these pumping stations are being dismantled and the people who live in the immediate vicinity feel that the field is reviving and the gas pressure is stronger than it was a year ago. The Indiana & Ohio Natural Gas Co. has taken up their pipe line from Red Key and the surrounding field in the past year and sold it for junk.

There has been one great evil practiced in the oil and gas field, and that is the neglect of properly plugging the oil and gas wells. It has been a very hard task for the supervisor and his assistants to catch any of these violators, as they do not have to report the plugging of these wells at this office until after the deed has been done, and the only means that this office has of finding out is through the farmers or someone who is disinterested in the work. Every field in the state is affected by the water from old wells, and if this evil is not remedied, before two years there will be no more gas or oil found, because it will be impossible to exhaust the water. Leases that were producing plenty of gas up to one year ago are now out of business on account of the fresh water reaching the rock from old abandoned wells, and even the farmers are complaining of tasting salt water in their water wells, which goes to show that the wells are steadily filling up, the salt water coming to the fresh water level and mixing up with the fresh water and traveling through the fresh water and gravel for an unlimited number of miles.

At Greenfield the Southern Indiana Gas Co., which has been supplying that city and the surrounding towns, is still producing a fair quantity of gas. This same company is also supplying Shelbyville with natural gas. There are two companies in Shelbyville, the other one being the Shelbyville Natural Gas Company. They are forcing the gas into the city by the use of pumps, and at the present time are getting their gas from in and around Wilkinson and Shirley. There are many complaints from the farmers in that vicinity, some of whom have come to this office protesting against the damage the pumping stations are doing to the Trenton rock. These two companies have drilled in the neighborhood of fifty wells in the past year, and expect, as I understand, to drill about the same number this year. The Richmond Natural Gas Co. drilled about the same number of wells and by the use of a pumping station are supplying the city of Richmond.

The largest gas well in the State at the present time is in Jay County, six miles from Union City. It is known as the Riley Allen well and has a rock pressure of 315 pounds to the square inch and a volume of three million feet. The towns throughout Jay County, excepting Red Key and Dunkirk in the southwestern part, are having a better supply of gas than for several years. The reason that Red Key and Dunkirk are so unfortunate as to not have the natural product at this time is that the big pumping station owned by the Indiana & Ohio Consolidated Natural Gas Co., which was in operation within one mile of Red Key for the past ten or twelve years, drew millions of feet of gas from this locality and exhausted the field for several miles around.

The history of the Petersburg field from the time the Jumbo well was drilled in 1897, proves without a doubt that the wells in this field have been neglected in regard to plugging them properly. In the first place the old iron in the wells was allowed to become unsafe, the pipe being perforated and allowing the fresh water to penetrate to the oil and gas bearing rock from the upper strata. Many of these wells were improperly plugged and the pipe drawn from them and the result is that they are now suffering from fresh water in the oil bearing rock. A well that was drilled on the Lamb farm, N. E. quarter of Sec. 27, Washington township, was drowned out by the fresh and salt water at twenty feet in the rock but drilling was continued to about 90 feet in the rock in the hope of finding gas or oil and casing off this fresh water that was found in the upper strata, but nothing was found at that depth.

All of the so-called gas wells in the vicinity of Petersburg are dead with the exception of one, which merely supplies enough gas to run half a dozen fires in one house. During the last year only one well was put down, and that was on the L. Lamb farm, as mentioned above. It was practically a dry hole, showing no gas and a little oil at the top of the sand, which was immediately drowned out by fresh and salt water. The well was completed about Nov. 10, 1906, and was abandoned Nov. 16. 1906. The record of the well shows:

	Feet.
Drive pipe (10 in.)	103
Casing (8 in.)	672
Casing (6¼ in.)	1,072
Top of sand	1,164
Total depth	1,255

It is plugged.

The old Jumbo well, put down March 30, 1897, is on the Shafer tract in Washington township. It is claimed that at one time it showed the enormous rock pressure of 575 pounds. It ran seven years and was abandoned three years ago, due to the drowning out by water. It was first drilled with the following record, followed by a depth of fourteen feet later.

	Feet.
Drive pipe	45
Casing (5⅝ in.)	1,070
Top of sand	1,163
Total	1,163

This well was the first in the field and was the most successful. The following is the log of same:

Log of Jumbo Well at Petersburg, Indiana, Drilled in 1897.

		Feet.	Feet.
1.	Clay, sand and clay	37	37
2.	Blue and yellow limestone	11	48
3.	Slate and coal	13	61
4.	Shale	49	110
5.	Hard rock	1	111
6.	Coal	4	115
7.	Shale	30	145
8.	Coal	2	147
9.	Shale	23	170
10.	Hard sandstone	3	173
11.	Sandy shale	7	180
12.	Common shale	35	215
13.	Cannel coal or slate with streaks of fire-clay	10	225

		Feet.	Feet.
14.	Shale	40	265
15.	Limestone	3	268
16.	Hard sandy shale	32	300
17.	Streaks of limestone and shale	15	315
18.	Shale	60	375
19.	Rock and coal	5	380
20.	Dark and light shale	44	424
21.	Streaks of limestone	202	626
22.	Sandy limestone	51	677
23.	White sandstone, bearing salt	21	708
24.	Shale	8	716
25.	White sandstone	45	761
26.	Black shale	24	785
27.	White shale	20	805
28.	Black shale	17	822
29.	Hard limestone	4	826
30.	Blue limestone	14	840
31.	Dark shale	18	858
32.	Light shale	8	866
33.	Limestone and slate	24	890
34.	Limestone	30	920
35.	Slate	7	927
36.	Hard sandstone	7	934
(At this depth a strong flow of Blue Lick water was struck.)			
37.	Shale	2	936
38.	Hard sandstone	9	945
39.	Limestone	35	980
40.	Shale	5	985
41.	Limestone	7	992
42.	Red marl and slate	23	1015
43.	Streaks of limestone and shale	18	1033
44.	Limestone	19	1052
45.	Drab shale	13	1065
46.	Red marl	6	1071
47.	Shale	20	1091
48.	Streaks of limestone and shale	21	1112
49.	Limestone	24	1136
50.	Black shale	7	1143
51.	Hard sandy rock	1	1144
52.	Black shale	17	1161

On the same tract of land just west of the Fair grounds, 1,000 feet south of the above well, a fairly good gas well was struck. It was drilled to a depth of 1,170 feet, the top of the sand being found at 1,160 feet. It was completed Oct. 16, 1902, and has been abandoned.

Just northwest of the Jumbo well at the edge of town on the main street of Petersburg, a well was drilled to the depth of 1,197 feet. There were seven feet of sand in which a fair show of oil was received, perhaps the largest in the vicinity. The output was approximately four barrels. It is abandoned like the others. Completed Oct. 7, 1898.

In the southwest quarter of section 27, Washington township, on the J. M. Burger tract, a well known as the Stafford well was drilled in 1904. A showing of oil and gas was found, the oil being had at 1,150 feet and the gas at 1,015 feet. tI was abandoned, as the pay was light and the gas weak until recently, when gas was found to flow from the well. It was secured and is used in a few nearby houses. It is the only one that at this time furnishes gas for use. Completed December, 1905.

In the southeast quarter of section 13, Washington township, on the Jacob Shandy farm, a well was drilled to 1,205 feet to the black lime or shale. It was completely dry and was void of a trace of sand. Completed Feb. 18, 1898.

Four miles northeast of Petersburg, on the H. Rogers tract near Rogers Station, northeast quarter of section 7, Washington township, was an oil well of two barrels pay. It was drilled to a depth of 1,020 feet but was abandoned at an early date. Completed June, 1898.

On the Jones tract, northeast quarter section 34, Washington township, a well completely dry and without a showing of sand was put down 1,208 feet in depth. Completed August, 1899.

On the Fair Grounds tract, south of Petersburg, a well was drilled 1,170 feet deep. The sand was gotten at 1,160 feet and the hole filled up with water soon after it was drilled, causing its abandonment. There was no oil present, and but a meager showing of gas. Completed in November, 1902.

On the Graybill tract, northeast quarter of section 34, Washington township, just south of the Fair Grounds, a practically dry hole was secured with the same drilling depth as the above well. Completed in August, 1905. The total number of wells in the vicinity is eleven, all abandoned except the Stafford well and the one unplugged. The average drive pipe depth is from 30 to 105 feet. Salt water is found from 500 to 580 feet, oil at 1,160-1,197 and sand at the average depth of 1,160 feet. A glass factory was the main cause of the decrease in pressure of gas. It was known as the J. D. Carter Glass Co.

REPORT OF THE STATE INSPECTOR OF MINES FOR THE YEAR 1906.

OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, IND., February 26, 1907.

Prof. W. S. Blatchley, State Geologist:

Dear Sir: I have the honor to submit to you herewith my eighth annual report as Inspector of Mines, covering the calendar year of 1906, and being the Twenty-eighth Annual Report of this Department and the sixteenth made to the Department of Geology and Natural Resources.

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

JAMES EPPERSON,
Inspector of Mines.

CONTENTS.

TWENTY-EIGHTH ANNUAL REPORT OF THE INSPECTOR OF MINES FOR THE STATE OF INDIANA.

This report includes the following general subjects, viz:

General Review of the Coal Industry for 1906.
Recommended Legislation.
Labor.
Mine Accidents and Statistics.

These subjects are arranged under different heads and treated in a manner such as we think will cover all information that is desirable and of public interest. In the review of coal industry we treat as fully as possible all of the conditions governing the trade during the year, including market demands and railroad service.

Under recommended legislation we advise certain changes in the present mining laws, also such new laws as we think should be enacted. Under the head of labor we include strikes, Terre Haute and Brazil Agreement and all other conditions relating to labor. Under statistics, tables are given showing the number of tons of various grades of coal produced, the block and bituminous coal each shown separately, tons shipped outside the State and tons consumed in the State, wages paid, number of mine employes, days worked, number of kegs of powder used, number of mules, average wage tables, comparative tables of production of wages, table of new and abandoned mines. Under the head of mine accidents we exhibit in various tables the number of fatal, serious and minor accidents, the causes thereof, age and occupation of persons killed and the number of dependents left at each death, a table showing the number of tons of coal produced for each death as compared with former years and accidents to mine property. There are included in this report the following additional tables, viz.: tables treating on mine explosions, table showing the geological number of coal seam mined at each mine in the State and a table showing the name of the different coal carrying railroads, tonnage transported. It is with profound regret we record the death of Assistant Inspector Andrew Dodds, occurring December 25th, after a protracted illness extending from early in April. He was appointed Assistant Inspector of Mines March 11, 1901, which position he filled until the time of his death. His inspection work, statistical and other reports were eminently satisfactory, not only to this office but to all parties concerned. Mr. Dodds entered the mines in Scotland when but a boy and emigrated to America while yet a young man. He was sixty-five years of age and had spent more than half a century in the mines of this country and Scotland; he had served in all of the various capacities in and about mines and his knowledge acquired during all these years of experience rendered him a valuable assistant to this department. Mr. Robert M. Irving of Cayuga, Vermillion County, was appointed Mr. Dodds' successor December 26. His work in connection with the office has been entirely satisfactory.

The following summary contains most of the important totals for the year:

SUMMARY.

Number of coal seams operated in the State	6
Number of coal producing counties	18
Number of counties having shipping mines	14
Number of coal carrying railroads (see foot note)	14
Number of traffic connections the coal roads have with other railroads	151
Number of new coal companies organized	7
Number of block coal mines	35
Number of bituminous mines	175
Number of new block coal mines opened	3
Number of new bituminous mines opened	10
Number of mines changing hands	10
Number of bituminous mines abandoned	8
Number of abandoned mines in block coal field	3
Number of electric chain machine mines	57
Number of compressed air punching machine mines	13
Total number of machine mines	70
Number of hand mines	140
Total number of mines employing more than ten men	210
Number of pick miners employed	9,343
Number of machine runners and helpers employed	879
Number of loaders employed	3,610
Number of inside day and monthly men employed	1,830
Total number of mine employes	19,562
Number of mules used	1,467
Number of kegs of powder used	427,025
Total number of days the mines have been operated	28,632
Number of tons of hand-mined block coal (screenings)	113,241
Number of tons of hand-mined block coal (run-of-mine)	26,890
Total number of hand-mined block coal	641,727

Number of tons machine-mined block coal (lump)............	89,716
Number of tons machine-mined block coal (screenings)........	15,227
Total tons machine-mined block coal..........................	104,943
Total tons of all kinds of block coal..........................	746,670
Number of tons hand-mined bituminous coal (lump)..........	1,997,135
Number of tons hand-mined bituminous coal (screenings).....	1,246,808
Number of tons hand-mined run-of-mine bituminous coal......	3,333,896
Total number of tons hand-mined bituminous coal............	6,577,839
Number of tons machine-mined bituminous coal (lump).......	1,495,729
Number of tons machine-mined bituminous coal (screenings)..	839,649
Number of tons machine-mined run-of-mine bituminous coal...	1,762,140
Total number of tons machine-mined bituminous coal.........	4,097,518
Total number of bituminous coal............................	10,675,357
Total tons of all kinds of coal produced......................	11,422,027
Number of tons of coal shipped outside the State............	5,335,426
Number of tons coal consumed at home markets..............	6,086,601
Total wages paid to block coal miners........................	$634,148.44
Total wages paid to inside day and monthly men at block coal mines	$111,488.78
Total wages paid to outside day and monthly men at block coal mines	$228,912.49
Total wages paid to block coal employes....................	$974,549.71
Total wages paid to bituminous miners......................	$6,134,671.23
Total wages paid to inside day and monthly men at bituminous mines	$1,987,693.57
Total wages paid to outside day and monthly men at bituminous mines	$876,126.87
Total wages paid to bituminous mine employes..............	$8,998,491.67
Grand total wages paid to mine employes....................	$9,973,041.38
Total amount of money expended on improvements..........	$125,345.00
Number of fatal accidents..................................	31
Number of serious accidents................................	104
Number of minor accidents..................................	98
Total number of accidents to mine employes..................	233
Total number of serious accidents to mine property...........	5

Note.—The coal carrying railroads refer only to those traversing coal producing counties and having mines situated along their lines.

TABLE

Exhibiting by Counties the Geological Number of Coal Seams Operated in the Bituminous Coal Fields of Indiana, and the Number of Tons Produced from Each Seam in 1906.

COUNTY.	Geological Number of Coal Seams and Tons Mined.					
	II.	III.	IV.	V.	VI.	VII.
Clay	....	135,289	114,177	137,483	347,890	....
Daviess	....	22,555	....	41,056	....	....
Fountain	....	78,135	....	....	....	....
Gibson	....	....	....	93,853	....	....
Greene	....	253,277	1,861,089	75,897	....	....
Knox	....	....	....	87,200	138,741	87,040
Parke	....	222,403	3,870	....	336,340	....
Perry	7,644	....	....	....	....	....
Pike	....	....	....	465,287	....	....
Sullivan	....	119,316	178,681	275,436	1,632,762	119,898
Vanderburgh	....	....	....	304,080	....	....
Vermillion	....	....	....	....	259,806	1,373,180
Vigo	....	....	....	75,151	1,507,665	4,540
Warrick	....	....	....	315,616	....	....
Total	7,644	830,955	2,157,817	1,871,059	4,223,204	1,584,658

TABLE

Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1906 *at Mines Employing More Than Ten Men.*

MONTHS.	CLAY COUNTY.		DAVIESS COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	108,707	$106,178 77	7,974	$9,161 00
February	118,463	112,948 47	8,710	9,116 93
March	176,937	137,079 74	8,798	9,502 33
April	18,309	16,909 01	....	....
May	9,060	10,012 73	....	....
June	67,121	68,238 53	727	1,449 40
July	88,355	98,824 75	1,985	2,363 54
August	105,082	112,597 64	4,387	4,324 60
September	97,193	108,933 07	6,771	8,379 75
October	130,970	143,845 42	7,556	3,628 50
November	119,109	126,606 98	8,464	13,178 36
December	134,374	137,493 84	8,239	9,956 75
Total	1,173,680	$1,179,668 95	63,611	$71,061 16

Table Showing by Months and by Counties the Number of Tons Mined, etc.—Con.

MONTHS.	FOUNTAIN COUNTY.		GIBSON COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	7,989	$7,650 51	10,066	$11,167 83
February	5,936	5,863 37	14,887	12,317 30
March	7,633	6,604 87	14,360	13,260 55
April	5,162	5,084 22	....	....
May	6,163	6,020 58	....	....
June	7,088	7,103 75	1,350	2,648 09
July	6,605	6,476 97	4,898	4,670 04
August	6,698	6,812 25	7,114	6,510 35
September	5,331	5,723 06	7,800	7,073 13
October	7,632	6,089 68	11,408	9,557 27
November	6,022	6,075 57	10,500	9,050 00
December	5,876	5,725 83	11,470	9,452 61
Total	78,135	$75,230 66	93,853	$85,707 17

MONTHS.	GREENE COUNTY.		KNOX COUNTY.	
January	226,162	$204,768 24	26,411	$27,379 49
February	265,057	218,851 98	31,529	26,989 68
March	343,060	256,703 38	51,025	34,868 74
April	12,380	11,569 35	5,212	5,833 19
May	16,289	22,550 11	13,750	12,578 34
June	119,386	116,427 77	17,613	16,651 24
July	158,321	137,187 18	16,443	17,842 73
August	173,558	162,032 73	17,849	16,874 60
September	159,459	141,881 70	20,423	19,816 51
October	213,025	175,708 84	31,053	28,344 13
November	241,995	191,121 33	36,644	31,081 60
December	261,571	202,185 53	45,029	34,361 09
Total	2,190,263	$1,840,988 14	312,981	$272,621 34

MONTHS.	PARKE COUNTY.		PERRY COUNTY.	
January	82,611	$76,708 96	504	$510 42
February	94,774	87,438 31	555	670 78
March	114,188	102,427 43	583	555 33
April	22,576	16,866 03	779	705 95
May	23,278	18,480 65	778	875 37
June	46,079	47,666 21	718	744 54
July	57,310	56,355 03	499	608 07
August	64,011	66,544 65	717	794 40
September	65,446	69,330 54	600	683 13
October	92,331	89,125 75	535	656 34
November	83,243	99,051 41	750	715 00
December	80,776	81,348 52	626	664 33
Total	826,623	$811,343 49	7,644	$8,183 66

Table Showing by Months and by Counties the Number of Tons Mined, etc.—Con.

MONTHS.	PIKE COUNTY.		SULLIVAN COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	46,661	$38,393 01	267,658	$218,371 61
February	57,610	44,553 18	277,318	220,168 55
March	68,867	50,930 43	355,777	257,805 53
April	....	....	5,821	6,278 23
May	....	....	12,428	12,327 97
June	18,715	18,149 39	113,287	123,865 45
July	31,403	28,038 21	129,992	136,466 82
August	36,521	31,885 89	175,897	167,140 11
September	36,374	36,394 67	198,080	182,010 04
October	59,239	47,393 21	275,305	219,938 63
November	55,730	42,983 73	264,090	224,468 06
December	54,167	45,822 64	279,573	242,985 35
Total	465,287	$384,544 86	2,355,226	$2,011,826 35

MONTHS.	VANDERBURGH COUNTY.		VERMILLION COUNTY.	
January	28,811	$26,588 37	183,702	$142,138 35
February	27,721	25,112 16	188,542	142,173 44
March	46,048	27,779 75	241,790	174,458 72
April	10,856	12,278 12	....	....
May	22,058	20,509 42	....	1,756 66
June	20,774	20,280 09	82,543	78,760 17
July	14,104	15,959 14	112,850	84,057 84
August	19,655	20,444 41	139,144	112,769 02
September	23,004	21,230 61	141,629	129,312 66
October	37,162	35,115 89	182,898	145,559 40
November	36,082	33,809 42	171,808	139,587 34
December	33,036	31,790 46	188,080	149,064 67
Total	319,311	$290,897 84	1,632,986	$1,299 638 27

MONTHS.	VIGO COUNTY.		WARRICK COUNTY.	
January	198,427	$179,393 63	36,120	$21,635 25
February	205,962	174,318 30	35,322	21,219 26
March	239,433	189,227 98	53,679	32,946 78
April	17,834	14,633 96	....	....
May	32,114	25,730 06	....	....
June	95,268	91,033 86	12,691	9,131 87
July	83,984	77,976 78	16,098	11,070 40
August	109,345	102,342 18	16,486	10,872 32
September	136,972	123,737 60	27,753	16,035 03
October	157,706	139,643 45	36,361	21,649 55
November	174,644	157,797 76	34,071	38,371 12
December	178,478	157,713 89	47,035	24,848 46
Total	1,631,175	$1,433,549 45	315,616	$207,780 04

REVIEW FOR 1906.

The fact that Indiana coal is still prominent in the home trade, forging ahead in adjoining states and adding new territory in the face of a strong competitive battle for markets is evidenced by a comparison of the output for 1906 with that of 1905. A heavy increase in the total production is noticed notwithstanding the prolonged strike of last spring, involving more than three-fourths of the largest producing mines in the State and extending over a period of about two and one-half months, the severe market congestion, the unusual car shortage, the numerous embargoes laid on coal from the Southern Indiana Railroad and the refusal of the Big Four to accept transfers from the Southern Railroad to Terre Haute. This latter condition resulted in considerable loss to operators along the Southern Indiana, and the matter on appeal from the shippers was finally referred to the State Railroad Commission for adjustment. The total production for 1906 was 11,422,027 tons, an increase of 426,055 tons, or a fraction over 3.8 per cent. over 1905; 6,086,601 tons of this production was consumed in Indiana and 5,335,426 tons were shipped to other states. Prices were more irregular in range than for years past, touching the extreme minimum of 80 cents and a maximum of $3.00 per ton mine run f. o. b. cars at the mine for bituminous coal. Of the total production, 746,670 tons was block coal, an increase of 87,935 tons over 1905. The price of block coal ranged from $2.00 to $2.75 per ton screened coal f. o. b. at the mine, $2.35 being about a general average for the year. The maximum price referred to above grew out of the abnormal demand caused by the failure of the miners and operators to reach an agreement as to scale of prices and other mining conditions at their joint convention held in the latter part of January and the almost certain probability of a strike at the end of the scale year April 1st. From the time of the disagreement until April 1st all mines were operated to full capacity in anticipation of the pending strike, stocking up the market at prices ranging from one dollar and a half to three dollars per ton. The miners as predicted went out on April 1st, but resumed work in June when a still glutted market with no demand, owing to the previous heavy stocking, tumbled prices to the 80-cent level, from which they ranged to as much as $1.10 during the summer months. With the commencement of the fall and winter trade, however, prices grew stronger, reaching $1.45 per ton for run-of-mine during the winter months. Taking the year as a whole $1.10 per ton for run-of-mine would probably be a fair average.

Considering the extraordinary high prices in February and March, the medium prices during the fall and winter months and the increased production, the operators have had a fairly prosperous year. The total wages paid in 1906 was $9,973,041.38, an increase of $561,233.67, or a fraction over 6.5 per cent. over 1905, while the total number of employes was 19,562, an increase of 953 or a fraction over 5.1 per cent. in employes over that of 1905. The aggregate wages paid show an average of $510.75 per each person employed in the mines. From the above showing it is evident that the mine employes have also had a prosperous year.

A careful review of the mining industry in its many phases, i. e.: total production, wages paid, number of persons employed and other information given in descriptive tables, will prove beyond doubt that 1906 was the banner year in the history of mining in Indiana.

TABLE

Showing by Counties the Name of Mine, Number of Tons Screened, Slack, 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....	15,245	2,860	....	18,105	2,079	415	....	2,494	12,911	7,688	$14,895 95	$13,501 90	$6,777 95	$35,175 80
Total............	15,245	2,860	....	18,105	2,079	415	....	2,494	12,911	7,688	$14,895 95	$13,501 90	$6,777 95	$35,175 80

PARKE COUNTY.

NAME OF MINE.	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.
Mary................	43,689	7,770	......	51,459	....	....	....	....	....	51,459	$31,578 82	$18,548 09	$5,875 96	$56,002 87
Total............	43.689	7,770	......	51,459	....	....	....	....	....	51,459	$31,578 82	$18,548 09	$5,875 96	$56,002 87

BLOCK HAND OR PICK 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 No. 4					35,306	7,070		42,376	5,445	36,931	$38,964 33	$10,765 03	$7,101 81	$56,831 17
Brazil No. 7					26,160	5,243		31,403	16,152	15,251	28,525 47	7,691 81	6,024 19	42,241 47
Brazil No. 8					12,977	2,690		15,667	1,415	14,252	15,070 60	6,224 65	4,392 67	25,687 92
Continental No. 1					2,171	370		2,541	370	2,171	2,062 83	566 42	418 21	3,047 46
Rebstock					27,137	6,590		33,727	12,158	21,569	26,885 81	9,783 61	3,317 63	39,987 05
Superior No. 4					30,462	7,400	466	38,328	38,328		36,788 21	12,672 17	5,954 14	55,414 52
Superior No. 7					4,256	950	49	5,255	5,255		4,146 25	2,212 08	1,105 85	7,464 18
Crawford No. 4					9,411	1,680		11,091	5,603	5,488	9,556 84	4,964 20	2,383 82	16,904 86
Crawford No. 2					5,745	1,260		7,005	2,686	4,319	8,234 81	2,645 45	1,525 11	12,405 37
Crawford No. 6					47,729	12,146	67	59,942	16,266	43,676	51,046 21	12,440 50	4,970 42	68,457 13
Crawford No. 8					4,814	1,300		6,114	4,069	2,045	5,779 01	3,015 19	1,750 70	10,544 90
Crawford No. 9					28,849	6,580		35,429	16,314	19,115	32,065 75	12,038 77	5,040 13	49,144 65
Glenn No. 1					14,255	3,138	1,330	18,723		18,723	15,183 65	7,013 10	3,506 50	25,703 25
Plymouth No. 2					15,153	3,370	1,692	20,215		20,215	16,298 90	3,611 00	1,749 50	21,659 40
Monarch							7,333	7,333	7,333		4,900 00	10,886 18	1,204 94	16,991 12
Indiana Block					4,593	903		5,496	1,585	3,911	5,588 10	3,821 37	1,881 62	11,291 09
Worlds Fair No. 2					3,584	779		4,363	4,363		4,932 96	2,080 01	1,617 22	8,630 19
Eureka No. 5					28,072	6,455	204	34,731	22,109	12,622	29,582 75	6,601 10	4,596 80	40,780 65
Treager					15,900	1,832	4,623	22,355	22,355		6,824 15	1,836 35	939 25	9,599 75
Stunkard							9,156	9,156	9,156		7,772 93	2,632 70	1,179 50	11,585 13
Lower Vein No. 1					8,732	2,202		10,934	4,427	6,507	8,607 53	3,326 10	1,762 97	13,696 60
Total					325,306	71,958	24,920	422,184	195,389	226,795	$358,817 09	$126,827 79	$62,422 98	$548,067 86

PARKE COUNTY.

Pan American	....	....	....	....	7,225	600	....	7,825	1,780	6,045	$6,897 60	$1,829 35	$1,527 40	$10,254 35
Brazil Block No. 9	....	....	....	....	37,616	7,535	....	45,151	15,810	29,341	40,847 33	13,650 34	6,130 24	60,627 91
Brazil Block No. 12	....	....	....	....	16,926	3,385	....	20,311	2,347	17,964	18,878 61	9,309 48	4,839 23	33,027 32
Superior No. 1	....	....	....	....	39,737	9,950	300	49,987	49,987	....	41,500 99	14,022 56	7,011 13	62,534 68
Superior No. 2	....	....	....	....	29,191	7,250	1,553	37,994	37,994	....	32,632 27	10,000 60	5,000 15	47,633 02
Superior No. 3	....	....	....	....	34,684	8,650	....	43,334	43,334	....	39,210 50	8,769 12	4,384 49	52,364 11
Superior No. 5	....	....	....	....	4,065	950	....	5,015	5,015	....	9,480 80	2,937 47	1,326 14	13,744 41
Total	....	....	....	....	169,444	38,320	1,853	209,617	156,267	53,350	$189,448 10	$60,518 92	$30,218 78	$280,185 80

VIGO COUNTY.

Domestic Block	30,782	4,597	....	35,379	4,767	2,548	117	7,432	18,127	24,684	$39,408 48	$9,515 79	$6,193 11	$55,117 38
Total	30,782	4,597	....	35,379	4,767	2,548	117	7,432	18,127	24,684	$39,408 48	$9,515 79	$6,193 11	$55,117 38

RECAPITULATION.

Total pick mined block coal	....	....	....	....	494,750	110,278	26,773	631,801	351,656	280,145	$548,265 19	$187,346 71	$92,641 76	$828,253 66
Total machine mined block coal	89,716	15,227	....	104,943	6,846	2,963	117	9,926	31,038	83,831	85,883 25	41,565 78	18,847 02	146,296 05
Total block coal	89,716	15,227	....	104,943	501,596	113,241	26,890	641,727	382,694	363,976	$634,148 44	$228,912 49	$111,488 78	$974,549 71

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

Gifford No. 1	9,225	2,825	....	12,050	3,720	....	....	3,720	12,702	3,068	$9,647 98	$5,981 85	$1,714 17	$17,344 00
Gifford No. 2	34,834	13,811	....	48,645	17,103	790	....	17,893	....	66,538	37,873 38	19,597 91	5,453 26	62,924 55
Lewis	47,102	37,945	38,314	123,361	....	....	....	....	90,695	32,666	62,343 92	12,387 20	10,575 25	85,306 37
Vivian No. 2	5,372	6,026	41,890	53,288	....	....	....	....	44,274	9,014	25,237 11	9,965 86	4,910 31	40,113 28
Gold Knob	9,264	3,423	2,531	15,218	16,682	6,721	6,366	29,769	20,804	24,183	24,603 66	9,844 02	7,777 97	42,225 65
Island Valley No. 4	19,588	11,567	29,734	60,889	....	....	....	....	39,024	21,865	25,485 16	9,002 27	4,839 55	39,326 98
Total	125,385	75,597	112,469	313,451	37,505	7,511	6,366	51,382	207,499	157,334	$185,191 21	$66,779 11	$35,270 51	$287,240 83

BITUMINOUS MACHINE MINES—Continued.

GREENE 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.
Black Creek	31,400	15,556	7,117	54,073	19,886	10,468	5,770	36,124	60,180	30,017	$47,381 17	$17,910 40	$8,010 61	$73,302 18
Glenburn	9,704	6,365	5,084	21,153	26,515	14,014	15,364	55,893	51,158	25,888	45,860 57	15,303 41	8,624 20	69,788 18
Vandalia No. 2	....	....	40,609	40,609	....	....	91,072	91,072	130,535	1,146	69,671 24	29,292 78	7,994 17	106,958 19
Vandalia No. 5	44,861	20,666	11,258	76,785	33,691	16,425	10,020	60,136	129,372	7,549	79,030 73	30,284 05	12,564 00	121,878 78
Vandalia No. 8	38,790	17,546	50,577	106,913	3,736	2,192	4,259	10,187	109,963	7,137	58,821 98	30,687 84	8,992 90	98,502 72
Vandalia No. 9	12,169	8,654	41,180	62,003	5,019	2,586	8,617	16,222	76,969	1,256	41,184 35	15,463 46	6,484 60	63,132 41
Vandalia No. 21	26,871	16,757	12,883	56,511	....	....	....	....	51,362	5,149	25,955 73	6,549 75	5,253 70	37,759 18
Gilmour	....	....	87,026	87,026	....	....	....	....	37,827	49,199	61,436 00	17,721 00	5,730 00	84,887 00
Hoosier No. 1	8,656	5,382	6,853	20,891	1,046	....	1,102	2,148	....	23,039	12,414 92	7,091 19	4,112 00	23,618 11
Midland	14,414	6,410	7,645	28,469	....	....	....	....	....	28,469	14,572 84	4,734 16	2,819 71	22,126 71
Lattas Creek	79,832	78,463	30,852	189,147	7,237	....	957	8,194	....	197,341	112,621 21	41,197 85	13,999 46	167,818 52
Summitt No. 2	38,564	21,509	78,142	138,215	....	....	....	....	100,155	38,060	65,908 60	32,250 53	12,803 09	110,962 22
Green Valley	32,943	19,387	37,113	89,443	....	....	....	....	56,707	32,736	42,884 25	15,132 83	7,346 71	65,363 79
North West	29,814	16,314	18,617	64,745	16,335	8,687	9,478	34,500	62,081	37,164	55,304 56	21,118 67	7,674 53	84,097 76
Twin No. 5	61,029	22,722	61,044	144,795	....	....	....	....	143,020	1,775	83,020 45	20,193 55	11,059 41	114,273 41
Total	429,047	255,731	496,000	1,180,778	113,465	54,372	146,639	314,476	1,009,329	485,925	$816,068 60	$304,931 47	$123,469 09	$1,244,469 16

KNOX COUNTY.

NAME OF MINE.	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.
Knox	565	381	4,987	5,933	2,211	2,202	13,222	17,635	16,673	6,895	$11,016 91	$5,750 83	$3,720 52	$20,488 26
Lynn	5,043	3,420	24,593	33,056	1,921	1,288	5,999	9,208	30,797	11,467	18,526 41	8,120 55	6,282 43	32,929 39
Pine Knot	8,261	37,760	7,553	53,574	....	....	....	....	38,359	15,215	30,487 40	19,506 10	6,358 40	56,351 90
Freeman	6,179	3,085	12,104	21,368	....	....	....	....	18,211	3,157	6,652 10	3,104 55	4,090 08	13,846 73
Total	20,048	44,646	49,237	113,931	4,132	3,490	19,221	26,843	104,040	36,734	$66,682 82	$36,482 03	$20,451 43	$123,616 28

PARKE COUNTY.

Mecca No. 3	14,523	7,667	6,521	28,711	35,554	16,230	17,399	69,183	56,726	41,168	$61,404 95	$21,362 46	$6,364 04	$89,131 45
Parke No. 10			59,035	59,035			89,117	89,117	111,213	36,939	75,784 45	26,810 63	11,977 13	114,572 21
Parke No. 11			124,309	124,309			22,172	22,172	119,068	27,413	76,319 04	24,806 31	8,682 67	109,808 02
Total	14,523	7,667	189,865	212,055	35,554	16,230	128,688	180,472	287,007	105,520	$213,508 44	$72,979 40	$27,023 84	$313,511 68

SULLIVAN COUNTY.

Rainbow			38,675	38,675					12,875	25,800	$28,054 00	$6,502 00	$4,354 00	$38,910 00
Phoenix No. 4			60,515	60,515					22,834	37,681	41,612 00	11,560 00	6,256 00	59,428 00
Hocking	15,739	10,277	68,968	94,984					19,117	75,867	56,823 55	19,940 84	8,704 34	85,468 73
Citizens			28,257	28,257					17,177	11,080	19,172 00	5,614 00	3,914 00	28,700 00
Sun Flower	101,474	32,040	2,050	135,564					1,313	134,251	70,646 64	8,950 96	15,298 70	94,896 30
Consolidated No. 25	18,506	8,538	5,561	32,605					6,067	26,538	17,774 15	9,914 83	4,876 83	32,565 81
Consolidated No. 26	43,771	23,047		66,818					6,266	60,552	32,532 44	19,567 48	10,350 00	62,449 92
Consolidated No. 29	27,265	8,054		35,319					3,209	32,110	19,826 36	8,258 58	5,417 31	33,502 25
Consolidated No. 30	30,109	14,320	2,092	46,521					6,647	39,937	28,954 86	8,812 80	8,063 44	45,831 10
Consolidated No. 32	8,763	1,673	17,165	27,601					4,751	22,850	13,394 31	5,849 28	3,122 91	22,366 50
Consolidated No. 34	5,626	10,044	61,095	76,765					63,668	13,097	39,621 18	16,138 83	9,454 22	65,214 23
Jackson Hill No. 2	92,304	33,582	41,692	167,578					80,000	87,578	81,812 91	25,843 61	9,790 42	117,446 94
Jackson Hill No. 4	66,455	34,166	3,270	103,891					50,000	53,891	53,468 44	16,301 05	8,613 26	78,382 75
Keystone	5,366	4,065	1,543	10,974	16,970	6,570	3,139	26,679	9,820	27,833	24,523 85	10,932 60	6,813 45	42,269 90
Dering No. 13	39,647	19,758	35,809	95,214	475	223	2,805	3,503	5,642	93,075	46,184 45	23,597 35	7,810 75	77,592 55
Dering No. 14	88,005	71,775	757	160,537	350			350	10,269	150,618	82,396 81	32,618 64	16,320 77	131,336 22
Mammoth Vein	47,829	32,292	22,862	102,983					50,000	52,983	55,537 67	18,560 50	11,626 96	85,725 13
Little Giant	17,914	7,569	73,268	98,751	7,779	3,867	44,381	56,027	154,778		77,451 49	33,254 04	11,633 46	122,338 99
Shirley Hill No. 2	4,217	3,867	10,430	18,514	634	546	1,341	2,521	21,035		19,321 61	10,239 98	7,294 69	36,856 28
Pearl	27,505	14,033	18,952	60,490	3,123	1,009	994	5,126	47,080	18,536	33,145 42	15,676 60	9,463 96	58,285 98
Reliance	28,959	26,607	3,069	58,635	337		38	375	628	58,382	30,710 78	21,048 75	7,981 47	59,741 00
Black Hawk	2,672	1,061	1,390	5,123	6,178	3,259	8,427	17,864	14,172	8,815	14,030 57	4,310 82	2,840 81	21,182 20
Clover Leaf	18,384	5,637	13,505	37,526	626	202	1,180	2,008		39,534	23,881 98	6,736 79	13,474 61	44,093 38
Washington			23,090	23,090					9,654	13,436	16,710 00	4,190 00	2,110 00	23,010 00
Shirley Hill No. 1	13,834	5,750	48,474	68,058	5,487	3,025	19,244	27,756	93,725	2,089	60,826 09	22,025 68	9,016 85	91,868 62
Hamilton	4,069	2,375	5,504	11,948	2,522	1,558	3,536	7,616	10,591	8,973	9,735 24	9,402 17	4,878 97	24,016 38
Consolidated No. 28	11,730	5,399	737	17,866					1,576	16,290	8,898 16	8,208 66	3,684 78	20,791 60
Consolidated No. 33	133,426	49,544	11,114	194,084					13,892	180,192	102,944 47	30,756 46	9,341 43	143,042 36
Total	853,569	425,473	599,844	1,878,886	44,481	20,259	85,085	149,825	736,723	1,291,988	$1,109,991 43	$414,813 30	$222,508 39	$1,747,313 12

BITUMINOUS MACHINE MIENS—Continued.

VIGO 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.
Atberton	34,830	18,968	4,666	58,464	1,358	812	166	2,336	6,104	54,696	$29,662 88	$15,485 15	$6,795 47	$51,943 50
Vandalia No. 82	2,516	1,403	44	3,963	10,106	6,812	163	17,081	17,470	3,574	10,855 13	5,840 09	1,634 70	18,329 92
Ray No. 2	1,705	1,149	4,294	7,148	43,420	23,391	114,971	181,782	104,381	84,549	115,557 65	30,310 46	8,844 87	154,712 98
Forrest	....	....	57,733	57,733	....	....	....	....	36,500	21,233	39,010 00	7,610 00	4,556 00	51,176 00
Total	39,051	21,520	66,737	127,308	54,884	31,015	115,300	201,199	164,455	164,052	$195,085 66	$59,245 70	$21,831 04	$276,162 40

WARRICK 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.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Big Four	11,846	7,895	56,531	76,272	....	....	....	....	58,488	17,784	$33,156 43	$9,153 11	$5,408 08	$47,717 62
Big Vein No. 3	....	....	42,104	42,104	....	....	11,110	11,110	53,214	....	25,244 55	6,312 20	4,056 90	35,613 65
De Forrest	2,260	1,120	6,588	9,968	1,820	1,017	2,182	5,019	13,002	1,985	7,159 05	1,386 07	1,040 74	9,585 86
Electric	....	....	108,586	108,586	....	....	....	....	56,647	51,939	44,130 92	19,726 74	5,515 86	69,373 52
Dawson	....	....	2,428	2,428	....	....	....	....	....	2,428	1,037 67	386 19	282 24	1,706 10
Erie Canal	....	....	18,744	18,744	....	....	....	....	9,427	9,317	7,559 15	2,980 53	1,929 24	12,468 92
Castle Garden	....	....	13,007	13,007	....	....	13,683	13,683	12,666	14,024	13,921 72	3,041 29	1,388 10	18,351 11
Total	14,106	9,015	247,988	271,109	1,820	1,017	26,975	29,812	203,444	97,477	$132,209 49	$42,986 13	$19,621 16	$194,816 78

BITUMINOUS HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Vandalia No. 50	13,641	5,048	....	18,689	13,291	5,398	$16,151 00	$7,239 23	$2,975 55	$26,365 78
Vandalia No. 60	43,792	27,623	5,413	76,828	71,234	5,594	46,099 31	12,604 41	5,832 22	64,535 94
Vandalia No. 63	26,601	17,523	2,114	46,238	40,519	5,719	27,510 37	15,735 72	4,926 70	48,172 79
Vandalia No. 64	7,210	3,787	107	11,104	9,829	1,275	6,184 51	1,363 42	1,064 42	8,612 35
Vandalia No. 65	85,961	49,180	12,067	147,208	136,351	10,857	86,867 96	17,192 07	7,166 42	111,226 45
Fortner	10,407	3,715	....	14,122	....	14,122	9,963 92	2,024 97	2,056 78	14,045 67
Vivian No. 1	4,049	3,945	....	7,994	6,752	1,242	5,625 65	1,005 16	3,103 53	9,734 34
Klondyke No. 2	27,991	19,832	....	47,823	47,236	587	28,328 74	8,042 39	3,816 61	40,187 74
Total	219,652	130,653	19,701	370,006	325,212	44,794	$226,731 46	$65,207 37	$30,942 23	$322,881 06

DAVIESS COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Stucky	....	....	2,471	2,471	2,471	....	$1,644 72	$290 40	$311 33	$2,246 45
Montgomery No. 3	12,668	1,100	20,835	34,603	34,603	....	22,715 07	8,375 73	5,151 40	36,242 20
Mutual	9,505	1,850	11,200	22,555	15,205	7,350	21,766 30	5,016 50	2,547 60	29,330 40
Mandabach	570	192	3,220	3,982	3,982	....	2,343 21	434 60	464 30	3,242 11
Total	22,743	3,142	37,726	63,611	56,261	7,350	$48,469 30	$14,117 23	$8,474 63	$71,061 16

FOUNTAIN 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.
Indio	34,843	15,905	8,335	59,083	59,083	....	$39,109 75	$10,627 74	$5,118 50	$54,855 99
Silverwood	369	216	18,467	19,052	19,052	....	12,415 18	4,890 97	3,068 52	20,374 67
Total	35,212	16,121	26,802	78,135	78,135	....	$51,524 93	$15,518 71	$8,187 02	$75,230 66

BITUMINOUS HAND OR PICK MINES—Continued.

GIBSON COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Fort Branch	....	....	3,482	3,482	3,482	....	$2,103 47	$631 77	$526 33	$3,261 57
Oswald	22,872	24,528	27,520	74,920	74,920	....	45,734 42	13,496 31	8,045 05	67,275 78
Massey	2,272	2,399	10,780	15,451	11,271	4,180	10,662 08	2,681 92	1,825 82	15,169 82
Total	25,144	26,927	41,782	93,853	89,673	4,180	$58,499 97	$16,810 00	$10,397 20	$85,707 17

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.
Midvale	13,261	6,591	12,150	32,002	8,933	23,069	$21,782 77	$4,582 93	$2,085 94	$28,451 64
Sponsler	8,745	4,060	34,297	47,102	31,330	15,772	29,825 95	7,830 83	4,768 98	42,425 76
Antioch	6,530	3,164	39,901	49,595	31,193	18,402	30,980 46	12,581 21	6,188 69	49,750 36
North Linton	21,146	12,331	12,510	45,937	28,076	17,911	29,559 65	9,318 62	5,372 58	44,250 85
Vandalia No. 3	46,271	21,636	48,528	116,435	114,211	2,224	69,913 55	18,773 50	6,172 38	94,859 43
Vandalia No. 4	5,518	2,973	42,799	51,290	50,301	989	28,759 37	7,962 93	3,157 34	39,879 64
Vandalia No. 6	....	....	10,481	10,481	10,481	....	5,185 54	2,496 09	922 91	8,604 54
Letsinger	15,278	....	36,587	51,865	17,039	34,826	38,118 77	6,810 43	4,824 35	49,753 55
Tower Hill	23,070	10,363	84,392	117,825	....	117,825	73,370 63	14,333 10	8,798 95	96,502 68
Vulcan	6,033	2,850	10,503	19,386	5,689	13,697	11,996 99	1,836 18	2,331 70	16,164 87
Victoria	45,930	39,907	44,088	129,925	120,801	9,124	76,914 92	17,996 18	8,200 70	103,111 80
Queen	3,393	3,027	16,696	23,116	21,175	1,941	15,507 36	4,443 80	2,812 70	22,763 86
Total	195,175	106,902	392,932	695,009	439,229	255,780	$431,915 96	$108,965 80	$55,637 22	$596,518 98

KNOX COUNTY.

Bicknell	15,073	12,898	34,526	62,497	48,354	14,143	$39,866 78	$8,927 40	$6,738 48	$55,532 66
Prospect Hill	....	....	17,334	17,334	17,334	....	11,800 99	5,054 21	3,002 48	19,857 68
Vandalia No. 40	5,907	8,223	8,540	22,670	21,536	1,134	13,427 48	6,154 24	3,036 01	22,617 73
Wheatland	....	....	69,706	69,706	69,706	....	37,929 73	8,366 57	4,700 69	50,996 99
Total	20,980	21,121	130,106	172,207	156,930	15,277	$103,024 98	$28,502 42	$17,477 66	$149,005 06

PARKE COUNTY.

Lyford No. 1	6,361	4,025	31,321	41,707	....	41,707	$26,368 74	$8,290 08	$5,910 20	$40,569 02
Vandalia No. 316	38,636	18,702	2,578	59,916	40,169	19,747	$39,927 25	13,652 06	4,153 94	57,733 25
Vandalia No. 317	44,362	19,841	390	64,593	43,739	20,854	43,610 90	12,351 88	4,463 03	60,425 81
Harrison	....	....	3,870	3,870	3,870	....	2,212 62	504 44	198 00	2,915 06
Total	89,359	42,568	38,159	170,086	87,778	82,308	$112,119 51	$34,798 46	$14,725 17	$161,643 14

PERRY COUNTY.

Troy	....	....	7,644	7,644	7,644	....	$5,106 68	$1,753 63	$1,323 35	$8,183 66
Total	....	....	7,644	7,644	7,644	....	$5,106 68	$1,753 63	$1,323 35	$8,183 66

PIKE COUNTY.

Aberdeen (Idle)	....	....	....	....	....	....	....	....	....	....
Carbon (Idle)	....	....	....	....	....	....	....	....	....	....
Ayrshire No. 3	32,585	18,583	14,310	65,478	38,215	27,263	$35,432 38	$11,161 77	$5,030 06	$51,624 21
Ayrshire No. 4	65,392	46,541	37,351	149,284	58,251	91,033	88,400 97	27,337 50	10,367 21	126,105 68
Ayrshire No. 5	306	252	13,124	13,682	7,948	5,734	7,978 56	2,822 69	2,335 91	13,137 16
Rogers	....	....	5,100	5,100	5,100	....	2,749 08	474 54	297 42	3,521 04
Blackburn	....	....	29,741	29,741	26,177	3,564	16,134 02	4,643 78	3,516 51	24,294 31
Littles	44,589	58,201	13,294	116,084	69,382	46,702	64,162 79	15,238 60	5,626 95	85,028 34
Hartwell No. 1	17,040	8,515	51,033	76,588	50,845	25,743	48,694 81	17,647 94	6,128 64	72,471 39
Petersburg (Idle)	....	....	....	....	....	....	....	....	....	....
Winslow No. 4 (Idle)	....	....	....	....	....	....	....	....	....	....
Winslow No. 5 (Idle)	....	....	....	....	....	....	....	....	....	....
Hartwell No. 2	....	....	9,330	9,330	9,330	....	6,660 20	1,190 49	512 04	8,362 73
Total	159,912	132,092	173,283	465,287	265,248	200,039	$270,212 81	$80,517 31	$33,814 74	$384,544 86

BITUMINOUS HAND OR PICK MINES—Continued.

SULLIVAN COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Cummins	....	....	3,208	3,208	1,208	2,000	$2,670 00	$905 00	$525 00	$4,100 00
Consolidated No. 31	2,664	2,017	11,417	16,098	3,343	12,755	8,675 84	2,056 87	1,033 00	11,765 71
Vandalia No. 10	40,896	22,118	55,098	118,112	116,421	1,691	71,718 52	17,230 46	7,079 52	96,028 50
West Linton (Idle)	....	....	....	....	....	....	....	....	....	....
Freeman	....	....	43,274	43,274	....	43,274	24,850 35	9,540 00	5,301 00	39,691 35
Dering No. 12	18,995	11,967	546	31,508	....	31,508	18,092 00	9,721 25	3,006 10	30,819 35
Superior	28,013	21,531	35,638	85,182	56,559	28,623	55,115 93	21,061 87	5,930 52	82,108 32
Semi Block (Idle)	....	....	....	....	....	....	....	....	....	....
Total	90,568	57,633	149,181	297,382	177,531	119,851	$181,122 64	$60,515 45	$22,875 14	$264,513 23

VANDERBURGH 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.
Union (Idle)	....	....	....	....	....	....	....	....	....	....
Unity	35,826	29,881	76,471	142,178	142,178	....	$87,618 65	$23,023 80	$10,287 38	$120,929 83
First Avenue	16,236	10,283	11,633	38,152	38,152	....	25,639 36	6,498 43	5,368 50	37,506 29
Sunnyside	20,471	11,692	9,708	41,871	26,506	15,362	31,684 92	14,351 14	9,883 72	55,919 78
Diamond	22,550	14,342	8,750	45,642	45,642	....	26,205 03	8,610 72	5,477 28	40,293 03
Ingleside	3,807	....	32,430	36,237	36,237	....	24,236 35	5,759 96	6,252 60	36,248 91
Total	98,890	66,198	138,992	304,080	288,718	15,362	$195,384 31	$58,244 05	$37,269 48	$290,897 84

VERMILLION COUNTY

Dering No. 5	27,376	20,689	105,480	153,545	....	153,545	$81,555 23	$31,463 27	$6,280 42	$119,298 92
Dering No. 6	5,878	3,704	187,213	196,795	....	196,795	105,457 30	36,987 31	7,239 10	149,683 71
Dering No. 7	....	....	170,708	170,708	170,708	....	90,881 34	31,835 75	7,758 34	130,475 43
Dering No. 8	38,837	27,475	89,052	155,364	....	155,364	84,376 86	37,536 83	7,657 79	129,571 48
Dering No. 15	....	....	71,023	71,023	....	71,023	38,550 10	16,096 35	5,273 51	59,919 96
Eureka No. 1	....	....	18,075	18,075	18,075	....	10,844 72	3,760 58	3,445 98	18,051 28
Crown Hill No. 1	18,180	6,051	56,055	80,286	15,150	65,136	61,622 35	13,641 98	3,711 74	78,976 07
Dering No. 50	17,078	14,500	116,767	148,345	....	148,345	85,619 01	17,346 55	9,383 00	112,348 56
Dering No. 23	1,836	1,510	154,625	157,971	....	157,971	94,304 88	18,439 17	8,020 15	120,764 20
Dering No. 20	18,395	15,275	159,390	193,060	....	193,060	112,474 94	18,958 60	8,343 40	139,776 94
Prince	8,098	9,650	105,780	123,528	....	123,528	74,014 98	18,098 41	5,538 22	97,651 61
Crown Hill No. 2	44,670	14,869	104,747	164,286	26,863	137,423	116,063 75	21,983 08	5,073 28	143,120 11
Total	180,348	113,723	1,338,915	1,632,986	230,796	1,402,190	$955,765 46	$266,147 88	$77,724 93	$1,299,638 27

VIGO COUNTY.

Chicago No. 6 (Idle)	....	....	....	....	....	....	....	....	....	....
Diamond	13,058	5,107	9,050	27,215	27,215	....	$16,358 30	$4,977 80	$3,575 05	$24,911 15
Victor	12,268	6,797	9,143	28,208	16,297	11,911	19,053 65	4,893 50	3,375 25	27,322 40
Lawton	102,212	57,454	17,500	177,166	177,166	....	115,466 30	28,761 95	8,787 45	153,015 70
Grant No. 2	11,417	9,866	64,393	85,676	76,975	8,701	50,118 26	23,725 83	8,355 69	82,199 78
Vandalia No. 67	88,503	44,671	27,250	160,424	148,697	11,727	99,056 20	29,251 28	7,081 39	135,388 87
Vandalia No. 68	21,152	11,928	999	34,079	31,493	2,586	21,176 05	11,881 83	4,804 52	37,862 40
Vandalia No. 69	20,124	16,269	1,079	37,472	33,007	4,465	21,563 75	12,974 54	4,234 05	38,772 34
Vandalia No. 80	8,401	6,112	640	15,153	10,583	4,570	7,464 41	5,282 03	1,074 28	13,820 72
Vandalia No. 81	21,358	19,055	12,509	52,922	37,370	15,552	29,570 67	8,956 20	4,759 64	43,286 51
Miami No. 1	64,409	73,028	....	137,437	....	137,437	84,167 38	23,453 91	6,388 58	114,009 87
Miami No. 2	41,509	42,179	40,575	124,263	....	124,263	78,009 14	16,639 99	6,486 35	101,135 48
Miami No. 3	56,739	30,275	31,520	118,534	....	118,534	72,532 29	13,545 13	4,679 41	90,756 83
Fauvre No. 1	18,894	14,202	7,227	40,323	40,323	....	20,704 95	11,688 59	2,838 63	35,232 17
Larimer	....	....	4,540	4,540	4,540	....	2,593 80	1,054 66	434 00	4,082 46
Deep Vein	41,772	28,377	30,391	100,540	60,375	40,165	64,675 92	12,694 90	9,099 99	86,470 81
Fauvre No. 2	1,253	768	433	2,454	2,454	....	1,370 56	1,836 17	1,050 59	4,257 32
Sugar Valley	....	....	1,185	1,185	1,185	....	616 20	103 40	200 00	919 60
Dering No. 10	....	....	30,186	30,186	30,186	....	15,666 30	6,746 35	2,443 35	24,856 00
Vandalia No. 66	44,242	29,746	7,084	81,072	75,694	5,378	46,977 12	17,413 33	5,882 21	70,272 66
Total	567,311	395,834	295,704	1,258,849	773,560	485,289	$767,141 25	$235,881 39	$85,550 43	$1,088,573 07

BITUMINOUS HAND OR PICK MINES—Continued.

WARRICK COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Air Line (Idle)	...	...	...	...	...	...	...	...	...	...
Chandler	...	...	5,907	5,907	5,907	...	$3,810 90	$1,102 05	$819 35	$5,732 30
Star No. 1	...	...	8,788	8,788	8,788	...	5,103 42	1,394 68	732 86	7,230 96
Burke (Idle)	...	...	...	...	...	...	...	...	...	...
Total	...	...	14,695	14,695	14,695	...	$8,914 32	$2,496 73	$1,552 21	$12,963 26

RECAPITULATION.

Showing Total Production and Wages of Indiana Mines for 1906.

TOTAL PRODUCTION OF BLOCK COAL.

	Machine Mined.				Pick Mined.				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.	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.	Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Total machine mined block coal.........	89,716	15,227	....	104,943	6,846	2,963	117	9,926	31,038	83,831	$85,883 25	$41,565 78	$18,847 02	$146,296 05
Total pick mined block coal.........	....	....	....	....	494,750	110,278	26,773	631,801	351,656	280,145	548,265 19	187,346 71	92,641 76	828,253 66
Total block coal..	89,716	15,227	....	104,943	501,596	113,241	26,890	641,727	382,694	363,976	$634,148 44	$228,912 49	$111,488 78	$974,549 71

TOTAL PRODUCTION OF BITUMINOUS COAL.

	Machine Mined.				Pick Mined.				Distribution.		Wages.			
Total bituminous machine mined coal...	1,495,729	839,649	1,762,140	4,097,518	291,841	133,894	528,274	954,009	2,712,497	2,339,030	$2,718,737 65	$998,217 14	$470,175 46	$4,187,130 25
Total bituminous pick mined coal.........	....	....	....	....	1,705,294	1,112,914	2,805,622	5,623,830	2,991,410	2,632,420	3,415,933 58	989,476 43	405,951 41	4,811,361 42
Total bituminous coal	1,495,729	839,649	1,762,140	4,097,518	1,997,135	1,246,808	3,333,896	6,577,839	5,703,907	4,971,450	6,134,671 23	1,987,693 57	876,126 87	8,998,491 67
Total machine mined coal..............	1,585,445	854,876	1,762,140	4,202,461	298,687	136,857	528,391	963,935	2,743,535	2,422,861	2,804,620 90	1,039,782 92	489,022 48	4,333,426 30
Total pick mined coal..............	....	....	....	....	2,200,044	1,223,192	2,832,395	6,255,631	3,343,066	2,912,565	3,964,198 77	1,176,823 14	498,593 17	5,639,615 08
Grand Total.....	4,084,176	2,214,925	5,122,926	11,422,027	....	....	....	....	6,086,601	5,335,426	$6.768,819 67	$2,216,606 06	$987,615 65	$9,973,041 38

LABOR.

Joint Conferences Coal Miners and Operators of Western Pennsylvania, Ohio, Indiana and Illinois.

Indianapolis, Ind., January 25 to February 2, and March 20 to 29, 1906.

The following is a brief history of the proceedings of the National Convention of miners and operators of Western Pennsylvania, Ohio, Indiana and Illinois and the strike resulting therefrom April 1, 1906. The National Convention of miners and operators met in Tomlinson Hall January 25th for the purpose of arranging prices and conditions to govern the scale year beginning April 1, 1906.

First Conference—January 25, 1906.

The joint convention of miners and operators was called to order at 2 o'clock, p. m., with Mr. John Mitchell, National President of the United Mine Workers, acting as temporary chairman. The convention was organized by electing Mr. G. W. Traer (operator) of Illinois permanent chairman, W. B. Wilson (National Secretary to the Miners' Organization) as permanent Secretary and C. L. Scroggs (miner) of Illinois Assistant Secretary. The remainder of the day was consumed in the selection of various committees and other routine work incident to governing the convention.

January 26.

The joint convention was called to order at 4:15 p. m., with Mr. G. W. Traer in the chair. The first order of business transacted was the selection of the members of the scale committee and alternates. When the roll call of States was made Chairman Traer announced the Convention ready to proceed with its business.

Immediately following this announcement, Mr. Mitchell on the part of the miners made the following motion, to wit: That there be a general advance of 12½ per cent. over the present scale of wages, that the advance be on the run-of-mine basis, with a proper run-of-mine price for all of the states covered by the proposition; and that the differential between pick and machine mining be 7 cents per ton. After some little discussion on the proposition the convention adjourned until 9 o'clock, a. m., the following day.

January 27.

The convention was called to order at 9:30 o'clock by Chairman Traer. The forenoon of the session was taken up in a discussion of the uniform scale, the 7 cents differential between pick and machine mining and the shot firers' bill in Illinois, but with little headway. A vote was taken (on Mr. Mitchell's motion made the previous day) which lost, the miners voting in the affirmative and the operators in the negative. Just before the hour for adjournment Mr. Robins moved the matter of scale be referred to the joint scale committee (seconded by Mr. Mitchell), the miners and operators both voting in the affirmative. The joint convention was adjourned to wait the call of the committee.

JOINT SCALE COMMITTEE.

The Joint Scale Committee met and organized by electing Mr. W. D. Ryan (Secretary and Treasurer of the Miners' Organization of Illinois) as permanent chairman, C. L. Scroggs Secretary, W. D. Wilson and T. S. Brooks assistant secretaries, and adjourned to meet at 1:30 o'clock, p. m., in the palm room of the Claypool Hotel.

The first regular session of the Joint Scale Committee was called to order at 1:30 o'clock p. m., in the palm room of the Claypool Hotel, and after adopting rules, etc., to govern the deliberations of the committee, adjourned to meet at 10 o'clock a. m., Monday, the 29th.

January 29.

The Joint Scale Committee was called to order at 10 o'clock, a. m. Mr. Mitchell presented the miners' proposed scale in full, which read as follows:

PROPOSED SCALE.

We demand:

1st. A general advance of 12½ per cent. over the present scale of wages.

2d. To be paid on a run-of-mine basis with a proper relative run-of-mine price for all States covered by the contract.

3d. That the differential between machine and pick mining shall be 7 cents per ton.

4th. That a uniform outside day wage scale be established.

5th. That all yardage and dead work be advanced 12½ per cent.

6th. That no boy under 16 years of age be employed in or around the mines.

7th. That our contract become effective April 1, 1906, and expire March 31, 1907.

8th. That eight hours from bank to bank shall constitute a day's work.

9th. That when the men go into the mine in the morning they shall be entitled to two hours' pay whether or not the mine works the full two hours, that the men shall be paid for every hour thereafter by the hour for each hour or fractional part thereof. If, for any reason, the regular routine work can not be furnished the inside labor for a portion of the first two hours, the operators may furnish other than regular labor for the unexpired time.

10th. That the check-off for the collection of dues, initiation fees, fines and assessments levied by the United Mine Workers of America become a part of the Interstate Joint Agreement.

11th. That internal differences in any of the States or districts, both as to prices and conditions, shall be referred to the States or districts affected for adjustment.

When the scale had been read Mr. Mitchell moved its adoption (seconded by Mr. H. C. Perry, miner).

A motion was then made by Mr. Robins that the scale be taken up by sections. No objection being made Mr. Robins' motion was accepted, and the committee proceeded to discuss the scale in sections one by one. Several paragraphs of the proposed scale were debated during the two following days, Messrs. Penna, Mitchell, Robins, Winder, Wilson and Taylor taking the more prominent parts in the discussion. Little of interest transpired until the afternoon session of the 31st.

January 31.

The Joint Scale Committee was called to order at 4 o'clock, p. m., W. D. Ryan in the chair.

Mr. Taylor on the part of the operators offered the following, to wit: That the present interstate agreement be continued for one year from April 1, 1906; that the mining price at Danville, the basing point for Illinois, be 52 cents per ton for mine run coal loaded on the cars at the face, including the inspecting and shooting of shots, the timbering and care of working places and in machine mines the proper snubbing of the coal. This proposition on being put to a vote lost, the operators of the four states voting in the affirmative, the miners voting in the negative. Mr. Robins then moved to adjourn until 9 o'clock a. m. the following day. Mr. Wilson amended the motion to adjourn to meet the joint convention but withdrew the amendment and the committee adjourned to meet at 9 o'clock, February 1st.

February 1.

The Committee was called to order at 9 a. m., and Mr. Robins moved the scale adopted two years prior be adopted by this convention, covering the scale years from April 1, 1906, to March 31, 1907. Motion amended by Mr. Taylor that at Danville, the basing point of Illinois, the price per ton mine run loaded on the cars at the face be 52 cents, including the inspecting and shooting of shots and timbering and care of the working places and the proper snubbing of the coal. The amendment and motion on being put to a vote (separately) lost, the miners voting in the negative and the operators in the affirmative. A motion was then made and carried that the joint scale committee adjourn to meet the joint convention at 2 p. m.

JOINT CONVENTION.

Report of Joint Scale Committee.

The Joint Convention was called to order at 2 p. m. Secretary Scroggs read the report of the Joint Scale Committee. The report included the various paragraphs acted on, nearly all of which lost; also the motion and amendment made by Messrs. Robins and Taylor and the action taken thereon. After some further debate on part of Mr. Mitchell and Mr. Robins the convention adjourned to meet at 9 o'clock a. m., February 2d, the miners remaining for a separate session.

February 2.

The Joint Convention was called together at 9 o'clock, a. m., with Colonel Randolph Smith in the chair.

Mr. Mitchell: Yesterday afternoon our own convention endorsed the action of our scale committee in refusing to accept a settlement on a basis of the present settlement.

Mr. Robins, in order to have the records of this convention right, offered the same motion as made by him the day previous.

Mr. Taylor also made the same amendment as offered the day previous. On roll call of the States the amendment lost, the miners voting in the negative and the operators in the affirmative.

After considerable discussion Mr. Robins' motion was put to a vote. The roll call of the four States was as follows: The operators of Illinois did not vote, operators of Ohio, Indiana and Western Pennsylvania voted in the affirmative. The miners of Illinois, Indiana and Ohio voted in the negative. Mr. Dolan voted in the affirmative for Western Pennsylvania, the other delegates from that

District voted in the negative. Mr. Robins then moved to adjourn *sine die*, which carried, the convention adjourning without an agreement having been made.

Interstate Convention 1906.

Second Conference—March 20th to 29th.

Pursuant to the suggestion of President Roosevelt in a letter addressed (each) to National President John Mitchell and Francis L. Robins a second joint convention was called. This convention was called to order in Tomlinson Hall at 2 o'clock p. m., March 20, 1906, and organized by electing Mr. G. W. Traer of Illinois Chairman, W. B. Wilson Secretary and Messrs. T. S. Brooks and C. L. Scroggs Assistant Secretaries.

After the various committees (including scale committee) had been selected and other routine work accomplished President Mitchell on behalf of the miners offered the same scale of wages, conditions of labor, etc., as offered at the former conference and moved its adoption, which was seconded by Mr. Wilson. The motion was immediately voted on and lost, the miners voting in the affirmative and the operators in the negative. After other preliminary work had been gone through Mr. Robins offered a motion that the matter of scale be referred to the Joint Scale Committee and that the Joint Scale Committee meet the following morning at 9 o'clock in the Claypool Hotel, and that the convention adjourn (seconded by Mr. Mitchell). All operators and miners voting in the affirmative, the motion was declared carried and the convention adjourned to wait the call of the committee.

Joint Scale Committee.

March 21.

The Joint Scale Committee was called to order at 9 o'clock a. m. in the palm room of the Claypool Hotel and organized by electing W. D. Ryan, Chairman; C. L. Scroggs, Secretary, and T. S. Brooks and W. B. Wilson, Assistant Secretaries. Immediately after the committee was organized Mr. Mitchell moved the adoption of the scale proposed in the joint convention (seconded.) The remainder of this date was consumed in a discussion of the shot firers' bill in Illinois, the operators claiming the bill was unjust and that they had not been treated fairly by the miners insisting on its enforcement, the miners' position being opposite that of the operators.

March 22.

The Joint Scale Committee was called to order at 9 o'clock, W. D. Ryan in the chair. The first business transacted on this date was a vote on the motion, regarding the scale, made by Mr. Mitchell the previous day. The miners voting in the affirmative and the operators in the negative, the motion was declared lost. Mr. Mitchell then moved that the subject of formulating a scale of wages be referred to a sub-committee composed of two representatives of the miners and two operators from each of the states affected (seconded). All the miners and the Pennsylvania operators voted in the affirmative and the operators from the other three states in the negative (motion lost). The shot firers' bill was again brought up for discussion, Mr. Taylor of Illinois offering the following motion, i. e.: That it be the sense of this meeting that the shot firers' bill affecting Danville, the basing point for Illinois, is an interstate matter. The motion on being put to a vote lost, all the operators voting in the affirmative and the miners in the negative. After some debate on the question of a sub-committee and other matters, Mr. Winder moved the adoption of the scale, agreed to two years previous, and which expired April 1, 1906. The miners at that time did their own shot firing.) This motion lost, the miners voting nay and the operators aye. A few minutes before adjournment Mr. Robins offered the following motion: That the scale of 1903, the same prices and conditions, be renewed for two years from April 1, 1906 (seconded). On roll call all of the miners of the four States and the operators of Pennsylvania voted in the affirmative and the operators of Ohio, Indiana and Illinois voted in the negative. The motion was declared lost. The committee then adjourned to meet at 9 a. m., Friday, March 23d. Little business of importance was transacted on the 23d and 24th.

March 27.

The Joint Scale Committee was called to order at 9 o'clock a. m., W. D. Ryan in the chair. Immediately after the meeting was opened Mr. Mitchell moved that the Joint Scale Committee adjourn to report a disagreement to the joint convention at 2 o'clock, p. m. (Seconded by Mr. Winder.) The roll call of States was made and the motion carried.

Joint Convention.

March 27.

The joint convention was called to order at 2 p. m., with G. W. Traer in the chair. The report of the Joint Scale Committee was read and on motion was adopted and made a part of the records of the convention. Mr. Winder then offered the following motion, to wit: That the scale adopted two years previous, expiring April 1, 1906, with all of the conditions existing at the time of its adoption, be re-affirmed, and that the mining price at Danville, the basing point in Illinois, include the mining, shooting and loading coal, the proper care and timbering of the working places and the inspection of shots. (Seconded.) This motion was voted on during the afternoon session of the 28th and lost. Mr. Mitchell then moved that as a basis of settlement there be a restoration of the 1903 mining scale, day wage and dead work scale. Amended by Mr. Robins that the agreement take effect April 1, 1906, and continue until March 31, 1908, subject to approval of the miners' convention. (Mr. Mitchell seconded the amendment.) Mr. Mitchell stated that before the miners could vote on the motion it would be necessary to hold a separate session and moved to adjourn until 2 o'clock, p. m., of the 29th. (Motion prevailed.)

March 29.

The convention was called to order at 2 o'clock in the German House, G. W. Traer in the chair.

Mr. Mitchell's motion, amended by Mr. Robins, after being debated on at considerable length, was put to a vote and lost, the operators of Ohio, Indiana and Illinois voting no, Mr. Robins, for Western Pennsylvania, and the miners of that district voting aye. A motion to adjourn *sine die* was made by Mr. Winder (seconded by Col. Randolph Smith of Illinois), the miners and operators both voting in the affirmative and the National Convention was again adjourned *sine die* without an agreement having been effected, thus precipitating a general strike which extended over a period of more than two months. The strike, while general in Indiana, affecting all the coal producing counties, did not include all mines in the State; a number of operators outside the large combines, representing probably one-tenth of the total production of the State, granted the miners' demands, signed the scale and continued to operate their mines. Owing to the heavy stocking prior to April 1st, there was very little demand and the tonnage produced during that month was comparatively small. In May, however, both prices and demand grew stronger and the independent operators one by one began signing the scale, and by the time a final settlement was made there were 54 mines in operation.

Note.—During the time of the first convention in January it was rumored that a motion had been passed at one of the miners' separate conferences providing that no State or District be permitted to sign an agreement until all States and Districts covered by the contract were ready to sign. A rumor was also current that at the second conference held in March action was taken permitting any operator, State or District, to sign the agreement and continue work. We have no record of either of the above motions and merely mention them as a connection between the adjournment of the second conference and occurrences that took place later. The above motion was repeatedly referred to during the conference as the Ryan resolution.

Terre Haute Convention.

Early in June a joint convention of miners and operators of District 11, covering the bituminous field in Indiana, was held in Terre Haute and after a conference of several days an agreement was finally made and signed on the 8th, inst., a copy of which we will give later. The block coal field covered by district No. 8, effected a settlement some time later. So ended the greatest history making struggle between miners and operators to the knowledge of the writer on record. A great many of the operators were ready to resume work at once; some had considerable cleaning up and repairs to make and it was probably the 15th of the month before all the mines had resumed operation.

Strike at Summit No. 2 Mine.

A strike covering some four weeks occurred at the above mine shortly after the resumption of work in June, resulting from the miners' refusal to clean a certain amount of falling slate without pay, the operator claiming that the recent Terre Haute Agreement required them to do so, the miners contending they were entitled to pay. After the mine had been idle the time above mentioned the matter was finally adjusted in favor of the miners.

Strike at the Vandalia Nos. 8 and 9 Mines.

A strike of several days' duration occurred at these two mines during the summer, which at one time threatened to involve all the mines owned by the Vandalia Coal Company. This trouble grew out of the discharge of three miners at Vandalia No. 8 Mine for violation of the State law governing shot firing in coal mines. The mine committees and officers of the miners' organization demanded reinstatement of the men discharged. On the company's refusal to reinstate them the miners in all of the Vandalia mines were ordered out by the State officials of the miners' organization. The company, however, conceded the demands of the miners on the morning this order was to take effect and work was continued at the other mines without interruption.

Strike at the Rosebud Mine.

A strike at this mine, owned by the Vandalia Coal Company, occurred during the fall arising over the question of payment for top coal required to be left up for the protection of the roof. (This matter included a greater number of the mines in the Seeleyville District.) After several days' idleness the question was finally settled in favor of the company.

There were numerous other local strikes at the mines during the year, but usually extended over a few days' time, hence no mention of them will be made.

We submit herewith the agreement of the miners and operators of the 11th District entered into in June; also the Brazil Agreement which was made a short time later:

TERRE HAUTE AGREEMENT.

Arranged and adopted by and between the United Mine Workers of District 11 and the Indiana Bituminous Coal Operators' Association, effective during the Scale Years from June 8th, 1906, to April 1st, 1908.

It is hereby agreed:

Section I.

That the bituminous coal district of Indiana shall pay fifty-five cents (55 cents) per ton for all mine-run coal loaded and shipped as such. All other coal mined in that district shall be passed over regulation screen, and be paid for at the rate of ninety cents (90 cents) per ton of two thousand (2,000) pounds for screened lump.

The standard height of coal in Indiana shall be 3 feet 3 inches in mines opened prior to April 1, 1901, and in mines opened since April 1, 1901, the standard height shall be 3 feet 6 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 $1.06 per ton for screened lump coal and 65 cents per ton for mine run coal.

Section II.

That the screen hereby adopted for the bituminous district of Indiana shall be uniform in size, six (6) feet wide by twelve (12) feet long, built of flat or Akron-shaped bar, of not less than five-eighths (⅝) of an inch surface, with one and one-fourth (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.

MACHINE MINING.

Section III.

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 3-10 cents; loading, shooting and timbering, 52 2-10 cents. Total, 72 cents.

Run-of-Mine—Runner, 6 6-10 cents; helper, 6 1-10 cents; loading, shooting and timbering. 32 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.

DAY WORK FOR PUNCHING MACHINES.

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 horse backs, etc.

YARDAGE AND ROOM TURNING.

SECTION IV.

PICK MINING YARDAGE.

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-foot entry being demanded by the operator, narrow entry prices shall be paid; if 14, 15, 16 or 17-foot 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.

MACHINE MINING YARDAGE.

In entries 7 to 9 feet wide	\$1 34
In entries 12 feet wide, ⅝ of price of 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—PICK MINES.

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.

BREAK THROUGHS—MACHINE MINES.

Break throughs between entries, same as entry prices. Break throughs between rooms shall be paid for at same price when similarly driven.

ROOM TURNING—PICK MINES.

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, of \$2.81¼.

ROOM TURNING—MACHINE MINES.

Room turning	\$3.37½

Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, price shall be ⅝ of regular price, or \$2.10.

Yardage in machine mines shall be divided as follows:

In narrow entries and narrow break throughs between entries in chain machine mines, the loader shall receive \$1.18 per yard and the machine runner and helper each 8 cents per yard, and in wide entries the same proportion. In entries and break throughs between entries in punching machine mines the loaders shall receive $1.14 per yard and the runner and helper each 10 cents per yard, except where coal is sheared, in which case runner and helper shall receive all the yardage.

Where machines are worked by the day the loaders shall receive all the yardage.

The price for mining herein agreed to for pick and machine work shall include all labor necessary to cut the coal, drill and blast the same, load it on the miner's car and properly care for and timber the miner's working place, and no division of the scale shall carry any exception to this rule. In case a miner fails to properly timber, shoot and care for his working place so that any of the company's property is injured, the miner whose fault has occasioned such damage shall repair the same without compensation. Provided, however, that where shot-firers are employed and partially paid by the company the condition shall continue during the life of this agreement.

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.

The blacksmith's wages shall be $2.94 per day of nine hours at all mines north of the B. & O. S. W. R. R.

In addition to his ordinary duties he shall do any other labor required of him by the mine management. Provided, however, that he shall receive his regular wages therefor.

DAY LABOR.

SECTION V.

The wages of inside day labor shall be $2.56 per day of eight hours where and when men are employed, except as herein provided.

The wages of spike team driver shall be $2.80 per day. The drivers 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.

The wages of motor men shall be $3.01 per day, and trappers $1.13 per day.

All day laborers working at the mines, excepting weighmasters, head flat-trimmer, dumper, fire-bosses and boss drivers who shall be regarded strictly as company men, shall be recognized as members of the U. M. W. of A. In emergencies or in the absence of any regular employe the right of the operator to employ men not members of the U. M. W. of A. for outside day labor shall not be questioned. Any and all flat-trimmers shall dock for dirty coal.

The wages of outside men except as herein provided shall be $2.02½ per day of eight hours on and north of the B. & O. S. W. R. R.

South of the B. & O. S. W. R. R. the wages shall be 20¼ cents per hour.

The present wages of all outside day labor south of the B. & O. S. W. not herein specifically stated shall be advanced 5 87-100 per cent.

All day men shall at all times do and perform any and all kinds of labor required of them by the mine management. Provided, however, that on idle days men shall have an equal division of the work they usually perform when the mine hoists, and where men are employed as drivers, cagers and motor men they shall have an equal share of all extra work, such as cleaning roads, getting in rails, timber or any other work required of them, when the same does not interfere with the work of other men.

In the absence of any driver, any miner who can drive shall be expected to do so when requested. Any miner leaving his place to drive shall be permitted to load one car for that day. Provided, however, that no miner shall be permitted to make up more than one car in any one week.

DEAD WORK.

Section VI.

It is agreed that the companies shall have the working places as dry as local conditions will permit, and said working places shall be in working condition at time of starting work in the morning. If any company shall fail to have said working places dry or reasonably so one hour after starting time two successive days, the company shall, if said failure is traceable to neglect or carelessness of the company's agent, give miner or miners so affected other work or pay him or them for time so lost.

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.

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 32 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.

In mines where it is necessary to remove top or bottom in working places, commonly known as brushing, the following scale shall be paid:

When necessary to shoot top or bottom in entries 9 inches in thickness, 45 cents per yard, and 5 cents per inch per yard for any additional thickness. In rooms, where necessary to shoot 9 inches in thickness, 36 cents per yard, and for each additional inch 4 cents.

When brushing is necessary and can be done without shooting the price in entries shall be 4 cents per inch per yard, and in rooms 3 cents per inch per yard.

No brushing shall be done nor paid for without ordered and amount specified by the mine boss. The miner doing the brushing in entries shall load or "gob" the same, as directed by the mine boss. In rooms the miner shall "gob" the refuse. Brushing shall be six feet wide in entries and five feet wide in rooms.

ENGINEERS' WAGES AND THEIR DUTIES.

Section VII.

The engineers' wages shall be:

First engineer	$84 37
Second engineer	73 13
Third engineer	67 50

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.

In case of either local or general suspension of mining, either at the expiration of this contract, or otherwise, the engineers shall not suspend work, but shall, when mining is suspended, fully protect all of the company's property under their care, and operate fans and pumps, and lower and hoist such men, mules or supplies as may be required, and any and all coal required to keep up steam at the company's coal plants, but it is understood and agreed that the operators will not ask them to hoist any coal produced for sale on the market, and there shall be no change in engineers' wages during the suspension.

All hoisting engineers at pick mines shall do the firing where the production does not exceed 300 tons of coal per day, and at machine mines in process of development until the production shall have reached 200 tons per day. Engineers shall do the firing on idle days at the option of operator, except when dynamos or compressors are being run to furnish power to operate mining machines to cut coal, but the services of the fireman shall not be dispensed with where a mine ceases hoisting coal in the midst of a shift.

The wages of firemen shall be: Per day of 10 hours, $2.45; per month, $65.00; per night of 12 hours, $2.35; per month, $63.50. The day firemen shall do and perform any service required of them by the mine management, and shall be entitled to an equal division of labor with other outside day men on idle days at such labor as they are competent to perform.

The night fireman, or watchman, in addition to his other duties, shall be responsible for the pumps within a distance of 250 feet from the main shaft bottom, and shall go into the mine when necessary to start them.

GENERAL.

SECTION VIII.

When the coal is paid for mine-run it shall be mined in as good condition as when paid for on a screened lump basis, and when loaded on the miner's car, it shall as nearly as possible be free from slate, bone coal, or other impurities, and if any miner shall load impurities in such quantities as to indicate knowledge and intent he shall be discharged. In case of dispute the impurities shall be kept until the case has been disposed of.

Wages shall be paid semi-monthly on or before the 10th and 25th of each month.

Day work shall be done on idle days, and in cases of emergency on overtime.

The time of beginning work in the morning and the length of intermission at noon shall be considered a local question which must be so arranged as to secure eight hours' work per day.

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. 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 shall be discharged.

It is agreed that if any differences arise between an employer or employee in or about the mines, an attempt shall be made to adjust the same by the person, or persons, affected with the company's representative in immediate charge. If they fail to agree the question shall be referred to the mine boss and mine committee. If they fail to agree it shall be referred to the mine superintendent and mine committee. If they fail to agree it shall be referred to the district officers of the U. M. W. of A. and officers of the Indiana Bituminous Coal Operators' Association. If they fail to agree it shall be referred to the executive committees of the two associations. Provided, that nothing in this clause shall prevent the district officers from taking up for adjustment any dispute with the officers of the company affected.

That pending negotiations the miners shall not cease work because of any dispute, and an agreement reached at any stage of the proceedings shall be binding on both parties thereto, and not subject to review or revision of any other party or branch of either association.

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.

No restriction shall be placed on the amount of coal which machines may mine, nor upon the number of places in which machines may cut, nor upon the number of loaders that may work after one machine, nor upon the amount of narrow work that any machine runner may be required to do, nor upon the number of cars that any miner may load in any specified time.

The operators shall have the privilege of working a night shift for cutting coal with machines. All men so employed shall be paid 28 cents extra for each eight hours' work at night, in addition to the scale price per ton.

Work on driving entries and drawing pillars may be by double shift at the option of the operator.

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.

All local rules in violation of this contract shall be null and void, and no local union nor group of local unions shall pass any rules in violation, neither shall any company enforce any rule in violation of this contract.

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.

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.

Men shall work double in wide entries at option of operator in developing the mine or for running entries for purpose of increasing production.

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.

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.

At all mines where coal companies deliver powder in the miner's working place such delivery shall be regarded only as an accommodation, and the company shall not be responsible for same after it leaves the magazine, but in the event of kegs being broken or powder being caked powder shall be replaced.

All local rules regarding the number of cars required above the tipple south of the Vandalia are hereby abolished, and in lieu of which it is agreed that the operators shall blow the whistle at eight o'clock in the evening when intending to work the following day, and again at five o'clock in the morning if cars are there or promised by the railroad company to be there by seven o'clock, or starting time.

If the company blows the whistle at five o'clock a. m. without the promise of cars and the miners report for work at 7 a. m. or starting time, and there are no cars the company shall pay to the local union a fine of $25.00

The U. M. W. of A. shall have no jurisdiction nor exercise any control over construction work, such as the erection of tipples or mine buildings, scales, machinery, or screening apparatus necessary to hoist and prepare coal.

Where dirt must be removed to prepare pillars the miner shall be paid as agreed upon by miner and mine boss, or company, to remove same.

Any employe absenting himself from work for three days without a reasonable excuse, or having notified the mine manager and obtained his consent, may be discharged.

All miners shall put down their points and last pair of rails in their working places, and shall nail one end of same, but are not expected to tie and permanently lay their road.

The chief electrician shall be exempted from control of mine committee or local union, but in case of any dispute between him and the company the district officers shall adjust the same with officers of company involved.

Where any company operate more than one mine on the same line of road and in the same vein of coal, the work between the respective mines shall be as nearly as business conditions will permit equally divided.

All machine men shall work on idle days at operators' option to make up time lost on previous working day.

Every miner shall be given an opportunity to load an equal turn with every other miner doing the same class of mining. Where pick and machine miners are working in the same mine the turn shall be in proportion to the ratio between pick mining prices and machine loading prices.

The check-weighman shall furnish the boss-driver or mine-boss from day to day a turn sheet, and he shall cause the turn to be regulated. Provided, further, that no run or entry in machine mines shall be permitted to get more than five cars in advance of another run or entry, and in pick mines not more than two cars, except in case of accident.

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.

It is agreed that when miners come out or stay out of the mine for the purpose of redressing a grievance, real or supposed, thus entirely or partially shutting down mine or mines contrary to agreement, each employe so ceasing or refraining from work shall be fined in the sum of one dollar per day during such shut-down. The fine thus assessed shall be deducted from each person so offending through the pay roll, and this agreement is the company's authority for making such deduction.

All money collected as fines shall be divided equally between District No. 11, U. M. W. of A., and the Indiana Bituminous Coal Operators' Association.

It is agreed that in the event of an inside employe being wrongfully discharged, and it is so discovered by methods herein provided, and by the same methods is reinstated, he shall be paid for time lost at the rate per day prevailing for inside day labor; provided, however, that the company shall have the option of permitting the accused to continue at work pending the investigation, and the same shall apply to outside day laborers, except the outside day labor scale shall be paid.

Except in case of fatal accidents in the mine the mine shall in no case be thrown idle because of any death or funeral; in the event of a fatal accident in the mine, the employes may discontinue work for the remainder of the day, but work at the option of the operator shall be resumed the day following and continue thereafter. Nothing herein shall be construed to prevent an employe from absenting himself from work to attend the funeral of a fellow employe or member of his family.

In consideration of the observance of the above rule, and the enforcement of same, it is agreed that the folowing schedule of death benefits shall be paid to all parties entitled to receive the same: For a man, $50.00; for an employe's wife, $50.00; for any member of the family over the age of fourteen years, excepting married children, $35.00; the company to pay one-half of the above amounts and the local union the remainder. Provided, however, that in the event of the mine being thrown idle on the day of any funeral by reason of an insufficient number of men reporting for work, then the company shall not be expected to pay any part of the amounts herein named.

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, 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.

Signed this 8th day of June, 1906:

In behalf of the Indiana Bituminous Coal Operators' Association:

J. C. KOLSEM, President.
P. H. PENNA, Secretary.

In behalf of Miners:

WELLINGTON O'CONNOR, President District 11, U. M. W. of A.
J. H. KENNEDY, Sec.-Treas. District 11, U. M. W. of A.

Attest:

W. B. WILSON, International Sec.-Treas. U. M. W. of A.
H. M. WOFERS.

CONTRACT.

PICK MINING SCALE FROM JUNE 11, 1906, TO APRIL 1, 1908.

BRAZIL BLOCK AGREEMENT.

1. Entered into this 11th day of June, 1906, between the operators' scale committee of the Brazil Block Coal District and the Executive Board of the United Mine Workers of America representing District No. 8.

PICK SCALE AND YARDAGE.

2. The price for mining screened block coal in the Block Coal District of Indiana shall be $1 per ton of two thousand pounds, it being understood also that the price for digging unscreened coal shall be an equivalent of the price paid for screened coal.

3. Further details in the scale price for pick mining in the Block Coal District shall be as follows:

4. The payment for low coal shall be upon the following scale:

5. For all coal two feet ten inches and under three feet one inch, $1.05 per ton.

6. For all coal under two feet ten inches, $1.10 per ton.

7. The price of yardage shall be as follows:

Single yardage for coal three feet one inch and over	$1 00
Double yardage for coal three feet one inch and over	2 00
Gob entries in coal three feet one inch and over	1 50
Gob entries in coal three feet one inch and over, without brushing	50
Single yardage for coal two feet ten inches and under three feet one inch	1 05
Double yardage for coal two feet ten inches and under three feet one inch	2 10
Gob entries in coal two feet ten inches and under three feet one inch	1 57½
Gob entries in coal two feet ten inches and under three feet one inch, without brushing	52½
Single yardage in coal below two feet ten inches	1 10
Double yardage in coal below two feet ten inches	2 20
Gob entries in coal below two feet ten inches	1 65
Gob entries in coal below two feet ten inches, without brushing	55

All entries to be driven when required by the operator 5½ in the clear in height, and the miners agree to gob the dirt when they are 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 Zellar-McClellan Company, and in these two mines the same conditions shall continue as were in force during the years just ended, viz.: The miners shall continue to gob the break-throughs. Twenty-five cents per yard shall be paid extra for all double yardage when the same is worked double shift, and 12½ cents per yard for all single yardage when the same is worked double shift. Work on driving entries and drawing pillars may be by double shift at the option of the operator.

DAY MEN'S SCALE.

8. Inside day scale:

Track layers	$2 56
Trappers	1 13
Bottom cagers	2 56
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 other outside day labor	2 02½

9. The fireman and night pumpers shall be paid at the rate of 25 3-10 cents per hour for their labor. The above wage is based on an eight-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 any emergency the firemen and night pumpers will not limit their time, but continue working until such emergency is passed.

10. The firemen and night pumpers shall be subject to the same rules and regulations as top men and be in their class, and may be laid off in case the mine shall work parts of days, and the work of firemen and top men shall be interchanged if it is found to be to the interest of the employer so to do. For example: Where work can be performed by one man the firing and any other work about the top shall be done by any one of the top men selected.

11. When the miner is working a deficient place and is being paid by the day, his pay shall be $2.56 per day, and if he uses his own tools during such time he shall be paid ten cents per day for the use of the same. The operator shall have the option of furnishing the tools for such work.

12. The price of blacksmithing shall be 1½ cents on the dollar.

13. The semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme Court of Indiana and of the United States.

14. A 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.

HOURS OF WORK.

16. The hours of beginning work in the morning shall be 7 a. m., with thirty minutes' stop for dinner, and begin shooting at 3:30 p. m., from April 1, 1906, to October 1, 1906, and from October 1, 1906, to April 1, 1907, the mines shall start at 7:30 a. m., with thirty minutes'

stop for dinner, and begin shooting at 4 p. m., and no shooting shall be done at any other time except by mutual consent between the bank boss and bank committee, and in the event that the mine is to work half day only it shall be the duty of the mine boss to notify the bank committee of the fact. The Officers' and Miners' Board of District No. 8 hereby agree and pledge themselves to see that the men in the mines carry out the contract by working eight hours per day, and that they will put in effect and maintain rules which will compel the men to be at their working places on time and remain at work until the expiration of eight hours.

17. Eight hours a day means eight hours in the mine at the usual working places for all classes of inside men. This shall be exclusive of the time required in reaching such 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.

SETTING LONG PROPS.

19. The miners working at Zellar-McClellan's No. 4 mine and the Indiana Block Coal Company's mine at Saline, shall set all the props in their rooms and shall set all the props along the roadway. When bottom is blasted for the road and long props are made necessary along the roadway the miners agree to set them. And the operators agree to pay therefor 3 cents each for all long props so set by them. The companies above named shall provide the props of required length.

20. 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.

21. The operators agree to give each miner as near as possible an equal turn of cars for coal, and not to allow any day hands to load coal on idle days, but in no case shall a turn apply to the handling of dirt, but the operators agree to put in the mines a sufficient number of mules to remove all the coal and dirt therefrom. It is agreed that nothing herein shall conflict with the gobbing of dirt as hereinbefore provided. The operators will give an equal turn of work to all inside day men as near as practicable, who are compentent, excepting track layers and timbermen, adjustment of turns to be semi-monthly.

22. 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. If by the absence or refusal to work of any day men work is likely to be interfered with, the mine committee, when called upon, shall assist the mine boss to furnish competent men in case he fails to secure them at the scale rate, so that the mines shall continue work.

23. 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.

24. Should the mine boss or superintendent at any mine discharge a miner or mine laborer, and upon investigation by the mine committee they believe there were not good and sufficient causes for so doing, they shall at once notify such boss or superintendent of their decision, and pending the matter being decided upon by the final board as provided in such cases the management may at their option retain in their employ such persons so discharged, pending the final decision. If said board finds that the man was discharged without sufficient cause he shall be reinstated and shall be paid his regular wages for all time lost by such discharge, but in days in which the mine was not in operation during this period shall not be reckoned as lost.

SETTLEMENT OF DIFFERENCES.

25. It is further agreed that if any differences arise between the operator or miners at any pit, settlement shall be arrived at without any stopping of work. If the parties immediately affected can not reach an adjustment between themselves the question shall be referred to the Executive Board of the United Mine Workers of America representing District No. 8 and an equal number of operators, whose action shall be final, but no operator or miner interested in the difference shall be a member of said committee. The Officers' and Miners' Board of District No. 8, United Mine Workers of America, hereby agree and pledge themselves to put in effect at the different locals of the district certain rules and regulations requiring men to be fined one dollar per day for the violation of the above clause, said fine to be checked off by the operators and turned over to District No. 8. On failure of said officers and board to accomplish their agreement to see that this part of the contract is observed, the following clause shall become effective, from that time on it shall be binding and have full force and be a part of this contract, viz.: It is understood and agreed that when any of the workmen in and about a mine stops the same for the purpose of redressing a grievance, real or supposed, thus shutting the mine down, contrary to this agreement, each employe shall pay to the owner of said mine the sum of $1 per day during such shut down. The payment shall be deducted from each person through the pay-roll, and this agreement is authority for making such deduction. It is further agreed that no coal company, because of any grievance with an employe, real or supposed, shall stop the mine, and any company so shutting down its mine shall pay to each workman in and about the mine $1 per day during such shut down.

26. 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, excepting the engineer working at such mine. In no case shall the mine committee have power to send day men home when needed by the operator, but the mine committee may bring any grievance before the joint board through their district officials.

DRIVERS' RULES.

27. 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 such cars at the point named, but when the men go into the mine in the morning they shall be entitled to two hours' pay whether or not the mine works the full two hours, and 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.

28. But under no circumstances will the operators recognize or treat with the mine committee or any representative of the United Mine Workers of America during the suspension of work contrary to this agreement.

29. The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be 72 feet superficial area, of uniform size, 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.

30. 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.

31. 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 such mine.

32. The Crawford Coal Company in their mines at Center Point may continue to do the brushing in the entries where the coal is three feet one inch and under in thickness.

33. The wages of the blacksmith shall be $2.85 per day at all the mines, and in addition to his ordinary duties he shall do any other labor, and shall work at any mine owned by the company when required of him by the mine management, providing that he shall receive his regular wages therefor.

34. All local rules regarding the number of cars required above the tipple to be abolished.

35. In the event of death by accident in the mine the miners shall have the privilege of discontinuing work for the remainder of that day, but at the option of the operators work shall be resumed the following day.

36. The miners shall not stop work on the day of a funeral, where death is the result of an accident in the mine or otherwise, but instead men may absent themselves from work for the purpose of attending the funeral, and except in case of fatal accidents as above the mine shall not in any case be thrown idle because of any death or funeral.

FUNERAL BENEFITS.

37. In consideration of the enforcement of this agreement referring to funerals of employes only, of any particular mine, and not otherwise, the operators agree to pay to the family of the deceased, or legal representative thereof, the sum of twenty-five cents per man for all men employed at the mine, but in no case shall the operators pay more than $25. The miners also agree to give to said family twenty-five cents per man.

HOISTING ENGINEERS' SCALE.

38. On and after June 11, 1906, until April 1, 1908, 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, and 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.

39. 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.

40. 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 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 of the boilers on Sunday.

41. It is fully understood and agreed upon the part of the United Mine Workers of America that the engineers will not under any circumstances allow affiliation with any 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 organization; and further, that they will during the continuance of this contract at all times fully protect all the company's property under their care, and that they will operate fans and pumps, and lower and hoist such men or supplies as may be required to protect the company's property, and any and all coal that may be required to keep up the steam at the company's plant.

But it is understood that the operators will not ask them during this period to hoist any coal produced by non-union labor for sale on the market.

42. No engineer shall lay off or exchange shifts without the consent of the operators.

43. 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.

44. It is further agreed no hoisting engineer shall be subject to the interference or dictation of the mine committee, nor the local unions, but all differences between the engineer and his employer shall be adjusted by the officers of the United Mine Workers of America and employer interested.

45. 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.

46. This contract is entered into in good faith by both parties, and there is to be no deviation from it by the operators, miners, laborers or any local union.

Committee on behalf of the Operators for the Block Coal District:

JAS. H. McCLELLAND.
W. M. ZELLAR.
W. W. RISHER.
W. E. EPPERT.
JOHN CHESTERFIELD, JR.
E. F. McGRANAHAN.
H. W. JENKINS.
HUGH MASON.

Executive Committee District No. 8, United Mine Workers of America, for Block Coal Miners:

WILLIAM WILSON.
PATRICK GOLDEN.
HUGH KIRKLAND.
JAMES SHIEL.
JOHN FOGG.

CONTRACT.

Machine Mining Scale from June 11, 1906, to April 1, 1908,

MACHINE MINING SCALE.

Contract between the Machine Operators of the Block Coal District and the Executive Board of District No. 8, United Mine Workers of America, governing prices and conditions of mining in Machine Mines Block Coal District.

Entered into this 11th day of June, 1906, and continuing until April 1, 1908, between the Operators of Machine Mines of the Block Coal District and the Executive Board of the United Mine Workers of America, representing District No. 8.

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 feet wide, fifty-three and one-half (53½) cents per yard.

Price for entry driving, 9 to 12 feet wide, thirty-two and one-half (32½) cents per yard.

The loaders agree to keep the bug dust and draw slate back 14 feet from the working face.

All entries more than twelve 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, \$3.03¾.

Entry driving, 6 to 9 feet wide, machine runner to be paid 25 cents per yard.

Entry driving, 9 to 12 feet 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 the same.

2. That two men shall have the right to three places where they can take care of the 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 the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold bars in proper position.

This agreement to become a part of the agreement entered into the 11th day of June, 1906, 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:

JAS. H. McCLELLAND.
JOHN CHESTERFIELD.
E. F. McGRANAHAN.

On behalf of the Executive Board District No. 8, United Mine Workers of America:

WILLIAM WILSON.
PATRICK GOLDEN.
HUGH KIRKLAND.
JAMES SHIEL.
JOHN FOGG.

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Brazil Block No. 1	4	7	17	20	6	54	185	10	203
Brazil Block No. 4	98	.....	.....	20	10	128	178	6	2,843
Brazil Block No. 7	52	.....	.....	8	6	66	182	3	958
Brazil Block No. 8	24	.....	.....	9	3	36	168	3	655
Rebstock	47	.....	.....	11	5	63	164	2	1,181
Vandalia No. 50	41	.....	.....	11	5	57	148	4	1,664
Vandalia No. 60	94	.....	.....	22	10	126	70	6	2,394
Vandalia No. 63	55	.....	.....	17	7	79	132	6	1,287
Vandalia No. 64	26	.....	.....	6	6	38	68	3	282
Vandalia No. 65	161	.....	.....	30	15	206	160	11	5,146
Superior No. 4	65	.....	.....	18	6	89	216	5	2,654
Superior No. 7	21	.....	.....	11	3	35	55	4	227
Crawford No. 4	24	.....	.....	9	4	37	113	3	460
Crawford No. 2	25	.....	.....	10	5	40	86	2	530
Crawford No. 6	97	.....	.....	20	7	124	180	9	4,639
Crawford No. 8	27	.....	.....	5	4	36	125	2	658
Crawford No. 9	68	.....	.....	13	6	87	223	5	3,045
Fortner	18	.....	.....	5	3	26	153	3	550
Gifford No. 1	7	4	16	8	5	40	70	3	517
Gifford No. 2	29	8	34	29	9	109	191	8	1,885
Glenn No. 1	34	.....	.....	10	5	49	170	4	1,206
Plymouth No. 2	32	.....	.....	4	5	41	184	2	1,623
Monarch	12	.....	.....	10	2	24	296	3	908
Lewis	22	20	63	20	10	135	154	8	1,759
Vivian No. 1	14	.....	.....	5	12	31	125	2	741
Vivian No. 2	.....	16	55	30	12	113	104	7	661
Lower Vein No. 1	22	.....	.....	9	4	35	103	2	396
Gold Knob	33	12	16	12	11	84	137	4	1,666
Worlds Fair No. 2	25	.....	.....	6	4	35	199	2	280
Island Valley No. 4	.....	14	70	14	10	108	83	8	573
Harrison No. 4 (Idle)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Eureka No. 5	63	.....	.....	14	7	84	191	4	2,904
Treager	12	.....	.....	2	1	15	238	1	760
Stunkard	14	.....	.....	4	2	20	241	2	794
Klondyke No. 2	50	.....	.....	11	5	66	210	4	2,335
Crawford No. 2 (Idle)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Progressive (Idle)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	1,316	81	271	433	215	2,316	5,522	154	49,021

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.	Powder.
Stucky	8	.....	.....	1	2	11	121	.....	.....
Montgomery No. 3	47	.....	.....	12	9	68	216	8	1,896
Mutual	64	.....	.....	16	9	89	134	8	1,220
Mandabach	10	.....	.....	1	2	13	121	1	106
Winklepeck (Idle)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Overton (Idle)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	129	.....	.....	30	22	181	592	17	3,222

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

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.	Powder.
Indio	70	......	......	16	8	76	264	6	2,988
Silverwood	19	......	......	8	6	29	273	2	1,322
Total	89	......	......	24	14	127	537	8	4,310

GREENE 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.	Powder.
Black Creek	55	10	37	28	10	140	129	14	1,886
Sponsler	75	......	......	14	6	95	111	10	1,952
Glenburn	70	6	22	35	9	142	129	12	2,392
Antioch	52	......	......	22	8	82	160	12	3,032
Vandalia No. 2	75	10	50	35	15	185	129	14	3,931
North Linton	42	......	......	13	5	60	150	7	2,594
Vandalia No. 3	132	......	......	19	8	159	165	15	4,190
Vandalia No. 4	80	......	......	21	8	109	120	7	2,166
Vandalia No. 5	78	16	33	52	12	191	167	20	2,779
Vandalia No. 6	33	......	......	10	5	48	61	6	411
Vandalia No. 8	16	18	100	35	10	179	169	13	1,424
Vanadlia No. 9	14	8	44	18	7	91	192	10	1,480
Vandalia No. 21	......	22	53	11	10	96	128	4	631
Gilmour	20	16	83	55	17	191	122	25	1,749
Hoosier No. 1	14	8	25	17	8	72	67	3	640
Hoosier No. 2 (Idle)	......	......	......	......	......	......	......	......	......
Midland	......	12	52	27	11	102	18	9	336
Tower Hill	120	......	......	29	13	162	174	10	4,838
Lattas Creek	45	20	103	83	20	271	187	26	2,784
Vulcan	35	......	......	5	8	48	75	4	698
Summit No. 2	24	18	80	45	12	179	171	21	1,729
Victoria	80	......	......	24	9	113	224	12	4,282
Green Valley	......	16	84	30	11	141	106	12	1,002
Queen	30	......	......	8	3	41	240	4	1,298
Letsinger	45	......	......	10	8	63	150	4	2,462
North West	47	10	49	39	12	157	219	12	2,046
Twin No. 4	......	8	31	17	7	63	127	5	367
Twin No. 5	5	22	81	22	10	140	147	10	1,372
Midvale	57	......	......	11	7	75	131	5	1,851
Total	1,244	220	927	735	269	3,395	3,968	306	56,382

GIBSON 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.	Powder.
Oswald	70	......	......	23	10	75	214	9	2,787
Massey (Not reported)	......	......	......	......	......	......	......	......	1,016
Fort Branch	19	......	......	5	6	29	40	10	156
Total	89	......	......	28	16	104	254	19	3,959

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.	Powder.
Bicknell	55	......	......	14	9	78	121	9	4,153
Knox	56	4	14	12	8	94	112	6	1,330
Lynn	8	4	17	10	9	48	194	5	962
Prospect Hill	18	......	......	7	6	31	268	3	979
Vandalia No. 40	36	......	......	16	6	58	120	4	1,344
Wheatland	71	......	......	13	8	92	198	7	3,585
Pine Knot	50	12	28	15	11	116	157	6	1,042
Freeman	......	6	20	12	8	46	93	2	371
Total	294	26	79	104	65	563	1,263	42	13,766

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

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.	Powder.
Brazil Block No. 9	93	......	......	33	7	133	160	12	2,746
Brazil Block No. 12	49	......	......	14	4	67	168	6	1,454
Mecca No. 3	70	4	28	35	9	146	173	17	3,129
Lyford No. 1	53	......	......	11	8	72	144	3	2,514
Mary	8	16	45	37	11	117	230	10	426
Superior No. 1	81	......	......	22	6	109	227	10	2,121
Superior No. 2	61	......	......	19	7	87	202	10	2,230
Superior No. 3	71	......	......	13	5	89	195	6	3,316
Vandalia No. 316	67	......	......	35	14	116	134	14	2,289
Vandalia No. 317	70	......	......	21	8	99	197	8	2,618
Pan American	48	......	......	7	8	63	58	4	298
Parke No. 11	15	30	60	32	12	149	259	10	2,281
Harrison (Not reported)	......	......	......	......	......	......	......	......	......
Superior No. 5	36	......	......	10	3	49	72	3	784
Clay County (Not reported)	......	......	......	......	......	......	......	......	......
Bridgeton No. 1 (Not reported)	......	......	......	......	......	......	......	......	......
Parke No. 10	93	20	23	47	16	199	210	15	3,996
Total	815	70	156	336	118	1,495	2,429	128	30,202

PERRY 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.	Powder.
Troy	10	......	......	3	2	15	287	2	242
Total	10	......	......	3	2	15	287	2	242

PIKE 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.	Powder.
Aberdeen (Idle)	......	......	......	......	......	......	......	......	......
Carbon	33	......	......	14	6	53	298	6	154
Ayrshire No. 3 (Not reported)	......	......	......	......	......	......	......	......	2,424
Ayrshire No. 4 (Not reported)	......	......	......	......	......	......	......	......	7,267
Ayrshire No. 5 (Not reported)	......	......	......	......	......	......	......	......	658
Rogers (Not reported)	......	......	......	......	......	......	......	......	200
Blackburn	39	......	......	7	6	52	178	5	1,493
Littles	142	......	......	31	13	186	144	14	4,867
Hartwell	108	......	......	26	12	146	119	12	4,196
Petersburg (Idle)	......	......	......	......	......	......	......	......	......
Winslow No. 4 (Idle)	......	......	......	......	......	......	......	......	......
Winslow No. 5 (Idle)	......	......	......	......	......	......	......	......	......
Hartwell No. 2	50	......	......	6	3	59	90	......	434
Total	372	......	......	84	40	496	829	37	21,693

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

SULLIVAN 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.	Powder.
Caladonia	......	12	53	15	10	90	127	6	937
Phœnix No. 4	......	14	73	29	19	135	122	9	1,500
Cummins	25	......	......	9	5	39	38	3	40
Hocking	5	18	85	48	20	176	115	16	1,595
Citizens	......	19	41	21	13	94	142	7	1,006
Sun Flower	......	16	90	29	13	148	141	13	1,181
Consolidated No. 25	4	10	37	18	10	79	90	5	394
Consolidated No. 26	......	12	60	27	16	115	131	8	881
Consolidated No. 28	......	8	30	24	10	72	70	5	223
Consolidated No. 29	......	14	77	42	18	151	70	12	347
Consolidated No. 30	......	10	46	55	9	120	129	5	683
Consolidated No. 31	40	......	......	12	4	56	45	6	519
Consolidated No. 32	5	22	114	41	10	192	80	11	303
Consolidated No. 33	5	20	102	37	15	179	150	10	2,752
Consolidated No. 34	......	14	74	23	13	124	130	7	1,090
Vandalia No. 10	96	......	......	22	14	132	136	8	4,789
Vandalia No. 30 (Idle)	......	......	......	......	......	......	......	......	......
West Linton (Idle)	......	......	......	......	......	......	......	......	......
Jackson Hill No. 2	......	18	108	35	16	177	175	15	1,354
Jackson Hill No. 4	......	16	87	24	13	140	179	9	1,018
Keystone	5	8	12	4	7	36	139	11	1,223
Freeman	43	......	......	10	7	60	193	5	2,000
Dering No. 12	68	......	......	31	11	110	86	10	1,881
Dering No. 13	5	14	66	28	12	125	192	10	1,367
Dering No. 14	2	16	100	54	29	201	193	20	1,555
Semi Block (Idle)	......	......	......	......	......	......	......	......	......
Mammoth Vein	2	15	81	35	16	149	160	10	1,123
Shirley Hill No. 1	30	12	40	22	10	114	136	9	2,870
Little Giant	70	18	90	81	17	276	135	12	3,669
Shirley Hill No. 2	4	10	26	20	9	69	145	3	547
Superior	130	......	......	33	10	173	160	11	4,640
Pearl	16	8	50	20	10	104	169	6	944
Reliance	4	8	48	34	12	106	206	7	593
Hamilton	10	14	18	15	9	66	90	3	508
Black Hawk	28	6	14	6	4	58	95	3	777
Clover Leaf	......	8	44	28	9	89	100	6	760
Washington	24	8	43	30	11	116	70	10	551
Total	621	368	1,709	962	411	4,071	4,339	291	45,620

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.	Powder.
Diamond	66	......	......	15	14	95	241	6	1,738
Ingleside	52	......	......	12	11	75	258	6	1,908
Sunnyside	68	......	......	13	11	92	254	10	2,358
Union (Idle)	......	......	......	......	......	......	......	......	......
Unity	130	......	......	35	15	180	299	17	7,365
First Avenue	50	......	......	10	10	70	297	4	1,862
Total	366	......	......	85	61	512	1,349	43	15,231

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

VERMILLION 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.	Powder.
Dering No. 5	140			46	12	198	202	12	9,105
Dering No. 6	227			50	15	292	214	16	12,332
Dering No. 7	205			46	15	266	212	21	11,329
Dering No. 8	200			45	16	261	208	9	8,667
Dering No. 15	125			30	12	167	170	9	4,338
Eureka No. 1	20			6	3	29	220	5	828
Crown Hill No. 1	200			45	12	257	160	17	7,768
Oak Hill	145			40	11	196	190	12	10,600
Maple Valley No. 1	150			45	11	206	160	12	10,531
Buckeye No. 2	215			38	10	263	200	14	12,866
Prince	135			43	10	188	180	12	7,340
Crown Hill No. 3 (Idle)									
Crown Hill No. 2	150			36	8	194	185	9	12,967
Total	1,912			470	135	2,517	2,301	148	108,671

VIGO 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.	Powder.
Atherton	4	10	62	30	8	106	190	7	933
Chicago No. 6 (Idle)									
Diamond	86			34	12	132	70	14	1,009
Victor	73			9	8	90	155	5	1,255
Lawton	216			35	15	266	250	22	7,344
Grant No. 2	110			47	12	169	200	18	4,370
Dering No. 9 (Idle)									
Dering No. 10 (Idle)									
Vandalia No. 66	100			30	15	145	200	10	3,752
Vandalia No. 67	220			40	11	271	230	18	5,602
Vandalia No. 68	56			12	5	73	150	5	1,981
Vandalia No. 69	23			9	6	38	200	2	1,984
Vandalia No. 80	59			25	6	90	70	6	762
Vandalia No. 81	72			14	12	98		8	2,987
Vandalia No. 82	30	12	12	10	6	71	70	4	789
Miami No. 1	140			28	10	178	220	18	5,162
Miami No. 2	123			21	8	152	170	13	4,712
Miami No. 3	165			45	9	219	105	12	4,093
Fauvre No. 1	56			12	4	72	200	8	1,293
Larimer	10			3	2	15	60	2	365
Deep Vein	130			27	10	167	250	12	5,921
Ray No. 2	235	10	15	40	10	310	200	14	7,093
Forrest	20	16	52	24	13	146	170	15	1,959
Domestic Block No. 1	22	10	47	32	18	129	160	6	1,062
Sugar Valley (Idle)									
Fauvre No. 2	10			4	5	19	60	1	93
Lower Vein	37			10	6	53	220	3	137
Total	1,997	58	188	541	211	3,009	3,810	238	69,154

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.	Powder.
Air Line (Idle)									
Big Four		12	40	16	10	78	200	9	940
Big Vein No. 3	8	10	26	10	8	62	220	6	893
Castle Garden	15			4	4	28	85	5	241
DeForrest	19	4	14	4	2	43	180	2	357
Star No. 1	10			2	2	19	65		505
Electric		12	40	16	10	78	175		
Burke (Idle)									
Dawson		6	11	5	2	24	37	3	82
Erie Canal		6	28	14	7	55	100	4	316
Chandler	37	6	22	14	6	85	90	5	641
Total	89	56	181	85	51	462	1,152	34	3,975

TABLE

Showing by Counties the Number of Miners, the Number of Inside Day and Monthly Men, Number of Outside Day and Monthly Men, Wages Earned by Same and the Average Wages Per Employe in the Block and Bituminous Coal Mines, Each Exhibited Separately, as are the Hand and Machine Mines.

BLOCK COAL MACHINE MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number Inside Employes.	Total Wages.	Average Wages.	Number Outside Employes.	Total Wages.	Average Wages.
Clay	28	$14,895 95	$514 14	20	$13,501 90	675 10	6	$6,777 95	$1,129 66
Parke	69	31,578 82	457 66	37	18,548 09	501 30	11	5,875 96	531 45
Vigo	79	39,408 48	498,84	32	9,515 79	297 37	18	6,193 11	344 06
Total General average	176	$85,883 25	$487 97	89	$41,565 78	$467 03	35	$18,847 02	$538 49

BLOCK COAL PICK MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number Inside Employes.	Total Wages.	Average Wages.	Number Outside Employes.	Total Wages.	Average Wages.
Clay	762	$350,209 56	$455 05	193	$123,501 69	$636 52	89	$60,660 01	$690 45
Parke	439	189,448 10	571 18	118	60,518 92	512 87	40	30,218 78	755 44
Vigo	37	8,607 53	232 64	10	3,326 10	332 61	6	1,762 97	293 83
General Average	1,238	$548,265 19	$484 85	321	$187,346 71	$440 54	135	$92,641 76	$674 45
Total General average Block Employes	1,414	$634,148 44	$484 17	410	$228,912 49	$445 13	170	$111,488 78	$646 46

BITUMINOUS COAL MACHINE MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number Inside Employes.	Total Wages.	Average Wages.	Number Outside Employes.	Total Wages.	Average Wages.
Clay	419	$185,191 21	$441 98	113	$66,779 11	$590 97	57	$35,270 51	$618 78
Greene	1,610	816,068 60	506 87	549	304,931 47	555 43	181	123,469 09	682 15
Knox	219	66,682 82	304 49	49	36,482 03	744 53	36	20,451 43	568 10
Parke	392	213,508 44	544 66	114	72,979 40	640 17	37	27,023 84	730 37
Sullivan	2,296	1,109,991 43	483,45	845	414,813 30	479,07	360	222,508 39	618 07
Vigo	478	195,085 66	408 12	104	59,245 70	569 67	37	21,831 04	590 03
Warrick	301	132,209 49	439,23	79	42,986 13	544 13	45	19,621 16	436 02
General average	5,715	$2,718,737 65	$475 72	1,853	$998,217 14	$538 70	753	$470,175 46	$624 40

BITUMINOUS COAL PICK MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number Inside Employes.	Total Wages.	Average Wages.	Number Outside Employes.	Total Wages.	Average Wages.
Clay	459	$226,731 46	$493 96	107	$65,207 37	$609 41	63	$30,942 23	$491 14
Daviess	129	48,469 30	375 73	30	14,117 23	470 57	22	8,474 63	385 21
Fountain	89	51,524 93	578 93	24	15,518 71	646 61	14	8,187 02	584 79
Gibson	89	58,499 97	537 50	28	16,810 00	600 36	16	10,397 20	649 85
Greene	781	431,915 96	553 03	186	108,965 80	585 84	88	55,637 22	632 24
Knox	180	103,024 98	572 36	50	28,502 42	570 05	29	17,477 66	602 67
Parke	190	112,119 51	590 10	67	34,798 46	519 38	30	14,725 17	490 84
Perry	10	5,106 68	510 67	3	1,753 63	584 54	2	1,323 35	661 68
Pike	372	270,212 81	365 65	84	80,517 31	466 61	40	33,814 74	402 04
Sullivan	402	181,122 64	450 55	117	60,515 45	517 23	51	22,875 14	448 53
Vanderburgh	366	195,384 31	533 83	85	58,244 05	685 34	61	37,269 48	610 97
Vermillion	1,912	955,765 46	499 87	470	266,147 88	566 27	135	77,724 93	575 74
Vigo	1,884	767,141 25	407 18	395	235,881 39	597 16	150	85,550 43	570 33
Warrick	25	8,914 32	356 57	6	2,496 73	416 12	6	1,552 21	258 70
General average bituminous pick employes	6,888	$3,415,933 58	$495 92	1,652	$989,476 43	$598 96	707	$405,951 41	$574 18
General average bituminous machine and pick employes combined	12,603	$6,134,671 23	$486 76	3,505	$1,987,693 57	$567 10	1,460	$876,126 87	$600 09
General average bituminous and block employes combined	14,017	$6,768,819 67	$482 90	3,915	$2,216,606 06	$566 18	1,630	$282,078 28	$605 90
Grand total average of all employes	19,562	$9,973,041 38	$509 82						

TABLE

Exhibiting a Comparative Statement of Total Tons of Coal Produced, Total Number of Employes, Total Wages Paid and Per Cent. Gain or Loss in Number of Employes, Tons of Coal Produced and Wages Paid in the Block Coal Mines for Each Year from 1901 *to* 1906, *inclusive.*

YEAR.	Employes.	Per Cent. Gain.	Per Cent. Loss.	Tons Produced.	Per Cent. Gain.	Per Cent. Loss.	Wages Paid.	Per Cent. Gain.	Per Cent. Loss.
1901 and 1900	2,742	34	....	1,090,522	....	27.8	$1,228,372 72	....	.035
1902........	2,452	....	10.5	1,162,764	7	....	1,356,098 45	10.4	....
1903........	2,293	....	.06	1,025,940	....	11.7	1,402,935 99	.034	....
1904........	2,128	....	.071	727,062	....	29.1	1,085,056 33	....	29—
1905........	1,966	....	.076	658,735	....	.095	917,501 22	....	18.2
1906........	1,994	.014	....	746,670	13.3	....	974,549 71	.062	....
Loss, 1906, under 1901	....	....	27.2	....	....	31—	....	....	20.6

TABLE

Showing a Comparative Statement of Total Number of Employes, Total Tons Coal Produced, Total Wages Paid, Per Cent. Gain or Loss in Number of Employes in the Bituminous Mines of the State from 1901 *to* 1906, *Inclusive.*

YEAR.	Employes.	Per Cent. Gain.	Per Cent. Loss.	Tons Produced.	Per Cent. Gain.	Per Cent. Loss.	Wages Paid.	Per Cent. Gain.	Per Cent. Loss.
1901........	9,354	19	....	5,928,681	24	....	$4,452,167 14	.35	....
1902........	10,687	14.8	....	7,600,433	18	....	5,722,814 67	.29	....
1903........	12,835	.20	....	8,966,613	17—	....	7,746,636 13	.37	....
1904........	15,710	22—	....	9,145,332	.02	....	8,080,348 05	.43	....
1905........	16,643	.59	....	10,337,237	.13	....	8,436,393 43	.044	....
1906........	17,568	.055	....	10,675,357	.032—	....	8,998,491 67	.066	....
1906 over 1901.....	....	87—	....	....	80—	....	....	.102	....

TABLE

Showing by Counties the Number of Tons of Coal Mined, the Number Kegs of Powder Used, the Average Number of Tons Produced Per Keg in the Block Coal Mines of the State, both Pick and Machine Exhibited Separately. Also a General Average of Tons Produced Per Keg in Both Pick and Machine Mines Combined.

BLOCK COAL MACHINE MINES.

COUNTY.	Tons Produced.	Kegs of Powder.	Tons per Keg.
Clay	20,599	203	101.4
Parke	51,459	426	120.8
Vigo	32,885	1,062	31
General average	114,869	1,691	67--

BLOCK COAL PICK MINES.

COUNTY.	Tons Produced.	Kegs of Powder.	Tons per Keg.
Clay	418,242	27,599	15.2
Parke	212,551	12,949	16.4
Vigo	10,934	637	17.2
General average	631,801	41,185	15.3
Total average for all block mines	746,670	42,876	17.4

TABLE

Showing by Counties the Number of Tons of Coal Mined, the Number of Kegs of Powder Used, the Average Number of Tons Produced Per Keg in the Bituminous Pick Mines of the State, and a General Average of Tons Produced Per Keg in All of the Bituminous Pick Mines Combined.

BITUMINOUS PICK MINES.

COUNTY.	Tons Produced.	Kegs of Powder.	Tons per Keg.
Clay	370 006	13,608	27.2
Daveiss	63,611	3,222	19.7
Fountain	78,135	4,310	18.1
Gibson	93,853	3,959	23.7
Greene	695,009	29,774	23.3
Knox	172,207	10,061	17.1
Parke	170,086	7,635	22.3
Perry	7,644	242	31.6
Pike	465,287	21,694	21.4
Sullivan	297,382	13,569	21.9
Vanderburgh	304,080	15,231	19.9
Vermillion	1,632,986	108,671	15
Vigo	1,258,849	54,197	23.2
Warrick	14,695	746	19.7
General average	5,623,830	286,919	19.6

TABLE

Showing by Counties the Number of Tons of Coal Mined, the Number of Kegs of Powder Used, the Average Number of Tons Produced Per Keg in the Bituminous Machine Mines, and a General Average of Tons Produced Per Keg in all of the Bituminous Mines in the State. Also a Total General Average of Tons Produced Per Keg in the Bituminous Pick and Machine Mines Combined, and a Total General Average of Tons Produced Per Keg in all of the Block and Bituminous Mines Taken as a Whole.

BITUMINOUS MACHINE MINES.

COUNTY.	Tons Produced.	Kegs of Powder.	Tons per Keg.
Clay	364,833	7,061	51.6
Greene	1,495,254	26,548	56.3
Knox	140,774	3,705	38
Parke	392,527	9,406	41.7
Sullivan	2,028,711	32,051	63.3
Vigo	328,507	13,737	23.9
Warrick	300,921	4,722	63.7
General average	5,051,527	97,230	51.9
Total general average bituminous pick and machine	10,675,357	384,149	27.9
Total general average of entire State production	11,422,027	427,025	26.8

TABLE

Showing by Counties the Number of Kegs of Powder Per Miner Used in the Mines of Indiana During the Year 1906.

COUNTY.	Number of Mines.	Total Kegs of Powder.	Kegs Per Employe.
Clay	1,587	48,471	30.5—
Daviess	129	3,222	25.4
Fountain	89	4,310	44—
Greene	2,171	56,322	26—
Knox	373	13,766	36.9
Parke	971	30,416	31.3
Perry	10	242	24.2
Pike	372	21,694	58.3
Sullivan	2,330	45,620	19.5
Vanderburgh	366	15,231	41.3
Vermillion	1,912	108,671	52—
Vigo	2,185	69,633	32—
Warrick	270	5,468	20.2
Total	12,854	427,025	33.2

NOTE.—Pick Miners and Loaders are the only employes who use powder in mining coal and are both included in the above table.

NEW MINES.

Thirteen new mines, three of which are block coal and ten bituminous, were opened and developed during the year 1906, distributed in the different counties as follows:

Clay County, one block coal hand mine; Knox County, one bituminous electric machine mine; Parke County, one block and one bituminous hand mine; Pike County, one bituminous hand mine; Vigo County, one block and four bituminous, all of which are hand mines; Warrick County, three bituminous mines, two of which are electric machine and one a hand mine. The bituminous mines above noted, with two exceptions, are each exceptionally well equipped with the latest up-to-date machinery and will be capable of producing a large output of coal.

We exhibit in the following table the names of these new mines and the names of the companies owning them, geological number of coal seam mined, thickness of seam in feet and inches, depth and size of hoisting shaft, character of coal, i. e.: whether block or bituminous, whether hand or machine mined, date of first shipment of coal, location of mine as to county and nearest town or city and the railroad on which the mine is located.

TABLE OF NEW MINES.

CLAY COUNTY.

NAME OF COMPANY.	MINE.								Location of Mine.	Railroad.
Chicago Ind. Block Coal Co.....	Harrison No. 4..	III	4′9″	Block..	60	8x16	Pick.....	9- 1-06	Three miles east of Clay City.....	E. & I.
KNOX COUNTY.										
Knox Coal Company..........	Knox.........	V	7′	Bitum..	....	....	Pick.....	9- 1-06	¾ mile West of Bicknell	I. V. br. Vandalia.
PARKE COUNTY.										
Bridgeton Mining Co..........	Bridgeton No. 1.	IV	2′6″	Bitum..	....	Slope..	Pick.....	12- 1-06	One mile No. Bridgeton..........	C. & I.
Zellar-McClellan Co...........	Superior No. 5..	III	3′6″	Block..	145	8x21	Pick.....	9-21-06	Two miles N. E. Diamond........	C. & E. I.
PIKE COUNTY.										
Patoka Valley Coal Co..........	Hartwell No. 2..	V	5′	Bitum..	Slope	....	Pick.....	7- 1-06	Hartwell......................	Branch Southern.
VIGO COUNTY.										
Coal Bluff Mining Co...........	Plymouth No. 1.	III	3′10″	Block..	215	8′6″x20	Pick.....	6- 1-06	½ mile East Fontanet...........	C. C. C. & St. L.
Coal Bluff Mining Co...........	Victor.........	VI	6′6″	Bitum..	50	8′6″x19	Pick.....	9- 4-06	½ mile West Coal Bluff...........	C. C. C. & St. L.
Coal Bluff Mining Co...........	Wabash.........	IV	5′6″	Bitum..	300	8x18	Pick.....	None shipped	2½ miles N. W. Terre Haute.......	C. C. C. & St. L.
Fauvre Coal Co................	Fauvre No. 2...	V	4′6″	Bitum..	228	9x16	Pick.....	10- 1-06	West Terre Haute...............	Vandalia.
Sugar Valley Coal Co...........	Sugar Valley....	V	4′6″	Bitum..	185	7x14	Pick.....	1- 1-06	One mile West of W. Terre Haute.	Vandalia.
WARRICK COUNTY.										
Erie Canal Coal Company.......	Erie Canal......	V	5′	Bitum..	130	....	Machine..	8- 1-06	½ mile West of Chandler.........	Southern.
Chandler Coal Company........	Chandler.......	V	....	Bitum..	....	....	Machine..	9- -06	¼ mile West of Chandler.........	Southern.
Castle Garden Coal Co.........	Castle Garden...	V	4′	Bitum..	96	8′6″x18	Pick.....	9- 1-06	2 miles West of Chandler	Evansville br. Southern

IMPROVEMENTS.

The folowing sums of money were reported to this office during the year 1906 as having been expended in improvements of different kinds of mines in the counties throughout the State as follows:

Clay County $6,167.00. Daviess County $840.00. Fountain County $120.00. Greene County $15,331.19. Knox County $21,629.78. Parke County $3,339.18. Pike County $2,457.00. Sullivan County $41,218.00. Vanderburg County $4,886.00. Vermillion County $16,345.00. Vigo County $11,982.99. Warrick County $1,253.00, making a total of $125,569.14.

We give herewith some of the more important improvements made during the year. The Big Vein Coal Company of Terre Haute have installed new boilers, pumps, etc., at a cost of $2,935.00 at their Lewis Mine in Clay County. The Jasonville Coal Company, Clay County, expended $2,769.77 on numerous improvements in their Gold Knob Mine. The Southern Indiana Coal Company reports an expenditiure of $3,346.00 on improvements at their Midland Mine in Greene County. They do not report the nature of improvements made and as the mine has been idle since April 1, no inspections have been made and we have been unable to ascertain just what improvements were made. The Queen Coal Company, Greene County, sunk and equipped with a stairway the manway or escape shaft at their Fry Mine during the summer, the cost of which was $2,402.00. The Midvale Coal Company, Greene County, have expended $3,500 in sinking and equipping a second outlet at their Pennsylvania Mine. The Indiana Fairmont Coal Company, Greene County, have expended $980.00 improving their haulage roads and numerous other small improvements. The Knox Coal Company have sunk a second outlet, installed an electric plant and overhauled their tipple, making it almost entirely new at a cost of $20,000.00. This mine was sunk to the lower seam No. V. during the summer months and within a short time will rank among the largest producers in the State. The Big Muddy Coal Company expended $839.00 completing their manway and various other improvements in their Pine Knot Mine. The Patoka Valley Coal Company, Pike County, have extended their motor haulage road, installed new pumping machinery and made other important changes in their Hartwell Mine at a cost of $2,457.00, thereby increasing the capacity of the mine.

The Consolidated Indiana Coal Company report $14,186 having been expended on improvements in their Sullivan County Mines as follows: No. 25, $1,693.00; No. 26, $1,734.00; No. 28, $2,246.00; No. 29, $255.00; No. 32, $2,543.00; No. 33, $1,746.00; No. 34, $3,-419.00. In reporting the above amounts no statement was made as to the nature of improvements.

The Peabody-Alwart Coal Company of Chicago, Illinois, during the strike in April and May expended $2,378.00 improving the roadways, timbering, etc., in their Reliance Mine, Sullivan County.

The Diamond Coal and Mining Company, Chicago, Illinois, completed the manway and made other extensive improvements at their Hamilton Mine, Sullivan County, expending $7,669.00

The D. Ingle Coal Company, Vanderburgh County, remodeled the head frame and tipple at their Ingle Mine in Evansville during the summer at a cost of $1,851.32.

The Diamond Coal Company, also of Evansville, report $3,035.00 as having been spent on improvements in their Diamond Mine but do not report the nature of improvements.

The Dering Coal Company report an expenditure of $5,415.00 as having been spent on improvements in their Vermillion County mines Nos. 5, 6, 7, 8, 9 and 15.

The Clinton Coal Company have installed a box car loader and one new boiler at their Crown Hill No. 1 Mine at a cost of $1,-130.50. They have also made extensive improvements at their No. 2 Mine amounting to $2,340.00.

The Charles F. Keeler Coal Company of Chicago, Illinois, have installed new boilers and made other improvements in their Atherton Mine in Vigo County at a cost of $1,615.00.

The Deep Vein Coal Company, Vigo County, have completed the sinking of the manway at their Deep Vein Mine, also made other improvements, expending $2,807.00.

The Domestic Block Coal Company, Vigo County, extended their mine switch and completed the manway at their Domestic Block No. 1 Mine at a cost of $1,000.00.

The Big Four Coal Company, Warrick County, report improvements in their Big Four Mine amounting to $1,068.00.

The balance of the money was spent on mine buildings, new cages, cars, mining machines and the improvements of the mines in general.

Note 1. The Southern Indiana Coal Company installed a traction motor haulage system in their Lattas Creek Mine, using two ten-ton motors. They have also installed small gathering motors in their Hoosier No. 1 Mine. We have been unable, however, to learn the cost of installation at either mine and have had no report as to what success has been met with since the motors have been installed.

Note 2. The Sullivan County Coal Company installed a rope haulage 900 feet in length in their Freeman Mine, Sullivan County, but this department has been unable to learn the cost of same.

CHANGES IN OWNERSHIP.

Several changes in the ownership and operation of mining properites were made during the past year and noted as follows:

The Fox Den Mine, Clay County, formerly owned by the Star Union Coal and Oil Company, was transferred to the Ideal Block Coal Company, who now own and operate it. The present owners have renamed the mine. It is now called the Fortner.

The Continental Clay & Mining Company went into the hands of a receiver early in the spring, under whose administration their Continental No. 1 Mine has since been operated.

The Pennsylvania & Indiana Coal Company suspended operations in the latter part of September on account of financial difficulties and the mine lay idle through October and part of November, when a receiver was appointed and the mine leased to the Midvale Coal Company, who have been operating it since that time.

The Shirley Hill Coal Company was organized in the spring and purchased the Victoria Mine formerly owned by the Victoria Coal Company, assuming control in June. This mine is nearly worked out and will hardly last through the winter. The ownership and control of the Shirley Hill No. 1 and No. 2 Mines, Sullivan County, owned by the Coal Bluff Mining Company, was also assumed at the time the company was organized.

The Letsinger Mine, Greene County, owned by the Letsinger Coal Company, was leased in May by the Indiana Fairmont Coal Company.

The Oswald mine, Gibson County, owned by the Princeton Coal & Mining Company, changed hands in August and is now the property of a Mr. Grover and Mr. Oliphant of Vincennes, but is operated under the name of the original company.

The Superior Mine, Sullivan County, owned by the Superior Coal Company of Terre Haute, was bought in August by the Hudson Coal Company of Chicago, who have made extensive repairs and increased the capacity of the mine to about 600 tons per day.

The Shelburn Mine, Sullivan County, formerly the property of the Keystone Coal Company, was purchased in the fall by the A. H. Whitsett Coal Company and the mine is known as the Keystone.

The First Avenue Mine in Evansville, owned by the C. Thomas Coal Co., was purchased by Charles Schimel, Henry Koff, Frank Gunther and Fred Jourden, who have organized and operate the mine under the name of the Banner Coal Co.

The Maple Valley No. 1 Mine, owned by the Maple Valley Coal Company, and the Prince mine, owned by the Keller Coal Company, were purchased by the Oak Hill Coal Company, who assumed control of the former in May and the latter October 15.

The above transfers, while not nearly so large as in 1905, will represent an aggregate of several hundred thousand dollars.

ABANDONED MINES.

The number of mines abandoned during the year 1906 was less by two than that of the new mines opened for the same period. Eleven mines in all were abandoned during the year, three of which were block coal mines, two in Clay County and one in Parke County; eight bituminous mines, one in Clay County, two in Sullivan, four in Vigo and one in Warrick County. The greater number of the bituminous mines abandoned have been known as among the largest producers of the State. In the following table will be found the names of the mines abandoned, the names of the companies owning them, date of abandonment, county in which they were operated and the railroad on which they were located.

TABLE

Abandoned Mines.

NAME OF MINE.	Name of Company.	Date.	County.	Railroad.
Crawford No. 4	Crawford Coal Company	Sept. 15, 1906	Clay	Vandalia.
Vandalia No. 64	Vandalia Coal Co.	March 31, 1906	Clay	Vandalia.
Superior No. 7	Zellar-McClellan & Co.	March 31, 1906	Clay	E. & I.
Pan-American	Plymouth Block Coal Co.	March 31, 1906	Parke	C. C. C. & St. L.
Consolidated No. 29	Consolidated Indiana Coal Co.	May 1, 1906	Sullivan	E. & T. H.
Vandalia No. 80	Vandalia Coal Co.	March 31, 1906	Vigo	Vandalia.
Vandalia No. 82	Vandalia Coal Co.	March 31, 1906	Vigo	Vandalia.
Peerless	Coal Bluff Mining Co.	June 29, 1906	Vigo	C. & E. I.
Diamond	Coal Bluff Mining Co.	March 31, 1906	Vigo	C. C. C. & St. L.
Dering No. 9	Dering Coal Co.	March 31, 1906	Vigo	C. & I. C.
Dering No. 10	Dering Coal Co.	March 31, 1906	Vigo	C. & I. C.
Star No. 1	John Archibald Coal Co.	March 31, 1906	Warrick	Interurban.

NOTE.—The Knox Coal Company abandoned the Upper Seam No. 6, which they formerly mined and sunk to No. 5 during the year.

TABLE

Exhibiting the Names of Coal Companies, Names of Mines Operated by Them, the Geological Number of the Different Coal Seams Mined, the Thickness of Each Seam, the Depth from Surface to Each Seam, Pick or Machines Mines, and whether the Coal Seams are Gaseous or Non-Gaseous.

BLOCK COAL MINES.

CLAY COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Brazil Block Coal Co.	Brazil No. 1	C. & E. I.	IV	3'6"	101	Machine	No.
Brazil Block Coal Co	Brazil No. 4	C. & E. I.	III	3'9"	160	Pick	No.
Brazil Block Coal Co.	Brazil No. 7	Vandalia	III	3"6"	75	Pick	No.
Brazil Block Coal Co	Brazil No. 8	C. & E. I.	III	3'6"	89	Pick	No.
Supe. .ior Block Coal Co.	Continental	Vandalia	IV	4'6"	65	Pick	No.
Superior Block Coal Co.	Rebstock	C. & E. I.	IV	4'6"	85	Pick	No.
Zellar-McClellan Coal Co.	Superior No. 4	Vandalia	IV	3'9"	80	Pick	No.
Zellar-McClellan Coal Co.	Superior No. 7	Vandalia	IV	3'9"	75	Pick	No.
Chicago-Indiana Block Coal Co.	Harrison No. 4	E. & I.	IV	4'9"	60	Pick	No.
Crawford Coal Co.	Crawford No. 4	Vandalia	IV	4'	60	Pick	No.
Crawford Coal Co.	Crawford No. 2	Vandalia	IV	3'6"	68	Pick	No.
Crawford Coal Co.	Crawford No. 6	Vandalia	III	3'6"	116	Pick	No.
Crawford Coal Co.	Crawford No. 8	E. & I.	III	3'	50	Pick	No.
Crawford Coal Co	Crawford No. 9	C. & E. I.	IV	4'	86	Pick	No.
American Clay Mfg. Co.	Monarch	C. & E. I.	IV	3'6"	81		No.
Indiana Block Coal Co.	Lower Vein No. 1	E & I.	IV	3'	58	Pick	No.
Dan Davis Coal Co.	World's Fair No. 2	E. & I.	IV	3'6"	57	Pick	No.
Eureka Block Coal Co.	Eureka No. 5	C. C. C. & St. L.	III	3'6"	116	Pick	No.
McLaughlin & Treager	Treager	Wagon mine	IV	4'	60	Pick	No.
Vandalia Coal Co.	Vandalia No. 50	Center Point branch Vandalia	III	3'	105	Pick	No.
Coal Bluff Mining Co.	Glenn No. 1	C & E. I.	IV	4'6"	215	Pick	No.
Coal Bluff Mining Co.	Plymouth No. 2	C. & E. I.	III	3'3"	110	Pick	No.

PARKE COUNTY.

Brazil Block Coal Co.*	Brazil No. 12	C. & I. C.	III	3′6″	98	Pick	None
Otter Creek Coal Co.	Mary	C. & I. C.	III	4′10″	105	Machine	Small per cent.
Brazil Block Coal Co.	Brazil No. 9	C. & I. C.	III	4′6″	120	Pick	Pick, Non-gaseous.
Zellar-McClellan & Co.	Superior No. 1	C. & I. C.	III	5′	108	Pick	Non-gaseous.
Zellar-McClellan & Co.	Superior No. 2	C. & I. C.	III-IV	3′6″-3′8″	135	Pick	Non-gaseous.
Zellar-McClellan & Co.	Superior No. 3	C. & I. C.	III-IV	4′	40	Pick	Non-gaseous.
Zellar-McClellan & Co.	Superior No. 5	C. & I. C.	III	3′6″	145	Pick	Non-gaseous.
Plymouth Block Coal Co.	Pan-American	C. C. C. & St. L.	III	4′	70	Pick	Non-gaseous.

VIGO COUNTY.

Domestic Block Coal Co.	Domestic Block No. 1	C. & E. I.	IV	4′	110	Pick	Non-gaseous.

BITUMINOUS COAL MINES.

CLAY COUNTY.

Vandalia Coal Co.	Vandalia No. 60	Vandalia (main line)	VI	7′	32	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 63	Vandalia (main line)	VI	7′	100	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 64	Vandalia (main line)	VI	7′	90	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 65	Vandalia (main line)	VI	7′	100	Pick	Non-gaseous.
Ideal Block Coal Co.	Fortner	Vandalia (main line)	V	3′4″	110	Pick	Non-gaseous.
Collins Coal Co.	Gifford No. 1	C. & I. C.	III	4′4″	75	Pick	Small per cent.
Collins Coal Co.	Gifford No. 2	C. & I. C.	III	4′6″	77	Pick	Small per cent.
Big Vein Mining Co.	Lewis	Southern Indiana	V	8′	107	Pick	Non-gaseous.
Vivian Mining Co.	Vivian No. 1	Southern Indiana	III	5′6″	43	Pick	Non-gaseous.
Vivian Mining Co.	Vivian No. 2	Southern Indiana	IV	5′		Pick	Non-gaseous.
Jasonville Coal Co.	Gold Knob	Southern Indiana	III	6′6″	104	Pick	Small per cent.
United Fourth Vein Coal Co.	Island Valley No. 4	Southern Indiana	IV	5′6″	20	Pick	Non-gaseous.
Stunkard Coal Co.	Stunkard	Wagon mine	II	3′6″	25	Pick	Non-gaseous.
C. Ehrlich Coal Co.	Klondyke No. 2	Vandalia (main line)	VI	7′		Pick	Non-gaseous.

BITUMINOUS COAL MINES—Continued.

DAVIESS COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Stucky & Osborn	Stucky	Wagon mine	III	3′	Drift	Pick	Non-gaseous.
Daviess Coal Co.	Montgomery No. 3	B. & O. S. W.	V	3′8″	100	Pick	Non-gaseous.
Mutual Mining Co.	Mutual	B. & O. S. W.	III	4′6″	100	Pick	Non-gaseous.
Mandabach Bros.	Mandabach	Wagon mine	V	6′	56	Pick	Non-gaseous.

FOUNTAIN COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Rush Coal Co.	Indio	Clover Leaf	III	5′5″	80	Pick	Non-gaseous.
Silverwood Coal Co.	Silverwood	Clover Leaf	III	3′9″	45	Pick	Non-gaseous.

GIBSON COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Princeton Coal & Mining Co.	Oswald	Southern	V	6′10″	450	Pick	Very gaseous.
Fort Branch Coal Co.	Fort Branch	E. & T. H.	V	4′ 6″	262	Pick	Gaseous.
Massey Coal Co.	Massey	E. & I.	VI	4′ 6″	50	Pick	Non-gaseous.

GREENE COUNTY.

United Fourth Vein Coal Co.	Black Creek	Southern Indiana	IV	4′8″	82	Machine	Non-gaseous.
United Fourth Vein Coal Co.	Island Valley No. 3	Southern Indiana	IV	5′6″	47	Pick	Non-gaseous.
United Fourth Vein Coal Co.	Glenburn	Southern Indiana	IV	4′6″	102	Machine	Non-gaseous.
United Fourth Vein Coal Co.	Antioch	Southern Indiana	IV	4′6″	176	Pick	Small per cent.
United Fourth Vein Coal Co.	North Linton	Southern Indiana	IV	4′2″	68	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 2	I. & V. branch Vandalia	IV	5′	66	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 3	I. & V. branch Vandalia	IV	5′	81	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 4	I. & V. branch Vandalia	IV	5′	55	Pick	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 5	I. & V. branch Vandalia	IV	5′	95	Machine	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 6	I. & V. branch Vandalia	IV	5′	72	Machine	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 8	I. & V. branch Vandalia	IV	5′6″	132	Machine	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 9	I. & V. branch Vandalia	IV	5′	128	Machine	Non-gaseous.
Vandalia Coal Co.	Vandalia No. 21	I. & V. branch Vandalia	IV	5′	95	Machine	Non-gaseous.
Midvale Coal Co.	Midvale	Southern Indiana	III	7′6″	217	Pick	Small per cent.
Indiana Southern Coal Co.	Gilmour	Southern Indiana	IV	5′4″	152	Machine	Non-gaseous.
Southern Indiana Coal Co.	Hoosier No. 1	Southern Indiana	IV	3′7″	133	Pick	Non-gaseous.
Southern Indiana Coal Co.	Hoosier No. 2	Southern Indiana	V	7′	46	Pick	Non-gaseous.
Southern Indiana Coal Co.	Tower Hill	Southern Indiana	III	7′	132	Machine	Non-gaseous.
Southern Indiana Coal Co.	Midland	Southern Indiana	III	7′	245	Machine	Small per cent.
Southern Indiana Coal Co.	Lattas Creek	Southern Indiana	IV	5′	153	Machine	Non-gaseous.
Summitt Coal Co.	Summitt No. 2	I. & V. branch Vandalia	IV	5′6″	150	Machine	Non-gaseous.
Green Valley Coal Co.	Green Valley	Southern Indiana	IV	5′2″	121	Machine	Non-gaseous.
Vulcan Coal Co.	Vulcan	Indianapolis Southern	V	6′	Slope	Pick	Non-gaseous.
Shirley Hill Coal Co.	Victoria	Indianapolis Southern	IV	5′8″	22	Pick	Non-gaseous.
Queen Coal Co.	Queen	Southern Indiana	IV	3′7″	87	Pick	Non-gaseous.
Indiana Fairmont Coal Co.	Letsinger	Southern Indiana	III	7′6″	....	Pick	Small per cent.
Calora Coal Co.	North West	Southern Indiana	IV	5′	75	Pick	Non-gaseous.
Coal Bluff Mining Co.	Twin No. 4	Southern Indiana	V	6′	56	Machine	Non-gaseous.
Coal Bluff Mining Co.	Twin No. 5	Southern Indiana	IV	4′	152	Machine	Non-gaseous.

KNOX COUNTY.

Knox Coal Company	Knox	I. & V. (Vandalia)	V	7′	....	Machine	Small per cent.
Bicknell Coal Company	Bicknell	I. & V. (Vandalia)	VI	4′4″	92	Pick	Small per cent.
Prospect Hill Coal Co.	Prospect Hill	Wagon mine	VII	3′	335	Pick	Gaseous at times.
Vandalia Coal Co.	Vandalia No. 40	I. & V. (Vandalia)	VI	4′3″	154	Pick	Gaseous at times.
Big Muddy Coal Co.	Pine Knot	I. & V. (Vandalia)	VI	4′6″	210	Machine	Gaseous at times.
Freeman Coal Co.	Freeman	I. & V. (Vandalia)	V	7′	234	Machine	Small per cent.
Washington-Wheatland Coal Co.	Wheatland	B. & O. S. W.	VII	5′	100	Pick	Small per cent.
Lynn Coal Co.	Lynn	I. & V. (Vandalia)	V	6′	200	Machine	Small per cent.

BITUMINOUS COAL MINES—Continued.

PARKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
United Coal & Mining Co....	Mecca No. 3	C. & I. C.	III	5′	166	Pick	Non-gaseous.
Lincoln Coal & Mining Co.	Lyford No. 1	C. & E. I.	VI	6′6″	....	Pick	Small per cent.
Vandalia Coal Co.	Vandalia No. 316	Logansport (Vandalia)	III	4′6″	150	Pick	Small per cent
Vandalia Coal Co.	Vandalia No. 317	Logansport (Vandalia)	III	5′	....	Pick	Small per cent.
W. P. Harrison	Harrison	Wagon mine	IV	4′	Slope	Pick	Small per cent.
Parke County Coal Co.	Parke No. 11	Logansport (Vandalia)	VI	6′6″	102	Machine	Small per cent.

PERRY COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Bergenroth Bros.	Troy	Ohio River transportation	II	3′	50	Pick	Non-gaseous.

PIKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Muren Coal Co.	Muren	Southern	V	4′6″	43	Pick	Non-gaseous.
D. Ingle Coal Co.	Ayrshire No. 3	Southern	V	5′	22	Pick	Non-gaseous.
D. Ingle Coal Co.	Aryshire No. 4	Southern	V	4′8″	....	Pick	Non-gaseous.
D. Ingle Coal Co.	Ayrshire No. 5	Southern	V	5′	Drift	Pick	Non-gaseous.
S. W. Little Coal Co.	Rogers	E. & I.	V	7′	Slope	Pick	Non-gaseous.
S. W. Little Coal Co.	Blackburn	E. & I.	V	6′6″	Slope	Pick	Non-gaseous.
S. W. Little Coal Co.	Littles	E. & I.	V	6′6″	80	Pick	Non-gaseous.
Patoka Valley Coal Co.	Hartwell No. 1	Southern	V	5′	Drift	Pick	Non-gaseous.
Patoka Valley Coal Co.	Hartwell No. 2	Southern	V	5′	Drift	Pick	Non-gaseous.

SULLIVAN COUNTY.

Indiana Southern Coal Co.	Bunker Hill	Indianapolis Southern	VI	4'6"	72	Machine	Fire damp in faults.
Indiana Southern Coal Co.	Caladonia	Indianapolis Southern	VI	5'3"	106	Machine	Fire damp in faults.
Indiana Southern Coal Co.	Phœnix No. 4	E. & T. H	VI	6'6"	....	Machine	Fire damp in faults.
Indiana Southern Coal Co.	Cummins	Southern Indiana	VII	5'	Slope	Pick	Fire damp in faults.
Indiana Southern Coal Co.	Hocking	Southern Indiana	VI	5'6"	80	Machine	Fire damp in faults.
Indiana Southern Coal Co.	Citizens	Southern Indiana	VI	5'	165	Machine	Fire damp in faults.
Sunflower Coal Co.	Sunflower	Indianapolis Southern	VI	6'	....	Machine	Fire damp in faults.
Consolidated Indiana Coal Co.	Consolidated No. 25	E. & T. H	VI	5'6"	235	Machine	Fire damp in faults.
Consolidated Indiana Coal Co.	Consolidated No. 26	Southern Indiana	....	5'	110	Machine	Fire damp in faults.
Consolidated Indiana Coal Co.	Consolidated No. 28	Southern Indiana	VI	6'	200	Machine	Fire damp in faults.
Consolidated Indiana Coal Co.	Consolidated No. 29	E. & T. H	VI	5'6"	120	Machine	Fire damp in faults.
Consolidated Indiana Coal Co.	Consolidated No. 30	E. & T. H	VI	5'6"	197	Machine	Fire damp in faults.
Consolidated Indiana Coal Co.	Consolidated No 31	E. & T. H	V	6'	53	Pick	Non-gaseous.
Consolidated Indiana Coal Co.	Consolidated No. 32	Southern Indiana	V	7'	105	Machine	Gaseous.
Consolidated Indiana Coal Co.	Consolidated No. 33	Southern Indiana	V	6'	....	Machine	Gaseous.
Consolidated Indiana Coal Co.	Consolidated No. 34	E. & T. H	III	6'	....	Machine	Gaseous.
Vandalia Coal Co.	Vandalia No. 10	I. V. (Vandalia)	IV	5'6"	260	Pick	Gas in faults.
Jackson Hill Coal Co.	Jackson Hill No. 2	E. & T. H	VI	5'8"	104	Machine	Gas in faults.
Jackson Hill Coal Co.	Jackson Hill No. 4	E. & T. H	VI	5'	155	Machine	Gas in faults.
A. H. Whitsett Coal Co.	Shelburn	E. & T. H	V	6'	317	Machine	Very gaseous.
Sullivan County Coal Co.	Freeman	Indianapolis Southern	VI	5'	100	Pick	Gas in faults.
Dering Coal Co.	Dering No. 12	E. & T. H	VII	5'6"	80	Pick	Gas in faults.
Dering Coal Co.	Dering No. 13	E. & T. H	VI	5'	144	Machine	Gas in faults.
Dering Coal Co.	Dering No. 14	E. & T. H	VI	5'6"	103	Machine	Gas in faults.
Southern Indiana Coal Co.	Semi-Block	Southern Indiana	III	6'6"	235	Machine	Very gaseous.
Southern Indiana Coal Co.	Mammoth Vein	Southern Indiana	VI	6'	173	Machine	Gas in faults.
Shirley Hill Coal Co.	Shirley Hill No. 1	Monon	VI	5'6"	110	Machine	Gas in faults.
Shirley Hill Coal Co.	Little Giant	Monon	VI	5'6"	....	Machine	Gas in faults.
Shirley Hill Coal Co.	Shirley Hill No. 2	I. & V. (Vandalia)	IV	4'7"	307	Machine	Gas in faults.
Hudson Coal Co.	Superior	E. & T. H	VII	5'6"	112	Pick	Gaseous.
Kettle Creek Mining Co.	Kettle Creek	E. & T. H	VI	5'3"	152	Machine	Gas in faults.
Peabody-Alwart Coal & Mining Co.	Reliance	E. & T. H	VI	5'	237	Machine	Gas in faults.
Diamond Coal & Mining Co.	Hamilton	E. & T. H	III	6'6"	255	Machine	Gaseous.
United Fourth Vein Coal Co.	Black Hawk	Southern Indiana	III	6'4"	240	Machine	Small per cent of gas.
Clover Leaf Coal Co.	Cloverleaf	Indianapolis Southern	IV	4'7"	307	Machine	Very gaseous.
Carlisle Coal & Clay Co.	Carlisle	E. & T. H	VI	4'7"	307	Machine	Gas in faults.

BIMUMINOUS COAL MINES—Continued,

VANDERBURGH COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Diamond Coal Co	Diamond	Wagon mine	V	4′	256	Pick	Small per cent.
Banner Coal Co	Avenue	Wagon mine	V	4′	265	Pick	Small per cent.
D. Ingle Coal Co	Ingleside	L. & N.	V	4′	235	Pick	Small per cent.
Sunnyside Coal Co	Sunnyside	L. & N.	V	4′	255	Pick	Small per cent.
Union Coal Co	Union	Wagon mine	V	4′	235	Pick	Small per cent.
Crescent Coal Co	Unity	L. & N.	V	4′	225	Pick	Small per cent.

VERMILLION COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of Coal Seam.	Thickness of Coal Seam.	Depth from surface to Coal Seam.	Pick or Machine Mine.	Fire Damp.
Dering Coal Company	Dering No. 5	C. & E. I.	VII	4′10″	85	Pick	Non-gaseous.
Dering Coal Company	Dering No. 7	C. & E. I.	VI	5′ 6″	265	Pick	Small per cent.
Dering Coal Company	Dering No. 8	C. & E. I.	VII	6′	100	Pick	Non-gaseous.
Dering Coal Company	Dering No. 15	C. & E. I.	VI	5′ 6″	176	Pick	Small per cent.
Cayuga Brick & Coal Co	Eureka	Consumed at Brick yard	VI	5′ 6″	110	Pick	Small per cent.
Clinton Coal Co	Crown Hill No. 1	C. & E. I.	VII	5′	164	Pick	Non-gaseous.
Clinton Coal Co	Crown Hill No. 2	C. & E. I.	VII	4′10″	151	Pick	Non-gaseous.
Oak Hill Coal & Mining Co	Oak Hill	C. & E. I.	VII	6′ 6″	40	Pick	Non-gaseous.
Oak Hill Coal & Mining Co	Maple Valley No. 1	C. & E. I.	VII	4′ 8″	....	Pick	Non-gaseous.
Oak Hill Coal & Mining Co	Buckeye No. 2	C. & E. I.	VII	4′10″	110	Pick	Non-gaseous.
Oak Hill Coal & Mining Co	Prince	C. & E. I.	VII	....	130	Pick	Non-gaseous.

VIGO COUNTY.

Dering Coal Company	Dering No. 6	C. & E. I.	VI	4'8"	110	Pick	Non-gaseous.
Chas. F. Keeler Coal Co	Atherton	C. & E. I.	VI	6'9"	165	Machine	Small per cent.
Coal Bluff Mining Co	Diamond	C. C. C. & St. L.	VI	6'	54	Pick	Small per cent.
Coal Bluff Mining Co	Peerless	C. & I. C.	VI	7'	101	Pick	Non-gaseous.
Coal Bluff Mining Co	Lawton	C. C. C. & St. L.	VI	6'6"	110	Pick	Small per cent.
Grant Coal & Mining Co	Grant No. 2	C. & E. I.	VI	6'6"	120	Pick	Small per cent.
Dering Coal Company	Dering No. 9	C. & I. C.	VI	6'6"	....	Pick	Non-gaseous.
Dering Coal Company	Dering No. 10	C. & I. C.	VI	6'6"	Slope	Pick	Non-gaseous.
Vandalia Coal Company	Vandalia No. 66	Vandalia	VI	6'	103	Pick	Non-gaseous.
Vandalia Coal Company	Vandalia No. 67	Vandalia	VI	6'	110	Pick	Non-gaseous.
Vandalia Coal Company	Vandalia No. 68	Vandalia	VI	7'	133	Pick	Small per cent.
Vandalia Coal Company	Vandalia No. 69	Vandalia	VI	6'	120	Pick	Small per cent.
Vandalia Coal Company	Vandalia No. 80	Vandalia	VI	....	....	Pick	Small per cent.
Vandalia Coal Company	Vandalia No. 81	Vandalia	VII	4'4"	80	Pick	Small per cent.
Vandalia Coal Company	Vandalia No. 82	Vandalia	V	6'	105	Machine	Small per cent.
Coal Bluff Mining Company	Wabash	C. C. C. & St. L.	IV	5½'	300	Pick	Gaseous.
Lower Vein Coal Company	Lower Vein No. 1	C. C. C. & St. L.	V	4'6"	201	Pick	Gaseous.
Miami Coal Company	Miami No. 1	C. & E. I.	VI	7'	82	Pick	Non-gaseous.
Miami Coal Company	Miami No. 2	C. & E. I.	VI	6'	50	Pick	Non-gaseous.
Miami Coal Company	Miami No. 3	C. & E. I.	VI	7'	85	Pick	Non-gaseous.
Parke County Coal Company	Parke No. 10	Logansport (Vandalia)	VI	6'6"	100	Machine	Non-gaseous.
Fauvre Coal Company	Fauvre No. 1	Vandalia	VI	6'	90	Pick	Gaseous.
Domestic Block Coal Co	Domestic Block No. 1	C. & E. I.	IV	4'	110	Pick	Non-gaseous.
Coal Bluff Mining Co	Plymouth No. 1	C. C. C. & St. L.	III	....	215	Pick	Non-gaseous.
Fauvre Coal Company	Fauvre No. 2	Vandalia	V	4'6"	228	Pick	
West Terre Haute Coal Co	Larimer	Wagon mine	VII	4'8"	110	Pick	Non-gaseous.
Deep Vein Coal Company	Deep Vein	Vandalia	VI	6'	170	Pick	Gaseous.
Vigo County Coal Company	Ray No. 2	Vandalia	VI	7'4"	95	Pick	Non-gaseous.
Indiana Southern Coal Co	Forrest	C. C. C. & St. L.	VI	6'5"	150	Machine	Small per cent.
Sugar Valley Coal Company	Sugar Valley No. 1	Wagon mine	V	4'6"	185	Pick	Small per cent.
Coal Bluff Mining Company	Victor	C. C. C. & St. L.	VI	6'6"	50	Pick	Non-gaseous.

WARRICK COUNTY.

Big Four Coal Company	Big Four	Southern	V	7'	Slope	Machine	Non-gaseosu.
J. Woolly Coal Company	Big Vein No. 3	Southern	V	7'	37	Machine	Non-gaseous.
C. Menden Coal Company	DeForrest	Southern	V	7'	65	Machine	Small per cent.
John Archibald Coal Co	Star No. 1	Southern	V	4'4"	100	Pick	Non-gaseous.
T. D. Scales Coal Co	Electric	Southern	V	7'	30	Machine	Non-gaseous.
Worsham Coal Company	Burke	Southern	V	4'4"	110	Pick	Non-gaseous.
Caladonia Coal Company	Dawson	Southern	V	4'	87	Pick	Non-gaseous.
Erie Canal Coal Company	Erie Canal	Southern	V	5'	130	Machine	Small per cent.
Chandler Coal Company	Chandler	Southern	V	....	....	Machine	Small per cent.
Castle Garden Coal Co	Castle Garden	Southern	V	4'	96	Pick	Small per cent.
Elberfield Coal Company	Elberfield	E. & I.	V	4'4"	175	Pick	Non-gaseous.

NOTE.—Where "small per cent." is designated in above tables, fire damp is only occasionally found in drill holes and not in sufficient quantity to endanger an explosion.

EXAMINATIONS.

Examinations of applicants for certificates of competency to serve as mine boss, fire boss and hoisting engineers were held at three different times during the year 1906, all of which examinations were held in Terre Haute. There was a total of one hundred and fifty nine (159) candidates examined, ninety-eight or a fraction over sixty-one per cent. (61%) of whom passed a successful examination and were granted certificates. The date of each examination, the number of each class of applicants examined, the number passed and the number who failed is shown in the annexed table.

	Total Applicants.			Passed.			Failed.		
	M. B.	F. B.	H. E.	M. B.	F. B.	H. E.	M. B.	F B.	H. E.
May 15, 16	24	5	17	18	2	9	6	3	8
August 9, 10	44	8	15	21	6	6	23	2	9
November 20, 21	21	6	19	20	4	12	1	2	7
Total	89	19	51	59	12	27	30	7	24

The following is a list of the names and addresses of persons to whom certificates have been granted, also the number of the certificate, the per cent. grade made by each applicant and the date of the examination at which they passed.

MINE BOSS.

Examinations held May 15 and 16, 1906.

No. Certificate.	*Name and Address.*	*Per cent.*
1.	Wm. M. Lee, Jasonville	83
2.	W. B. Sharps, Mecca	77
3.	M. F. Collins, Seeleyville	76
4.	Wm. McGlossin, Cloverland	76
5.	W. E. Cox, Bicknell	79
6.	Wm. H. Raney, Princeton	76
8.	Wm. P. Evans, Brazil	79
9.	J. N. Hathaway, Sullivan	81
12.	Calvin S. Miller, Linton	82
14.	Wm. S. Ball, Brazil	80
15.	E. W. Worsham, Evansville	77
16.	Fred McClanahan, Hymera	80
17.	Eli P. Berry, Bridgeton	88
18.	J. L. Brayer, Seeleyville	86
21.	Edward G. Epple, Jasonville	83
23.	Alfred K. Froeschke, Linton	77
24.	Jacob T. Pope, Midland	76

FIRE BOSS.

No. Certificate.	*Name and Address.*	*Per cent.*
43.	James M. Templeton, Vicksburg	85
44.	Wm. Humthrey, Farmersburg	80

HOISTING ENGINEER.

28.	Ray Scott, Bridgeton	85
30.	J. W. McKee, Linton	80
31.	Park Phillips, Mecca	76
34.	James Scott, Vincennes	80
36.	F. L. McElroy, Shelburn	78
38.	Wm. Squire, Lyons	80
39.	David O. Squire, Lyons	81
40.	Byrd Squire, Linton	80
46.	C. E. Williams, Linton	76

MINE BOSS.

Examination held August 9 and 10, 1906.

1.	James Owens, Linton	80
2.	Richard Anderson, Clinton	75
3.	Wm. Sheffler, Linton	84
5.	Robert Tarrants, Boonville	78
6.	Henry West, Brazil	75
13.	Nick Anderson, Linton	80
14.	Henry Hilton, Dugger	85
22.	E. H. Powell, Carlisle	77
23.	M. H. Head, Midland	77
25.	Jos. Vonderschmitt, Jasonville	80
36.	James Dunn, Shelburn	88
49.	Charles Stahlberg, Jasonville	76
50.	Thomas Oxley, Jasonville	79
52.	Wm. Knowles, Elsworth	77
55.	James Navin, Diamond	80
56.	Ebert Hammack, Boonville	76
64.	Wm. F. Brown, Midland	77
66.	P. B. Rossiter, Shelburn	80
68.	Alexander Hunter, Farmersburg	80
71.	William Stinson, Terre Haute	80
73.	Wellington O'Connor, Terre Haute	81

FIRE BOSS.

53.	W. W. Burgess, Shelburn	80
58.	John Dawson, Sullivan	81
59.	W. E. Cox, Bicknell	84
60.	Thomas Gillespie, Bicknell	81
61.	Jack Smith, Jackson Hill	76
62.	David Price, Farmersburg	81

HOISTING ENGINEER.

No. Certificate.	*Name and Address.*	*Per cent.*
29.	Dan Fitzpatrick, Dugger	79
38.	Noble Azbell, Linton	78
39.	Wm. Thompson, Bicknell	85
42.	Oliver D. Targett, Brazil	89
44.	W. H. Sexton, Midland	85
48.	Shirley Devine, Brazil	86

MINE BOSS.

Examinaation held November 20 and 21, 1906.

1.	Joseph Osha, Washington	78
2.	Thomas Gillespie, Bicknell	81
3.	James Robertson, Bicknell	83
4.	A. J. Miller, Linton	84
5.	Thomas Fleming, Brazil	85
8.	Henry Thompson, Jasonville	77
9.	Thomas Rosser, Jasonville	76
10.	Samuel Roebuck, Farmersburg	85
11.	P. A. Roberts, Clinton	82
12.	Hugh Barron, Bicknell	82
13.	Morgan Jenkins, Brazil	76
14.	Bernerd Navin, Brazil	84
16.	Pat McQuade, Brazil	82
17.	Wm. Burrows, Shelburn	80
19.	H. A. Barrick, Jasonville	80
20.	Thos. J. McKanna, Brazil	80
42.	George Wilkes, Dugger	79
43.	David Price, Farmersburg	75
49.	Wm. Seckenger, Farmersburg	85

FIRE BOSS.

6.	James Kerr, Paxton	79
7.	John Richards, Dugger	80
46.	Emile Dubrell, Linton	80
47.	Victor Novens, Midland	85

HOISTING ENGINEER.

22.	James Marlow, Hymera	80
23.	Wm. Jeffreys, Brazil	77
26.	Edward Pirtle, Paxton	87
25.	O. B. Martin, Linton	79
27.	W. H. Gladish, Winslow	82
28.	Henry Ammis, Clinton	78
30.	Con McCain, Petersburg	78
31.	P. H. McKee, Midland	79
32.	Bert R. Sherwood, Sullivan	79
34.	Frank Lyib, Bicknell	83
36.	Eli Dickey, Clay City	79
41.	Christ J. George, Elberfield	77

SERVICE CERTIFICATES.

Certificates of service have been granted to the following persons in 1906:

MINE BOSS.

John Bray, Brazil................................November 21.

HOISTING ENGINEER.

John C. Crenshaw, Boonville.....................September 24.
John H. Wetsel, Brazil..........................September 24.

FIRE BOSS.

Enoch Atkinson, Shelburn................................July 24.

Note.—Owing to the fact that the larger number of mines opened at the present time are sunk to the lower coal measures, which in numerous instances generates fire damp, the demand for good fire bosses is increasing daily and the young man who studies and equips himself for this line of work will find a ready demand for his services in the future.

FATALITIES AND INJURIES.

It is pleasing to note that notwithstanding the fact that more coal was mined in Indiana during the year 1906 than in any preceding year, yet the year shows a decrease under 1905 (the next largest year in production in the history of the State) of sixteen in the number of fatal accidents or seventeen under the total number of mine casualties.

The monthly reports of mine bosses made to this office in 1906 show an aggregate of two hundred and thirty-three accidents to mine employes, classed as follows: Fatal, thirty-one; serious, one hundred and four; minor, ninety-eight. The different causes of these accidents will be found in the annexed table.

TABLE.

Exhibiting the Number of Casualties Occurring in the Mines of Indiana, During the Year 1906, and the Different Causes of Such Accidents.

CAUSE OF ACCIDENT.	Fatal.	Serious.	Minor.	Total.
Falling slate	19	28	30	77
Falling coal	....	8	15	23
Ascending cage	....	1	....	1
Descending cage	2	5	1	8
Kicked by mule	....	1	12	13
Injured by mine car	3	22	25	50
Falling down shaft	1	1	....	2
Mining machines	....	5	9	13
Railroad cars	1	1	....	2
Coal falling down shaft	....	1	2	3
Delayed shots	....	2	2	4
Premature shots	....	4	....	4
Misplaced or windy shots	2	....	....	2
Shot blowing through pillar	1	3	1	5
Smoke explosion	1	12	1	14
Fire damp explosion	1	5	2	8
Powder explosion	....	5	1	6
Total	31	104	98	233

FATAL ACCIDENTS.

Each of the above fatal accidents have been investigated either by myself or one of my assistants, acting in conjunction with the coroner of the county in which the accident occurred and we submit herewith, by months, the number of accidents occurring, together with a detailed statement of facts and circumstances adduced at investigation, also such comments on same as we deem necessary.

JANUARY.

Four fatalities resulting from mine accidents, due to different causes, occurred during this month. The first of which was that of Jerry Richardson, American, loader, aged 24 years, who was fatally injured by falling slate, on the 12th inst., in the Citizens Mine, located within the corporate limits of the town of Sullivan. Richardson and one other person were employed to drive a room through a fault which had been struck and were working by the day. About 10:30 o'clock a. m. of above date, he was engaged at work about 8 feet back from the face of his room when a piece of slate 4 feet long, 3 feet wide, ranging from 3 to 11 inches thick, fell on him, injuring him so badly he died 7 hours later. He leaves a dependent wife.

On January 18, Elmer Turpin, a driver, aged 23 years, American, single, was almost instantly killed by being run over by a loaded mine car, in the Vandalia No. 8 Mine, Greene County. About 2:45 o'clock P. M. he was coming out of the mine with a loaded trip. The mule was traveling at a very rapid pace, and decedent was riding on the front end of the car, standing with one foot on the draw-bar of the car and the other on the tail chain, when by some means, either by being kicked by the mule or by slipping, he fell off the tail chain under the rapidly moving car and was dragged some ten or twelve feet. He made one outcry after falling, calling for help, but when assistance arrived a few moments later and the car was raised up, he was dead.

On January 27th, Charles Robins, loader, aged 38 years, American, single, was killed by falling slate in the Forest Mine. There were no eye witnesses to this accident, but from evidence adduced at the investigation, which was conducted by the Coroner of Vigo County and assisted by Inspector Thomas, it was learned decedent was last seen alive about 3:30 o'clock P. M. A searching party on going into the mine to look for him at 10:30 o'clock P. M. found him lying under a large piece of slate, dead. On inspecting decedent's working place, Mr. Thomas found it well timbered to within 14 feet of the face, the usual distance timber is kept back from the face in electric chain machine mines. The roof inside that point, however, was not very good and should have been timbered.

January 29, Fred Waldon, driver, aged 19 years, American, single, was fatally injured by being run over by a loaded mine car in the Gilmoure Mine, Greene County. This accident was similar to that occurring to Elmer Turpin at the Vandalia No. 8 Mine. Waldon was coming out of the mine with a loaded trip about 9:45 o'clock p. m. when he was either kicked by the mule or slipped and fell off the tail chain under the moving car, injuring him so that he died just as they reached the top of the shaft.

FEBRUARY.

Two fatal accidents occurred on the 9th day of this month, when Silvio Andretta, aged 28 years, and John Morush, aged 24 years, both Italians and single, met their death from suffocation in the Maple Valley Mine, Vermillion County. Both men were employed as shot firers in the above mine and had gone into the mine on the evening of the above date as usual to fire the shots which had been prepared by the miners during the day, all other persons being out of the mine at this time. They commenced shooting on the first west cross entry and had lighted all of the shots (ten in number) on that entry and the second west and had gone into room number one on the first south entry for safety. All of the shots were tamped on fuse and it was presumed that they were lighted one after the other in rotation until all had been lighted, without waiting for any one of them to explode and that a number of them, perhaps all, exploded simultaneously; one of which, as found on inspection, was a blown-out shot causing an explosion creating an after damp, which together with the powder smoke brought death to the two men. The accident occurred about 3:40 o'clock p. m. and when the results were known a short time later, both men were found in the room to which they had gone for safety, lying face downward, dead. Two more lives were sacrificed in this instance that might have been prevented had squibs instead of fuse been used in firing the shots.

MARCH.

Eight fatalities is the record for this month. On the 1st day of the month Seth Hayden, a miner, aged 25 years, American, single, was fatally injured by falling slate in the Muren Mine, Pike County. About 8:30 o'clock a. m. decedent was engaged in timbering his room when a large piece of slate measuring 8 feet in length, 6 feet 6 inches in width and ranging from 3 to 10 inches thick, under which he was working, fell on him inflicting injuries from which he died at 9 o'clock p. m. of the same date.

March 2, Enoch James, miner, aged 36 years, Welshman, single, was fatally injured by falling roof in the Crawford No. 6 Mine, Clay County. This accident was investigated by Assistant Inspector Thomas, who reports decedent's working place well timbered to within 7 feet of the face, also that the roof was exceptionally good, other than a roll formation composed of slate, iron and black-jack, commonly called by miners a "pot," which lay across the place between the timbers and the face. At the time of his accident, decedent was engaged at face mining in the coal when a large piece of this formation about 10 feet in length, from 2 to 3 feet wide and 10 inches thick fell on him, crushing and injuring him so that he died one and one-half hours later. This is the first fatal accident to have been reported by this company.

March 2, Balis Yandell, aged 28 years, loader, American, was fatally injured by falling slate in the Reliance Mine, Sullivan County. This accident was investigated by myself, and on examining decedent's working place, i. e., the second northeast cross entry, I found it well timbered to within 20 feet of the face. The roof inside that point was, however, very bad, due to a large fault which had been struck in the face of the entry. Two props had been set by the day men under this loose slate where at least a half dozen were necessary. The entry had been undercut with an electric chain mining machine. The above fault lay directly across the place and had caused the last shot to blow out and leave a part of the shot. At the time of his accident decedent had just finished loading a car and was engaged shearing off the coal preparatory to placing a shot for shooting down the remainder of the under cut. While so engaged, a large piece of slate fell on him crushing and injuring him internally. His injuries, while serious, were not considered fatal, yet he succumbed on the 6th of the month following at the St. Anthony Hospital, where he had been taken for treatment. He leaves a dependent wife.

March 9th, N. E. Livingston, age 48 years, cager, American, was fatally injured by a descending cage in the Vandalia No. 9 Mine. About 2:45 o'clock p. m. one of the sills forming the cage seat had become disarranged, and Livingston was at work trying to move it in place, when the cage, which at that time was held stationary up in the shaft, was lowered down on him, crushing him, inflicting injuries from which he died on the 13th following. There seems to have been a misunderstanding on the part of deceased and the engineer, as the latter contends that he did not receive a signal from the bottom to hold the cage stationary in the shaft, but that he did receive a signal from the top to stop the cage on which a loaded car was being hoisted; this apparently was due to some changes necessary to be made in the tipple, or possibly changing flat cars. After a short delay the engineer received a signal to lower the cage, which he did, with the result above stated. There are two persons deserving of censure connected with this accident, viz.: decedent himself in going under the cage without some one at the bell to prevent the cage from being lowered. Also the mine management is deserving of censure in not giving explicit orders that no one should go into the sump for the purpose of making repairs, without some one to watch the cages and bells. Deceased leaves a dependent wife and five children.

March 14th, Jacob Hayworth, age 37 years, miner, American, single, was instantly killed by falling roof in the Superior Mine, Sullivan County. There were no eye witnesses to this accident, and the first knowledge of his death was when a searching party found him, at 9 o'clock p. m., lying under a large piece of slate, dead. On examining his working place we found a shot tamped on a fuse, the end of which was split, his knife and lamp were also laying on the floor just beneath the fuse, indicating that he was in the act of lighting his shot when the rock fell on him.

March 21st, Alvin Roberts, age 24 years, machine helper, American, was instantly killed at the top of the Vandalia No. 5 Mine, Greene County, by being struck with the iron cover of a descending cage. This accident occurred about 6:40 o'clock a. m., at a time when the miners were being lowered into the mine. There were two persons, viz.: the assistant mine boss and one other person in charge of the cage while the miners were descending the shaft, one stationed on each side of the shaft. Their duties were to prevent more than six persons getting on the cage at one time, the maximum number allowed to ride on a cage. Also to bell the cage away when loaded, and in general to look after the safety of persons descending the mine. At the time above mentioned seven men had gotten on the cage, and Roberts, being the seventh and last man to get on, was ordered off by the assistant mine boss, who called to the person on the opposite side of the shaft to hold the cage stationary. This order, however, was misunderstood, and the signal was given the engineer to lower the cage, which he did just as Roberts was in the act of stepping off, the heavy cage bonnet, made of one-fourth-inch boiler plate, striking him, driving him against the side of the shaft, crushing his skull and breaking his neck. He leaves a dependent wife and one child. A strict observance on the part of decedent of the state's regulation permitting only six persons to ride in a cage at one time, would have prevented this accident.

On March 27th a second fatal accident occurred in the Muren Mine, Pike County, when Elisha Copeland, miner, American, age 31 years, met his death from falling slate. About 8:15 o'clock a. m., decedent was engaged at his usual work at the face of his room, when a piece of slate ten feet in length, four feet wide and nine inches thick, fell on him, killing him instantly. From evidence adduced at the investigation, together with the examination of the deceased's working place, made by Mr. Dodds, who conducted the investigation, it was learned that decedent knew that the slate was loose and dangerous; also that there was a number of props of proper length on hand with which the loose slate could have been secured. Also that the length and breadth of the slate would have permitted a sufficient number of props to be set to have secured it. Deceased leaves a dependent wife and four children.

On March 29th Brownie Morris, age 20 years, driver, American, was fatally injured by being caught and crushed between a boulder in the roof and the top of a loaded mine car in the Crown Hill No. 2 Mine, Vermillion County. About 12:30 o'clock, noon, Morris was coming out of the mine with a trip of loaded cars, riding on the coupling between the two rear cars. When he had reached a point directly under the boulder, which extended down from the regular roof, and which he had apparently forgotten, he raised up and was caught between the boulder and the top of the rear car, and dragged through a space of nine inches, and crushed, inflicting injuries from which he died eight hours later. He leaves as dependents a wife and one child.

JULY.

Four fatal accidents is the record for this month. The first of these was that of Charles A. Bledsoe, age 38 years, miner, American, fatally injured by falling slate in the Pennsylvania and Indiana Mine on the 3rd day of the month. The accident was investigated by myself, and from my examination of decedent's working place and evidence adduced, it was learned that he was employed to drive the approach to the manway, which was then being sunk, and was within about 77 feet of the coal. The approach was being driven twelve feet wide, and was within about forty-five feet of the point where the manway would strike the coal. There were two plys or layers of draw slate overlying the coal in this place, the first one three, and the second one two inches thick, both of which had fallen. There were also two or three props, which I presume had been set, lying under this slate fall. Two shots had been fired which were badly overcharged, the coal being broken almost into dust and thrown back down the place some thirty-five feet, knocking out the props which had been set. These shots were fired on the evening of June 30th, and Bledsoe did not return to work until the morning of July 3rd, about 7:30 o'clock on this date. On entering the mine he found an empty car standing in the mouth of his place, which he pushed to where the coal was thrown out on the road. He had gone round the car to examine his place, taking his sledge with him, it is presumed, to reset his props. While making this examination the draw slate gave way and fell on him. He was so injured that he died at 8:30 o'clock p. m., of the same date. He leaves a dependent wife and four children.

July 10th Al Ralston, age 55 years, loader, American, was killed by falling slate in the Dering No. 14 Mine, Sullivan County. At

3:30 o'clock p. m., firing time, of above date, decedent had three shots prepared ready to fire in his room, which had been undercut with an electric chain mining machine. He had fired the center and one of the rib shots, and was returning to fire the remaining rib shot when a large piece of slate fell on him, breaking his neck and crushing him. He was killed instantly. On examining his working place the closest timber was found 17 feet back from the face. There were 33 loose props of proper length with which the place could have been made safe, and had a few of these been set this accident would have been prevented. Deceased leaves a dependent wife and five children.

July 11th, Henry Blacketer, age 58 years, loader, American, was fatally injured by falling slate in the Mecca No. 3 Mine, Park County. About 8:40 o'clock a. m., deceased was engaged in loading a car of coal, when a piece of slate 6 feet long, 4 feet wide, ranging from 4 to 6 inches thick, fell on him, injuring him so that he died about half an hour later. An examination of his working place showed it to be well timbered to within 12 feet of the face, but the roof inside that point was very loose, and evidence adduced at the investigation showed that deceased had knowledge of the fact. Also there were a number of loose props on hand with which the place could have been timbered securely. Deceased leaves a wife and four children.

July 28th, Theodore Rogers, age 35 years, machine runner, American, was killed by falling slate in the Sunflower Mine, Sullivan County. About 8:30 o'clock a. m., decedent was making an undercut with an electric chain machine. He had partially finished the cut and was sitting on the right side of the frame of the machine, when a fall of slate 18 feet long, 12 feet wide, varying from 1 to 6 inches thick, gave way and a portion of it fell on him, crushing him down on the machine frame, killing him instantly. His helper was also seriously injured. The machine helper testified that he had examined the slate, and knew it was loose, but thought they could finish undercutting the room in safety. Decedent leaves a wife and one child.

AUGUST.

Three fatal accidents occurred during this month. The first one on the 6th inst., when Edgar Allen, age 25 years, pumper, American, was killed by a gas explosion in the Semi Block Mine, Sullivan County. This mine had been closed down since December, 1905, and with the exception of an occasional visit from the Lattas

Creek mine superintendent, there were but two persons employed, viz.: Allen to do the pumping and Joseph Hagg, engineer, to keep up steam, run the fan and hoist and lower Allen into and out of the mine. It usually required but from two to three hours to do the pumping. However, owing to the fact that the mine generated fire damp, orders were given that the fan be run constantly during the day. It was supposed that by doing this, and by running it a couple of hours in the morning before Allen commenced pumping, the mine could be kept safe from fire damp. The last pumping done prior to the date of the accident was at noon, Saturday, the 4th. The engineer testified that he had started the fan at 6:45 o'clock a. m., on Monday morning of the 6th, and that Allen had gone down into the mine at 9 o'clock, the explosion occurring about 30 minutes later. There was no one present at the mine at the time of the accident, except the engineer, who telephoned the Lattas Creek Mine, some two and one-half miles distant, for help. The mine superintendant and assistant mine boss of that mine started for the scene of the accident at once, arriving at the mine about 10:30 o'clock. On going down into the mine they found Allen lying on the main east entry about 171 feet from the shaft bottom, dead, almost every bone in his body being broken, showing that an explosion of unusual violence had taken place. As evidence of this fact, every door on the side of the mine where the explosion occurred, was blown out, as also brattices, timbers, etc. An investigation of the accident was made by myself, and an examination of the mine made on the 8th inst., after the doors and brattices had been replaced and the ventilating current established, disclosed the fact that a considerable quantity of gas was being given off at three different points on the east side of the mine, viz.: the first and second northeast cross entries, the main east entry and air course, and the fifth room in the second southeast cross entry. The quantity of gas standing in the latter place was small, yet there was a sufficient quantity standing in either the north or east entries to have caused a heavy explosion. In the first north entry the gas was found one foot thick thirty feet from the face; on the second north 18 inches thick 40 feet from the face, and in the main east entry and air course, 18 inches from the roof, some 60 feet from the faces. Inasmuch as he knew that fire damp was being given off in various quantities in different places in the mine, the general mine superintendent, Mr. Thomas Hyatt, is deserving of the severest criticism in permitting Allen to perform the duties as above described, without any safeguard whatever. He knew that Allen was an inexperienced miner; that he had never worked in a mine prior to the time he commenced pumping; that he had no knowledge of fire damp, where to look for it, the dangers, etc., and that there was no safety lamp provided him with which to examine the mine for gas, had he been competent to do so. None but a competent miner, thoroughly conversant with the characteristics and dangers of fire damp, should have been employed to do the work for which Allen was employed. I think also that the engineer and decedent himself contributed in no small measure to the accident, as they both knew of the presence of fire damp in the mine, and that the fan had been idle for at least 40 hours. This, together with the fact that previous to this time the fan had only been run during working hours, and that I presume only for six days in the week, thus allowing gas to accumulate in places that were driven ahead of the air, and in high places over falls, etc. Common sense should have taught them that the fan should have been run at least 8 to 10 hours before anyone should be permitted to enter the mine. Decedent leaves a wife and one child.

August 8th, Robert Robison, age 55 years, miner, American, was fatally injured by falling slate in the Kettle Creek Mine, Sullivan County. About two o'clock p. m., deceased was at work at the face of his working place (a room neck) when a piece of slate 4 feet long, 3 feet wide, ranging from 2 to 3 inches thick, fell on him. At the time of the accident he was not thought to be seriously injured, but on being taken to the surface he began vomiting, and on examination the physician discovered his injuries to be internal, from which he died at 10:45 o'clock p. m. of the following day. He leaves a dependent wife and two children.

August 29th, Earl Bridgewater, age 23 years, loader, American, was fatally injured by falling slate in the Forest Mine, Vigo County. Decedent was engaged in loading coal out of a room, which had been undercut with an electric chain mining machine. On the evening of the 28th he had shot his place, but failed to bring the coal down, and about 10:30 o'clock of the following day he was working off this loose coal when a piece of draw slate 10x11 feet, 8½ inches thick, fell on him, injuring him so badly he died an hour and a half later. He leaves a wife and one child.

OCTOBER.

Five fatal accidents were recorded during this month. On the 3rd inst., Frank Grover, age 41 years, flat timer, American, was fatally injured by being run over by a railroad flat car at the Superior (road) Mine, Sullivan County. About 9:30 o'clock a. m. deceased was dropping a loaded car down from the tipple; he was riding on the front end of the car, and after it had dropped down the proper distance, he attempted to apply the brake, using a short stick to assist in setting it, when either the brake chain or the stick slipped, causing him to fall to the track in front of the moving car, which ran over his left leg, almost severing it at the thigh, from the body, inflicting injuries from which he died a short time later. He leaves a dependent wife and four children.

October 3rd, a second fatal accident occurred about 10 o'clock of this date, when Joseph Lightfoot, age 25 years, loader, was killed by falling slate in the Jackson Hill No. 4 Mine, Sullivan County. At the time of his accident he and his partner (Robert Johnson) were pushing a car into their room, when a large piece of slate fell on him, crushing his head and injuring him otherwise. He died half an hour later. He leaves a wife and one child.

October 15th, Francis Dispensut, age 32 years, miner, American, was killed by falling slate in the Ray No. 3 Mine, Vigo County. About 8:45 o'clock p. m. deceased was at work in the face of his room, mining in the coal, when a piece of draw slate 17½ feet long, 5 feet wide, 5 inches thick, suddenly gave way, falling on and killing him instantly. His room was well timbered to within 6 or 7 feet of the face, but no props had been set under the draw slate, although there was a sufficient number of available props to have done so. He leaves a dependent wife and two children.

October 18th, Oscar Deckard, age 27 years, loader, American, was fatally injured by falling slate in the Summit No. 2 Mine, Greene County. Decedent was engaged loading coal out of a room which had been undercut with an electric chain mining machine. He had shot his place down some time prior to the date of accident, and a piece of draw slate some 3 inches thick, which came down with the shot, was resting on the coal. About 1:30 o'clock p. m. he was working out some of the loose coal from under this slate, when a large piece of it slid off of the shot, catching him in a stooping position, knocking him down and falling on him. At the time he was not thought to be seriously injured, but on removing him to his home it was learned that his injuries were internal. He succumbed at 5 o'clock p. m. of the same date. He leaves a wife and one child.

October 30th, Thomas Farrell, age 35 years, shot firer, Irish, was fatally injured by a shot blowing through a pillar in the Oswald Mine, Gibson County. Farrell and one other person, Dud Downer, was employed to do the shot firing in this mine, and on the evening of above date were at their usual work. About 9:30 o'clock they had lighted a shot in room 18 and passed around into room 17 for the purpose of firing the shots in that room. The shot in room 18 was behind a chance parallel with the face of the room, and was drilled a short distance into the pillar. Just opposite the point of this drill hole, the pillar in room 17 had been gouged out, reducing its thickness some 2 or 3 feet; number 18 was also over the average width at this point. Taking the extra width in both rooms, the pillar would have been thined at least 6 feet, leaving it very thin at the point of the drill hole. Just as the two shot firers got opposite where the shot was placed in room 18, it exploded, blowing through the pillar pieces of coal, striking Farrell and injuring him so badly that he died at 5 o'clock a. m. the following day. Downer was also seriously injured. Decedent leaves a dependent wife.

NOVEMBER.

Two fatalities is the record for this month.

On the 8th day of the month John Lewis, age 68 years, miner, Norwegian, was killed by falling slate in the Vandalia No. 60 Mine, Clay County. There were no eye witnesses to this accident, and decedent was not found for some time after the accident. A driver went into the room to pull his car, and found Lewis lying under a large piece of slate, dead. From evidence adduced at this investigation it was learned that when last seen alive (about 8:10 o'clock a. m.) Lewis was loading a car of coal. It was also learned that he was usually a very careful miner, keeping his props within 7 to 10 feet of his working face, but that on the evening previous to the accident he had fired two shots, both of which were somewhat overcharged, throwing the coal back some 20 feet from the face, and knocking out 8 or 10 of the props. On going into his room on the following morning, instead of resetting his props at once, he, as is characteristic of the average miner, undertook to load a car of coal first, and while so engaged a large piece of slate 15x16 feet, 2½ inches thick, gave way, falling on and killing him instantly. He leaves a dependent wife.

November 19th, H. L. Gillham, age 55 years, blacksmith, American, was killed by falling down the Vandalia No. 10 shaft, Sullivan County. About 8 o'clock a. m. the keepers on one of the cages had become disarranged, and Gillham and one other person were at work repairing them. The cage had been hoisted a few feet above the ground landing and a skeleton platform laid across the shaft. Gillham was on the cage floor working at the keepers, and the other person was beneath the cage at work on the weights which throw the keeper. The exact cause of decedent's fall could not be learned, and the party (H. L. Davis) working beneath the cage just caught a glimpse of him as he went down the shaft, and he heard no outcry or struggle of any kind. Deceased fell to the bottom of the shaft some 300 feet, and when found was dead. He leaves a wife and six children.

DECEMBER.

Three fatal accidents are recorded for this month, the first of which occurred at the Superior (Road Mine), Sullivan County. On the 4th day of the month Frank Dean, age 22 years, miner, American, was killed by falling slate somewhere between the hours of 7 and 10 o'clock a. m. There were no eye witnesses to this accident, and the first known of his accident was when the driver went into his room to pull his car of coal and found him lying under the slate. On examining his working place it was learned that at the time of his accident he was mining off a loose shot mining in the top of the coal seam, when a large V-shaped stone of roll formation 9 feet long and 2 feet wide on the bottom, averaging 18 inches thick in center, suddenly gave way, falling on him and killing him instantly. He leaves a wife and one child.

On December 5th, about nine minutes after three o'clock p. m., a terrific smoke explosion occurred in the Vandalia No. 67 Mine, Vigo County, resulting in the fatal injury of Moriah Geisak, miner, age 30 years, single, who died on the 7th day of the month following from burns and other injuries received. Also the serious injury of 17 other persons. Considering the number of persons injured and the fact that one death resulted, this is probably the most serious mine accident occurring during the year 1906, and was due to what should be termed criminal negligence on the part of Oliver Lewis. A fellow miner, by the name of David Morgan, contributed in no small measure to the accident. Proof of the above contention is hereinafter set forth. An examination of the affected part of the mine was made on the day following the explosion by Assistant Inspector Thomas, the Mine Committee, Mine Boss, myself and others, at which time the seat of trouble was located in the face of the ninth northwest cross entry, the working place of David Morgan, and room neck No. 4, the working place of Oliver Lewis, located on the same entry. Before commencing our inspection it was the general opinion of those conversant with the situation that the explosion was due to a heavy charge of dynamite which had been fired, in a fault in the face of the tenth northwest cross entry. An examinaton of this place, however, disproves this theory entirely, as the explosive had done the work intended, throwing the material out in good shape, and there was absolutely no evidence whatever of an explosion having taken place on that entry. In the face of the ninth northwest we found a shot which had been drilled past the cutting or loose end 2 feet and 4 inches. The hole was drilled somewhere near the center of the place, and had apparently been what miners term, a cutting shot. All of the cutting had been blown out, the coal being ground almost into dust, some of it being thrown back down the entry 50 feet, and 2 feet and 4 inches of hole remaining had seamed flat ways. This shot undoubtedly created a large volume of powder smoke at an intense heat. Room neck No. 4 was driven in 15 feet, is 8 feet wide, and the face perfectly straight, with no cutting or chance whatever. On examining this place we found the drill holes of three shots which had been fired. The mouth of one of the holes was 3 feet from the south rib, and the hole was drilled 4 feet 6 inches deep, with a slight angle toward the rib. Two of the holes were located as near the north rib as they could be drilled, one near the bottom was drilled 2 feet and 2 inches deep, and one directly over it near the roof drilled 3 feet and 2 inches deep. Several very heavy shots were also fired in the three rooms outside of room No. 4 and while none of the latter seemed to have been misplacd yet the coal in each was all thrown out, and in some instances broken very fine, evidence that at least a number of them had been considerably overcharged, all of which intensified the heat and increased the volume of powder smoke. From the evidence adduced at the investigation of this accident it was learned that from two to four shots are fired each evening in each working place in this mine, also that shot firing is commenced at a given point, each miner lighting his shots in rotation one after the other, as long as there were any to light, without waiting for those lighted beyond him to explode. This same practice was followed on the evening of the explosion, and the result obtained from the three misplaced shots in room No. 4 on the ninth northwest was only what could have been expected, viz.: each one of them seamed resulting in blown out shots. The entry shot in this instance, in all probability, exploded first, and as the ninth entry acts as a return air way, the dense body of heated powder smoke created by it was driven down past room No. 4 about the time the first shot exploded in that place; this shot blowing out, very likely ignited gases contained in the smoke, the flame of which was carried on down to that made by the shots fired in the three rooms outside of No. 4, and the two remaining shots in No. 4, each of them seaming and blowing out, thus prolonging the explosion and causing it to travel down and out of the ninth north to a door on the main west, between the seventh and eighth north cross entries. This door was blown out and was the means of checking and dividing the course of the flame and force of the explosion, a portion of which passed out over the double parting just outside the door, and a portion travelling up the eighth north a distance of some 20 feet. Owing to the fact that shooting began somewhat early in the evening of the accident, a number of persons had fired their shots and had reached these two points, viz.: the mouth of the eighth north and the double parting on their way out of the mine. This is where the greater number of persons were injured. Several witnesses testified that they believed that coal dust affected this explosion, yet none of them could explain why, nor state what evidence they found on examination of its having done so. In this connection, I, myself, as did the Assistant General Mine Superintendent, Assistant Inspector Thomas and Mr. James Marsh, one of the Mine Committee, a gentleman thoroughly conversant with such work, being a graduate of the Scranton School of Mines, each of us made a careful examination for signs of coal dust having had any part in the explosion, beginning at a point outside where its force was expended, following in to the place of the ninth north, but we could find not the slightest evidence of its having done so. While it is true there was considerable quantity of dust on the roadway, the entire course over which the explosion traveled, it is mainly composed of fire clay, cut up from the floor by the mules and travel of persons to and from their work, and is non-combustible. We have evidence of this by reason of the fact that the force of the explosion was expended at a point on the eighth north, where the layer of dust on the floor is thicker, finer and dryer than in any other part of the mine where the explosion occurred. In my opinion the explosion was due absolutely to powder smoke, caused by the misplaced overcharge and blown out shots, which were located in room No. 4 on the ninth northwest, and the face of that entry.

On December 29th, Joe Roskeyoskie, age 32 years, machine runner, single, was killed by falling slate in the Phoenix No. 4 Mine, Sullivan County. At the time of the accident, 10:20 o'clock a. m., he was engaged in cutting a break through at the face of the third southeast cross entry, with an electric chain mining machine. He had made one undercut, had set his machine and started it on the second one, and while the machine was making this cut he stepped back from the face some 13 feet to get an oil can, when a large piece of rock 8 feet long and 3½ feet wide and 10 inches thick, suddenly gave way, falling on and killing him instantly. The entry was timbered with cross bars to within 20 feet of the face, and the roof inside that point, which was very loose, was timbered with props, pending such a time as the day man could put up cross bars. Decedent was aware of the fact that the slate was loose, yet on going into the place with his machine he found that it could be set more easily by knocking out one of the props, which he did, remarking at the time he would take a chance anyhow. This act of carelessness no doubt cost him his life.

TABLE OF FATAL ACCIDENTS

Exhibiting the Date on which each Fatality Occurred, the Names and Addresses of Persons Killed, the Number of Dependents and Cause of Accident.

Date.	Name.	Occupation.	Residence.	Married.	Widows.	Children.	Single.	Total Dependents.	Cause of Accident.
Jan. 12	Jerry Richardson	Loader	Sullivan	1	1	....	....	1	Falling slate.
Jan. 18	Elmer Turpin	Driver	Atlas	....	....	....	1	....	Run over by mine car.
Jan. 27	Chas. Robins	Loader	Forrest Park	....	....	....	1	....	Falling slate.
Jan. 29	Fred Waldon	Driver	Gilmour	....	....	....	1	....	Run over by mine car.
Feb. 9	Silvio Andretta	Shot firer	Clinton	....	....	....	1	....	Windy shot.
Feb. 9	John Morush	Shot firer	Clinton	....	....	....	1	....	Windy shot.
March 1	Selth Hayden	Miner	Carbon	....	....	....	1	....	Falling slate.
March 2	Enoch James	Miner	Brazil	....	....	....	1	....	Falling slate.
March 2	Balis Yandell	Loader	Shelburn	1	1	....	....	1	Falling slate.
March 9	N. E. Livingston	Cager	Atlas	1	1	5	....	6	Descending cage.
March 14	Jacob Hayworth	Miner	Shelburn	....	....	....	1	....	Falling slate.
March 21	Alvin Roberts	Machine helper	Linton	1	1	1	....	2	Cage bonnet.
March 27	Elisha Coopeland	Miner	Muren	1	1	4	....	5	Falling slate.
March 29	B. Morris	Driver	Clinton	1	1	1	....	2	Crushed between mine car and roof.
July 31	Jas. Bledsoe	Miner	Midland	1	1	4	....	5	Falling slate.
July 10	A. Batson	Loader	Farmesrburg	1	1	5	....	6	Falling slate.
July 11	Henry Blocketer	Loader	Mecca	1	1	4	....	5	Falling slate.
July 28	Theodore Rogers	Machine runner	Dugger	1	1	1	....	2	Falling slate.
Aug. 6	Edgar Allen	Pumper	Semi Block	1	1	1	....	2	Explosion of fire damp.
Aug. 8	Robert Robinson	Miner	Shelburn	1	1	2	....	3	Falling slate.
Aug. 29	Earl Bridgewater	Loader	Forrest	1	1	1	....	2	Falling slate.
Oct. 3	Frank Grover	Flat trimmer	Rood Station	1	1	4	....	5	Railroad car.
Oct. 3	Joseph Lightfoot	Loader	Jackson Hill	1	1	1	....	2	Falling slate.
Oct. 15	Francis Dispenett	Miner	Brazil	1	1	2	....	3	Falling slate.
Oct. 18	Oscar Deckard	Loader	Linton	1	1	1	....	2	Falling slate.
Oct. 30	Thos. Farrell	Shot firer	Princeton	1	1	....	....	1	Shot blown through pillar.
Nov. 8	John Lewis	Miner	Brazil	1	1	....	....	1	Falling slate.
Nov. 19	H. L. Gillham	Blacksmith	Superior	1	1	6	....	7	Fell down shaft.
Dec. 4	Frank Dean	Miner	Farmersburg	1	1	1	....	2	Falling slate.
Dec. 5	M. Geicak	Miner	Brazil	....	....	....	1	....	Smoke explosion.
Dec. 29	Joe Raskegaskie	Machine runner	Shelburn	....	....	....	1	....	Falling slate.

TABLE

Exhibiting the Number of Fatal and Serious Accidents Occurring from Use of Explosives in Indiana Coal Mines During the Years 1900 *to* 1906, *Inclusive.*

YEAR.	1900.		1901.		1902.		1903.		1904.		1905.		1906.	
Cause of Accident.	F.	S.	F.	S.	F.	S.	F.	S.	F.	S.	F.	S.	F.	S.
Smoke explosion	....	1	....	5	3	6	3	10	1	2	1	....	1	12
Powder explosion	....	....	....	5	....	....	4	2	3	5	3	2	....	5
Delayed shots	1	3	1	2	2	7	4	1	5	3	2	6	....	2
Premature shots	1	....	3	2	2	2	5	7	....	5	2	2	....	4
Misplaced, windy or blown out shots	....	2	....	7	....	4	2	5	....	2	9	7	2	....
Shot blowing through pillar	1	....	....	....	....	2	1	1	....	....	1	....	1	3
Smoke and dust combined	....	....	....	....	....	....	....	....	....	3	....	....	....	....
Total	3	6	4	21	7	21	19	26	9	20	18	17	4	26

NOTE.—The use of fuse in shot firing became general in the mines of this State during 1902 and 1903, and at present time at least 98% of shots are fired by this method.

TABLE

Exhibiting the Number of Deaths, also Serious Accidents, Due to Explosions of Various Kinds During the Years 1900 *to* 1906, *Inclusive.*

YEAR.	1900.		1901.		1902.		1903.		1904.		1905.		1906.	
Nature of Explosion.	F.	S.	F.	S.	F.	S.	F.	S.	F.	S.	F.	S.	F.	S.
Fire damp	....	....	....	2	....	2	1	....	....	....	1	9	....	....
Powder smoke	....	....	....	5	3	6	3	10	1	2	1	....	1	...
Gas, dust, smoke, combined	....	1	....	....	....	....	....	....	....	3	....	....	....	....
Explosion of powder	....	....	....	5	....	....	4	....	3	5	3	2	....	....
Misplaced, windy or blown out shots	....	1	....	7	....	4	2	5	....	2	9	7	2	....

TABLE

Comparative Table of Fatalities Covering a Period of Ten Years, from 1897 *to* 1906 *Inclusive, Exhibiting the Number of Fatalities Occurring Each Year and the Different Causes, and the Number of Tons of Coal Mined Each Year.*

YEAR.	Deaths Due to Use of Powder.								Other Causes.								Coal.
1897	....	1	....	....	....	2	2	....	....	....	9	....	1	1	....	....	4,228,085
1898	1	1	....	....	2	7	....	....	....	....	14	....	....	....	....	1	5,027,044
1899	....	....	....	2	....	....	....	....	....	....	8	....	2	2	1	....	5,864,975
1900	1	1	....	1	....	....	....	....	....	....	11	....	2	1	1	....	6,283,063
1901	1	3	....	....	....	....	....	....	....	....	10	2	4	3	1	....	7,019,203
1902	2	2	....	....	....	3	....	....	....	1	11	....	....	3	2	....	8,763,197
1903	4	5	....	1	2	3	4	2	1	1	17	1	5	5	3	....	9,992,553
1904	5	....	....	....	....	1	3	....	1	1	13	....	4	6	....	....	9,872,404
1905	2	2	9	1	....	1	3	1	....	1	18	....	2	3	4	1	10,995,972
1906	....	....	....	1	2	1	....	1	....	1	....	20	....	3	2	....	11,422,027

NOTE.—It will be noticed from the above table that since the use of fuse in shot firing and the excessive use of powder has become so prevalent, beginning in 1902 and 1903, accidents not only from this source have become more frequent, but accidents from falling slate have also nearly doubled. This is due to props and other timbers having been knocked down by flying coal when the miner fires his shots of an evening and the fact that instead of resetting these timbers the first thing in the morning, he commences loading out his coal, with the result a slate fall frequently occurs, causing the loss of life or serious injury to the workman.

SERIOUS ACCIDENTS.

The aggregate of one hundred and four accidents shown in the table of causes, includes only those resulting in broken bones, internal injuries, cuts and bruises of a nature serious enough to call for special mention are due to the same causes and conditions as shown in the description of fatal accidents.

Of these serious injuries, twenty-eight were caused by slate falls, the major portion of which occurred at the working faces that were directly in care of the workmen injured. It is safe to say that many of these accidents could have been prevented had ordinary care been used in resetting props knocked out by shots and to the matter of timbering or taking down loose slate.

Falling coal caused eight of these accidents, while those injured were mining off loose shots, and the same lack of precaution is evident as cited above.

Twenty-two drivers were hurt by mine cars and one by a mule kick. Driving is the most hazardous work in or about a mine, therefore this number, compared with those injured in any former year, taking into consideration the increased production of 1906, shows a gratifying decrease in the average of injured drivers.

Nine workmen were injured by shots, two by delayed, four by premature and three by shots blowing through pillars. In the first instance of delayed shots both men had gone back on lighted shots which were tamped on fuse. (Comments are unnecessary.) There is no direct information at hand concerning the premature shots, hence no comments.

Of the three accidents due to shots blowing through pillars, two resulted from gross carelessness and occurred at the same time. Both men were shot firers and had lighted a shot in one room that pointed into the pillar of the room to be fired next. After lighting the shot they passed into this room, stopping directly opposite the charge they had just lighted. The explosion blowed through the pillar and both men were badly hurt by pieces of flying coal.

Twelve men were burned by a smoke explosion following three badly misplaced shots in an eight-foot room neck.

Five men were burned and otherwise injured by explosions of fire damp and five by powder explosions. The remaining fifteen were hurt in various ways, by coal falling down the shaft, mining machines, etc.

The following table exhibits in detail the number of serious accidents, the dates, extent and causes of injuries, the names and occupations of those hurt, together with the names of the mines in which the accidents occurred, the companies owning same and the counties in which the properties are located:

TABLE

Serious Accidents.

CLAY COUNTY

Date.		Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
Jan.	2	Hugh Clements	Miner	Four ribs broken	Falling coal	Vandalia No. 65	Vandalia Coal Co.	1
Jan.	21	Jas. Masteller	Driver	Bruised	Mine car	Vandalia No. 63	Vandalia Coal Co.	3
Jan.	26	Jas. Beaty	Miner	Back and ankle	Falling coal	Lewis	Big Vein Coal Co.	2
Feb.	13	Geo. Froshour	Miner	Face and hands burned	Shot blowing through pillar	Vandalia No. 64	Vandalia Coal Co.	4
Feb.	13	Wm. Burkhart	Miner	Face and hands burned	Shot through pillar	Vandalia No. 64	Vandalia Coal Co.	1
Feb.	13	Geo. Roebuck	Miner	Face and hands burned	Shot through pillar	Vandalia No. 64	Vandalia Coal Co.	2
Feb.	27	Ed Clark	Miner	Foot mashed	Falling coal	Gold Knob	Jasonville Coal Co.	
July	11	Grover Craig	Miner	Spine fractured	Falling rock	Eureka	Eureka Block Coal Co.	
July	—	John Depew	Miner	Internally	Falling rock	Gifford No. 2	Collins Coal Co.	
July	—	Thomas Bledsoe	Miner	Face burned	Powder explosion	Vandalia No. 60	Vandalia Coal Co.	
July	—	Wm. Bryson	Miner	Crushed through chest	Falling coal	Superior No. 4	Zellar-McClellan & Co.	2

GIBSON COUNTY.

Date.		Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
Oct.	30	H. Downer	Shot firer	Severely burned	Shot through pillar	Oswald	Princeton Coal & Mining Co.	

GREENE COUNTY.

Date.		Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
Jan.	27	J. M. Tennis	Machine runner	Foot crushed	Falling slate	Gilmour	Indiana Southern Coal Co.	
Feb.	7	Walter Irwin	Timberman	Head cut, back injured	Falling slate	Gilmour	Indiana Southern Coal Co.	1
—		John W. Cruse	Loader	Back and ribs, foot	Falling slate	Gilmour	Indiana Southern Coal Co.	
March	17	John Wolger	Driver	Foot mashed	Mine car	Lattas Creek	Southern Indiana Coal Co.	
June	12	Newton Robinson	Jerryman	Leg bruised	Between cars	Lattas Creek	Southern Indiana Coal Co.	2
July	19	Evert Pribby	Driver	Body crushed	Between cars	Lattas Creek	Southern Indiana Coal Co.	
Aug.	29	L. L. Godberry	Loader	Spine injured	Falling slate	Lattas Creek	Southern Indiana Coal Co.	
Aug.	20	Earnest Lynn	Miner	Back injured	Falling slate	Vandalia No. 9	Vandalia Coal Company	4
Nov.	21	Randolph Pastler	Loader	Face and eyes burned	Delayed shot	Green Valley	Green Valley Coal Co.	2
Nov.	26	Sanford Briddle	Machine runner	Hip lacerated	Fell on machine	Green Valley	Green Valley Coal Co.	1
Sept.	18	Joseph Herd	Driver	Foot broken	Between car and rock	Summitt No. 2	Summitt Coal Co.	1

Serious Accidents—Continued.

KNOX COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
Feb. 28	Charles Macy	Miner	Face and hands burned	Gas explosion	Vandalia No. 40	Vandalia Coal Co.	1
Feb. 16	Benjamin Scott	Miner	Head injured	Falling slate	Vandalia No. 40	Vandalia Coal Co.	
June 4	Ottie Pulliam	Miner	Back injured	Falling rock	Wheatland	Washington-Wheat. Coal Co	2
Nov. 6	Henry Deitz	Miner	Face and hands burned	Gas explosion	Prospect Hill	Prospect Hill Coal Co.	

PARKE COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
July 31	Richards Henderson	Machine runner	Arm broken	Mining machine	Mary	Otter Creek Coal Company	3
Nov. 11	Chas. Connoley	Miner	Leg broken	Falling slate	Parke No. 11	Parke County Coal Co.	
Nov. 13	Clifford Adams	Driver	Finger cut off	Mine car	Miami No. 2	Miami Coal Co.	
Nov. 26	Joseph Stiff	Machine runner	Arm crushed	Falling slate	Parke No. 11	Parke County Coal Co.	
Nov. 6	Ww. L. Llewellyn	Miner	Back injured	Falling slate	Miami No. 2	Miami Coal Co.	
Nov. 6	Geo. Harfold	Driver	Foot badly crushed	Falling slate	Miami No. 2	Miami Coal Co.	
—	Nick Sanks	Miner	Crushed in breast	Falling coal	Miami No. 2	Miami Coal Co.	
Aug. 14	Walter Gentry	Driver	Shoulder crushed	Between cars	Miami No. 2	Miami Coal Co.	
Aug. 31	Edward Frayer	Driver	Crushed in breast	Between cars	Mecca No. 3	United Coal & Mining Co.	
July 27	Frank Green	Miner	Hip and ankle injured	Falling slate	Vandalia No. 317	Vandalia Coal Co.	

PIKE COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
March 19	Hiram Wright	Miner	Two fingers cut off	Falling slate	Ayrshire No. 4	D. Ingle Coal Co.	7

SULLIVAN COUNTY

Jan. 22	John Dick	Miner	Eye destroyed	Delayed shot	Little Giant	Shirley Hill Coal Co.	4
Feb. 21	Thomas Brown	Miner	Back bruised	Falling slate	Shirley Hill	Shirley Hill Coal Co.	4
March 3	John Sutton	Fire boss	Face and head badly burned	Gas explosion	Hocking	Indiana Southern Coal Co.	7
March 3	Robert Lockhart	Miner	Face and body burned	Gas explosion	Hocking	Indiana Southern Coal Co.	4
——	Jas. Onemans	Driver	Leg fractured	Car and door	Jackson Hill No. 2	Jackson Hill Coal Co.	
March 14	Isaac Bryant	Miner	Leg broken	Falling slate	Dering No. 12	Dering Coal Co.	1
March 15	John Isabel	Driver	Back injured	Mine car	Little Giant	Shirley Hill Coal Co.	
March 17	Commodore Parks	Driver	Collar bone broken	Between car and roof	Shirley Hill	Shirley Hill Coal Co.	
April 6	Robert Parks	Track layer	Burned	Gas explosion	Shelburn	D. H. Whitsett Coal Co.	
April 6	Chas. Martin	Miner	Burned	Gas explosion	Shelburn	D. H. Whitsett Coal Co.	
Feb. 21	Thos. Silverwood	Miner	Head mashed	Falling slate	Bunker Hill	Indiana Southern Coal Co.	
March 15	Joseph Booker	Machine runner	Foot cut	Foot caught in machine	Mammoth	Southern Indiana Coal Co.	
June 22	Andrew Mason	Miner	Back injured	Falling slate	Citizens	Indiana Southern Coal Co.	5
——	Chas. Godfrey	Driver	Hip injured	Between cars	Mammoth	Southern Indiana Coal Co.	3
July 10	Frank Ralston	Miner	Hip crushed	Falling slate	Dering No. 14	Dering Coal Co.	
——	Norman Davis	Driver	Arm broken	Fell off mine car	Jackson Hill	Jackson Hill Coal Co.	
Aug. 30	James Stone	Miner	Back and breast crushed	Falling slate	Freeman	Sullivan County Coal Co.	
Aug. 30	John Collins	Miner	Back and head injured	Engineer lost control of engine	Clover Leaf	Clover Leaf Coal Co.	
Aug. 30	Bogard Richardson	Miner	Back and head injured	Engineer lost control of engine	Clover Leaf	Clover Leaf Coal Co.	
Aug. 30	Ross Collins	Miner	Back and head injured	Engineer lost control of engine	Clover Leaf	Clover Leaf Coal Co.	
Aug. 30	Clarence Schraum	Miner	Back and head injured	Engineer lost control of engine	Clover Leaf	Clover Leaf Coal Co.	
Aug. 30	F. Burchard	Miner	Back and head injured	Engineer lost control of engine	Clover Leaf	Clover Leaf Coal Co.	
Sept. 14	A. Richmond	Miner	Body injured	Falling slate	Viola	Carlisle Clay & Coal Co.	
Nov. 17	Chas. Cartwright	Driver	Hip injured	Mine car	Mammoth	Southern Indiana Coal Co.	
Oct. 15	Joseph Hixon	Driver	Foot and ankle crushed	Mine car	Jackson Hill	Jackson Hill Coal Co.	
Dec. 27	Frank McComb	Driver	Collar bone broken	Mine car	Jackson Hill	Jackson Hill Coal Co.	
Nov. 6	Earl Chapman	Driver	Body bruised	Mine cars	St. Clair	Consolidated Indiana Coal Co	
June —	Millard Early	Miner	Leg broken	Falling coal	Superior	Superior Coal Co.	
Aug. 22	Thos. Kunup	Fire boss	Body burned	Gas explosion	Vandalia No. 10	Vandalia Coal Co.	
Sept. —	Robert Robinson	Loader	Leg broken	Falling slate	Kettle Creek	Kettle Creek Coal Co.	
Oct. 3	Joseph Lightfoot	Loader	Skull fractured	Falling slate	Jackson Hill	Jackson Hill Coal Co.	
Dec. 14	Oscar Cochran	Loader	Back sprained	Falling rock	Dering No. 13	Dering Coal Co.	
Nov. 12	Wm. Hayworth	Miner	Body burned	Powder explosion	Hocking	Indiana Southern Coal Co.	
Aug. 10	John Bedwell	Driver	Foot crushed	Mine cars	Citizens	Indiana Southern Coal Co.	
Aug. —	John Thomas	Driver	Leg crushed	Mine cars	Hocking	Indiana Southern Coal Co.	
Aug. 17	Joseph Watts	Driver		Kicked by mule	Shirley Hill	Shirley Hill Coal Co.	
July 31	O. Meade	Driver		Mine cars	Phœnix	Indiana Southern Coal Co.	

Serious Accidents—Continued.

VIGO COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
Jan. 9	Henry Lee	Dumper	Hip bruised	Stairway fell	Hector	Indiana Southern Coal Co.	
	James Bardnett	Miner	Hips and legs injured	Falling slate	Forrest	Indiana Southern Coal Co.	
Feb. 21	Lawrence Kane	Miner	Knee dislocated	Falling slate	Miami No. 2	Miami Coal Company	
Feb. 15	Edward Lindsley	Machine runner	Hand crushed	Mining machine	Domestic Block	Miami Coal Company	
	William Reef	Machine runner	Leg crushed	Mining machine	Atherton	Chas. F. Keeler Coal Co.	
June 24	Theodore Haskins	Miner	Head and body injured	Ascending cage	Miami No. 2	Miami Coal Co.	
May 4	Andrew Ridsavage	Miner	Face and body burned	Powder explosion	Ray No. 2	Vigo County Coal Co.	
May 4	Charles Ruggie	Miner	Face and body burned	Powder explosion	Ray No. 2	Vigo County Coal Co.	
June 25	Scott Montgomery	Miner	Head and legs injured	Falling slate	Miami No. 1	Miami Coal Company	
July 2	Major Gordon	Miner	Back injured	Falling slate	Miami No. 1	Miami Coal Company	
	Willard King	Pumper	Foot injured	Stepped on nail	Vandalia No. 68	Vandalia Coal Co.	
Aug. 20	James Elder	Timberman	Foot amputated	Between mine cars	Miami No. 2	Miami Coal Co.	
Sept. 28	John Gordon	Miner	Leg amputated	Between mine cars	Miami No. 1	Miami Coal Company	3
Nov. 15	Chas. Walker	Driver	Arm broken	Mine cars	Atherton	Chas F. Keeler Coal Co.	4
Nov. 21	Wm. Brennan	Loader	Arm injured	Dynamite cap	Forrest	Indiana Southern Coal Co.	
Aug. 29	E. Bridgewater	Loader	Leg broken	Falling slate	Forrest	Indiana Southern Coal Co.	
Dec. 5	David Morgan	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	William Yomen	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Riley Rinehard	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Samuel James	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Lewis James	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Edward Harveycamp	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	A. Lawson	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Carl Harveycamp	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	George Ambright	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Lewis Smith	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Elsie Danhour	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	William Travis	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Thomas Nealy	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Elmer Tirnay	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	
Dec. 5	Joseph Kowande	Miner	Badly burned	Smoke explosion	Vandalia No. 67	Vandalia Coal Company	

WARRICK COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.	Dependents.
Nov. 14	Charles Himan	Miner	Body burned	Premature shot	Chandler	Chandler Coal Company	6
Nov. 14	John Ferris	Miner	Body burned	Premature shot	Chandler	Chandler Coal Company	6

COMPARATIVE TABLE

Showing Number of Tons of Coal Mined Each Year, the Number of Persons Employed and the Number of Tons of Coal Produced per Each Death from January 1, 1881, *to January* 1, 1907.

YEAR.	Tons Produced.	Employes.	Fatal Accidents.	Tons Produced Per Death.
1881	1,771,536	4,567	10	177,153
1882	1,900,000	No report.	.....	....
1883	2,560,000	5,403	11	232,227
1884	2,260,000	5,716	9	228,888
1885	2,375,000	6,502	7	239,285
1886	3,000,000	6,406	7	228,571
1887	3,217,711	No report.	.....	....
1888	3,140,979	6,685	17	184,763
1889	No report.	....	.....	....
1890	3,791,211	6,550	5	758,242
1891	3,819,600	6,975	5	763,900
1892	4,408,471	7,600	19	232,024
1893	4,358,897	7,431	22	193,586
1894	No report.	....	.....	....
1895	4,202,084	7,885	23	182,699
1896	4,068,124	7,112	28	170,290
1897	4,088,100	7,934	16	262,630
1898	5,146,920	No report.	22	233,950
1899	5,864,975	7,366	15	390,997
1900	6,283,063	8,858	18	349,059
1901	7,019,203	10,296	24	292,466
1902	8,763,197	13,139	24	365,133
1903	9,992,563	15,128	55	181,683
1904	9,872,404	17,838	34	290,364
1905	10,995,972	17,856	47	233,956
1906	11,422,027	19,562	31	368,45

ACCIDENTS TO MINE PROPERTY.

Few accidents occurred to mine property during the past year, fires in the interior of mines causing the largest financial losses. Other and smaller losses were occasioned by local fires in surface plants, squeezes in the mines, and various minor accidents. The most serious loss occurred at firing time on the afternoon of March 26 in the Clover Leaf Mine in Sullivan County. A gas feeder was lighted from one of the shots fired which in turn ignited the coal. The mine was not examined that evening after the shooting and the fire was not discovered until morning, when it had reached such proportions that it necessitated the closing of that portion of the mine. A loss of $900.00 was incurred before the fire was extinguished and work resumed in the affected part of the mine. On Saturday evening, January 27, a similar fire to that of the Clover Leaf occurred in the second northeast cross entry in the Phoenix No. 4 Mine, Sullivan County, and as in the foregoing instance was not discovered until the following morning. By this time the fire had gained such headway the smoke and heat made it impossible to penetrate the mine any distance from the shaft bottom. It was then decided to smother the fire and the main entrance and air course were walled up, excluding the air and completely blocking off that entire side of the mine. After nine days the stoppings were removed, the fire having been extinguished, work was resumed. The financial loss in this instance, estimating the time lost, would probably reach the sum of eight hundred dollars ($800.00).

The Lost Creek Mine in Vigo County has been at a heavy expense combating a series of squeezes at intervals during the year. Early in January a squeeze set in on the north side of the mine, resulting in the entire loss of the first and second west, third and fourth east and the partial loss of the first and second east. At one time the entire north side of the mine was in danger of being closed. A later squeeze began in the south side of the mine and it was only with much difficulty and labor that several pairs of cross entries were saved. The mine has an extremely hard sandstone roof and a very soft fire clay bottom, conditions that require extra heavy and uniform pillars. Either through ignorance or negligence, however, this necessity had been utterly disregarded by a former mine management, as an examination showed the pillars to range in size anywhere from three to thirty feet in thickness.

About the 15th of March an extremely heavy squeeze started in the main west entry in the Superior Mine in Sullivan County. This was due to the robbing of pillars and the soft fire clay bottom. It extended from the second to the third north cross entries embracing several rooms on each entry and at one time looked as though that entire side of the mine would close. The company succeeded in stopping it after two months of incessant effort, however, and the mine is now producing about 600 tons per diem.

On June 7th the blacksmith shop at the Atherton Mine in Vigo County burned down. The loss was estimated at $750.00.

A small fire in the boiler room of the Miami Mine last October resulted in the loss of about $100.00.

MINE DIRECTORY

CLAY COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Brazil Block Coal Company	Brazil	Brazil No. 1.
Brazil Block Coal Company	Brazil	Brazil No. 4.
Brazil Block Coal Company	Brazil	Brazil No. 7.
Brazil Block Coal Company	Brazil	Brazil No. 8.
Continental Clay & Mining Co	Brazil	Continental No. 1
Superior Block Coal Co	Brazil	Rebstock.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 50.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 60.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 63.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 65.
Zellar-McClellan Co	Indianapolis, State Life Bldg	Superior No. 4.
Crawford Coal Company	Brazil	Crawford No. 2.
Crawford Coal Company	Brazil	Crawford No. 6.
Crawford Coal Company	Brazil	Crawford No. 8.
Crawford Coal Company	Brazil	Crawford No. 9.
Ideal Block Coal Co	Brazil	Fortner.
Collins Coal Company	Brazil	Gifford No. 1.
Collins Coal Company	Brazil	Gifford No. 2.
Coal Bluff Mining Co	Terre Haute	Glenn No. 1.
Coal Bluff Mining Co	Terre Haute	Plymouth No. 2.
American Clay Mfg. Co	Brazil	Monarch.
Big Vein Mining Co	Terre Haute	Lewis.
Vivian Mining Company	Chicago, Ill	Vivian No. 1.
Vivian Mining Company	Chicago, Ill	Vivian No. 2.
Progressive Coal Company	Brazil	Progressive.
Indiana Block Coal Co	Saline City	Lower Vein No. 1.
Jasonville Coal Company	Jasonville	Gold Knob.
Dan Davis Coal Company	Brazil	World's Fair.
United Fourth Vein Coal Co	Linton	Island Valley No. 4.
Chicago-Indiana Block Coal Co	Clay City	Harrison No. 4.
Eureka Block Coal Co	Brazil	Eureka No. 5.
McLaughlin & Treager	Brazil	Treager.
Stunkard Coal Company	Brazil	Stunkard.
C. Ehrlich Coal Company	Turner	Klondyke.

DAVIESS COUNTY.

Stucky & Osborn	Raglesville	Stucky.
Daviess County Coal Co	Montgomery	Montgomery No. 3.
Mutual Mining Company	Cannelburg	Mutual.
Mandabach Bros	Washington	Mandabach.
Overton Coal Company	Raglesville	Overton.
Winklepeck & Overton	Raglesville	Winklepeck.

FOUNTAIN COUNTY.

Rush Coal Company	Cleveland, Ohio	Indio.
Silverwood Coal Company	Silverwood	Silverwood.

GREENE COUNTY.

Name of Company.	Address of Company.	Name of Mine.
United Fourth Vein Coal Company	Linton	North Linton.
United Fourth Vein Coal Company	Linton	Sponsler.
United Fourth Vein Coal Company	Linton	Black Creek.
United Fourth Vein Coal Company	Linton	Glenburn.
United Fourth Vein Coal Company	Linton	Antioch.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 2.
Vandalia Coal Company	Indianapolis, State Lfe Bldg	Vandalia No. 3.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 4.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 5.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 6.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 8.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 9.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 21.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Hoosier No. 1.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Hoosier No. 2.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Midland.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Tower Hill.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Lattas Creek.
Indiana Southern Coal Co	Chicago, Ill., Old Colony Bldg	Gilmour.
Vulcan Coal Company	Indianapolis, Lemcke Bldg	Vulcan.
New Summitt Coal Co	Bloomfield	Summitt No. 2.
Shirley Hill Coal Company	Indianapolis, Terminal Bldg	Victoria.
Green Valley Coal Company	Jasonville	Green Valley.
Queen Coal Company	Jasonville	Queen.
Indiana Fairmont Coal Co	Terre Haute	Letsinger.
Calora Coal Company	Indianapolis, Terminal Bldg	North West.
Coal Bluff Mining Company	Terre Haute	Twin No. 4.
Coal Bluff Mining Company	Terre Haute	Twin No. 5.
Midvale Mining Company	Midland	Midvale.

GIBSON COUNTY.

Princeton Coal & Mining Company	Princeton	Oswald.
Massey Coal Company	Oakland City	Massey
Fort Branch Coal Company	Fort Branch	Fort Branch.

KNOX COUNTY.

Bicknell Coal Company	Bicknell	Bicknell.
Freeman Coal Company	Bicknell	Freeman.
Knox Coal Company	Bicknell	Knox.
Lynn Coal Company	Bicknell	Lynn.
Prospect Hill Coal Company	Vincennes	Prospect Hill.
Vandalia Coal Company	Bicknell	Vandalia No. 40.
Washington-Wheatland Coal Co	Washington	Wheatland.
Chicago & Big Muddy Coal Co	Bicknell	Pine Knot.

PARKE COUNTY.

Bridgeton Mining Company	Bridgeton	Bridgeton No. 1.
Brazil Block Coal Co	Brazil	Brazil No. 9.
Brazil Block Coal Co	Brazil	Brazil No. 12.
United Coal & Mining Co	Mecca	Mecca No. 3.
Lincoln Coal & Mining Co	Chicago, Ill	Lyford No. 1.
Otter Creek Coal Company	Chicago, Ill	Mary.
Zellar-McClellan & Co	Brazil	Superior No. 1.
Zellar-McClellan & Co	Brazil	Superior No. 2.
Zellar-McClellan & Co	Brazil	Superior No. 3.
Zellar-McClellan & Co	Brazil	Superior No .5.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 316.
Vandalia Coal Company	Indianapolis, State Life Bldg	Vandalia No. 317.
Parke County Coal Company	Rosedale	Parke No. 10.
Parke County Coal Company	Rosedale	Parke No. 11.
W. P. Harrison	Rockville	Harrison.
Clay County Coal Co	Carbon	Whips

PERRY COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Bergenroth Bros	Troy	Troy.

PIKE COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Muren Coal & Ice Co	St. Louis, Mo	Aberdeen.
D. Ingle Coal Co	Oakland City	Ayrshire No. 3.
D. Ingle Coal Co	Oakland City	Ayrshire No. 4.
D. Ingle Coal Co	Oakland City	Ayrshire No. 5.
Muren Coal & Ice Co	St. Louis, Mo	Carbon.
S. W. Little Coal Co	Evansville	Rogers.
S. W. Little Coal Co	Evansville	Blackburn.
S. W. Little Coal Co	Evansville	Littles.
Patoka Valley Coal Co	Huntingburg	Hartwell No. 1.
Patoka Valley Coal Co	Huntingburg	Hartwell No. 2.
Muncie Coal & Mining Co	Muncie	Petersburg.
Winslow Gas Coal Company	Winslow	Winslow No. 4.
Winslow Gas Coal Company	Winslow	Winslow No. 5.

SULLIVAN COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Indiana Southern Coal Company	Chicago, Ill., Old Colony Bldg	Washington.
Indiana Southern Coal Company	Chicago, Ill., Old Colony Bldg	Caledonia.
Indinaa Southern Coal Company	Chicago, Ill., Old Colony Bldg	Phœnix No. 4.
Indiana Southern Coal Company	Chicago, Ill., Old Colony Bldg	Cummins.
Indiana Southern Coal Company	Chicago, Ill., Old Colony Bldg	Hocking.
Indiana Southern Coal Company	Chicago, Ill., Old Colony Bldg	Citizens.
Sunflower Coal Company	Dugger	Sunflower.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 25.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 26.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 28.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 30.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 32.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 33.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 34.
Vandalia Coal Company	Indianapolis	Vandalia No. 10.
West Linton Coal Co	Indianapolis	West Linton.
Jackson Hill Coai Co	Terre Haute, Opera Block	Jackson Hill No. 2.
Jackson Hill Coal Co	Terre Haute, Opera Block	Jackson Hill No. 4.
A. H. Whitsett Coal Co	Shelburn	Keystone.
Sullivan County Coal Co	Dugger	Freeman.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 12.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 13.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 14.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Semi-Block.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Mammoth Vein.
Shirley Hill Coal Co	Indianapolis, Terminal Bldg	Shirley Hill No. 1.
Shirley Hill Coal Co	Indianapolis, Terminal Bldg	Shirley Hill No. 2.
Shirley Hill Coal Co	Indianapolis, Terminal Bldg	Little Giant.
Hudson Coal Company	Farmersburg	Hudson.
Kettle Creek Coal Company	Terre Haute	Pearl.
Peabody-Alwart Coal Co	Chicago, Ill	Reliance.
Diamond Coal & Mining Co	Chicago, Ill	Hamilton.
United Fourth Vein Coal Co	Linton	Black Hawk.
Clover Leaf Coal Co	Dugger	Clover Leaf.

VANDERBURGH COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Diamond Coal Co	Evansville	Diamond.
D. Ingle Coal Co	Evansville	Ingleside.
Sunnyside Coal Co	Evansville	Sunnyside.
Crescent Coal Co	Evansville	Unity.
Banner Coal Co	Evansville	First Avenue.

VERMILLION COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 5.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 6.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 7.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 8.
Dering Coal Company	Chicago, Ill., Old Colony Bldg	Dering No. 15.
Cayuga Brick & Coal Co	Cayuga	Eureka.
Clinton Coal Co	Clinton	Crown Hill No. 1.
Clinton Coal Co	Clinton	Crown Hill No. 2.
Oak Hill Coal Co	Clinton	Oak Hill.
Oak Hill Coal Co	Clinton	Maple Valley.
Oak Hill Coal Co	Clinton	Buckeye No. 2.
Oak Hill Coal Co	Clinton	Prince.

VIGO COUNTY.

Coal Bluff Mining Company	Terre Haute	Lawton.
Coal Bluff Mining Company	Terre Haute	Plymouth No. 1.
Coal Bluff Mining Company	Terre Haute	Victor.
Coal Bluff Mining Company	Terre Haute	Wabash.
Lower Vein Coal Company	Terre Haute	Lower Vein No. 1.
Vandalia Coal Company	Indianapolis	Vandalia No. 67.
Vandalia Coal Company	Indianapolis	Vandalia No. 68.
Vandalia Coal Company	Indianapolis	Vandalia No. 69.
Vandalia Coal Company	Indianapolis	Vandalia No. 80.
Vandalia Coal Company	Indianapolis	Vandalia No. 82.
Miami Coal Company	Brazil	Miami No. 1.
Miami Coal Company	Brazil	Miami No. 2.
Miami Coal Company	Brazil	Miami No. 3.
Parke County Coal Company	Rosedale	Parke No. 10.
Fauvre Coal Company	Indianapolis	Fauvre No. 1.
Fauvre Coal Company	Indianapolis	Fauvre No. 2.
West Terre Haute Coal Co	W. Terre Haute	Larimer.
Deep Vein Coal Company	Terre Haute	Deep Vein.
Vigo County Coal Co	Seeleyville	Ray No. 2.
Indiana Southern Coal Co	Chicago, Ill	Forrest.
Domestic Block Coal Co	Kokomo	Domestic Block No. 1.
Sugar Valley Coal Co	West Terre Haute	Sugar Valley No. 1.
Charles F. Keeler Coal Co	Chicago, Ill	Atherton.
M. D. West Coal Co	Cloverland	Chicago No. 6.
Grant Coal & Mining Co	Burnett	Grant No. 2.
Sugar Valley Coal Co	West Terre Haute	Sugar Valley.

WARRICK COUNTY.

Hall & Marsh	Chandler	Air Line.
Big Four Coal Company	Boonville	Big Four.
J. W. Woolley Coal Co	Boonville	Big Vein No. 3.
Chandler Coal Company	Evansville	Chandler.
John Archibald Coal Co	Evansville	Star No. 1.
Charles Menden Coal Co	Evansville	DeForest.
T. D. Scales Coal Co	Boonville	Electric.
Worsham Coal Company	Newburg	Star No. 2.
Caladonia Coal Company	Boonville	Dawson.
Erie Canal Coal Company	Boonville	Erie Canal.
Castle Garden Coal Company	Boonville	Castle Garden.

A PRELIMINARY LIST OF THE ARACHNIDA OF INDIANA, WITH KEYS TO FAMILIES AND GENERA OF SPIDERS.

By Nathan Banks.

The material for this paper was largely gathered by W. S. Blatchley and assistants. Several years ago quite a number of specimens were sent me by Dr. Mel. T. Cook, from Greencastle, Putnam County. Later Prof. W. J. Moenkhaus sent me some spiders from Huntingburg, Dubois County; and Mr. A. M. Banta has sent me several small collections from Indiana caves. To these gentlemen should be credited all material from the localities mentioned; but all other locality records are from the collections sent in by Mr. Blatchley.

In these collections I have found 148 species of spiders and 27 other Arachnida. Two of the spiders are new, and are described in this paper. The fauna as a whole is very similar to that of other parts of the northeastern United States; there are, however, minor differences. Some species very common, as *Phidippus multicolor*, are very rare in the eastern states. Phalangida also appear to be more common than in the East. Such common eastern spiders as *Misumena vatia* and *Oxyopes salticus*, appear to be absent, while *Cyclosa caudata* appears from only one locality in two specimens. Where there are peculiar forms, they are of southern origin; that is, species which have spread up the Mississippi Valley.

Under each species I have given a reference to a description, not always, however, the original description. I have also prepared a synoptic table of the families and genera of Indiana spiders. and to make it understandable I have given a brief account of the structure of a spider. Spiders, like many other animals, can only be easily identified in the mature state; therefore one should not attempt to use the tables except on forms showing an exposed vulva in the female, or a developed palpus in the male. Spiders should be collected and preserved in small vials of about 80 per cent. alcohol.

STRUCTURE OF A SPIDER.*

The body of a spider is very plainly divided into two parts; the front part is called the cephalothorax, and the hind part the abdomen. Upon the cephalothorax are several grooves radiating from a central, or dorsal groove; the part of the cephalothorax

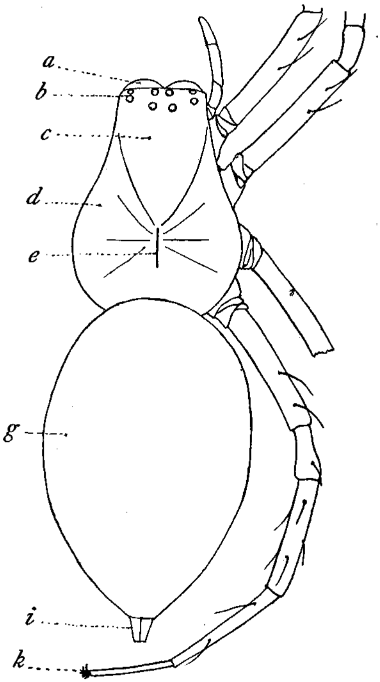


FIG. 1.—*a*, mandible; *b*, eyes; *c*, pars cephalica; *d*, cephalothorax; *e* dorsal groove; *g*, abdomen; *i*, spinnerets; *k*, claws

between the anterior pair of the furrows is called the head. Upon this head are situated the eyes, usually eight in number. They are arranged in two or more transverse rows. References to the eyes are in the form of abbreviations; A. E. for anterior eyes, P. E. for posterior eyes, S. E. for side eyes, M. E. for middle eyes, and various combinations, as P. M. E., posterior middle eyes, etc. In many spiders the eyes are of two colors, dark and light, the dark eyes for use by day, and the pale eyes for night use. The arrangement of the eyes is of the utmost value in the classification of spiders.

*The illustrations for this paper are from an article published in the American Naturalist for May, 1905, entitled "Families and Genera of Araneida." They were kindly loaned by Ginn & Co., Boston, Massachusetts.

The space between the front or lower eye-row and the front margin of the cephalothorax is called the clypeus. Attached just below the clypeus are the mandibles or falces. Each is of two parts, a large basal joint, and a smaller hook-like part, the fang. The mouth parts seen from below are a median piece, the lip or labium, and a piece each side, the maxillae. Each maxilla bears a jointed appendage, the palpus. In the female the palpus is always

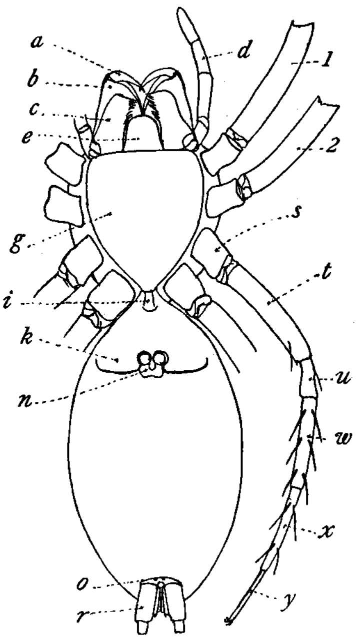


FIG. 2.—*a*, fang; *b*, mandible; *c*, maxilla; *d*, palpus; *e*, lip; *g*, sternum; *i*, pedicel; *k*, epigastric plate; *n*, epigynum; *o*, rima ventralis; *r*, spinnerets; *s*, coxa; *t*, femur; *u*, patella; *w*, tibia; *x*, metatarsus; *y*, tarsus; 1, leg I; 2, leg II.

simple, but in the male, when fully mature, the last joint is enlarged, concave within, and furnished with a number of more or less corneus and curved pieces, which serve as accessory sexual organs. The shape of these male palpi is of great use in the identification of species.

The sternum is the ventral plate of the cephalothorax; it is surrounded by eight legs. The legs are numbered from before backward as follows: I, II, III, IV. Each leg consists of seven parts or joints; each joint from the basal outward is known as follows: coxa, trochanter, femur, patella, tibia, metatarsus, tarsus. At the tip of the tarsus are two claws; sometimes there is a third claw, or a brush of hair between and beneath the paired claws. In a few

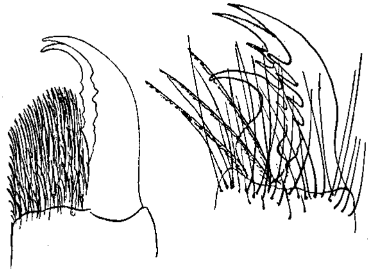


FIG. 3.—Tarsi with two claws and brush, and with three claws.

groups there are specialized branched hairs at the tip of the tarsus which act as accessory claws. Sometimes there is a brush of hairs along the lower side of the tarsus or metatarsus; this is the scopula. Sometimes there is a row of serrate bristles under tarsus IV; this is called a comb.

The abdomen is joined to the cephalothorax by a slender pedicel. At or near the tip of the abdomen are the spinning organs or spinnerets, three pairs of them. In some forms one pair is very plainly two-jointed. At the base of the lower pair there is sometimes a transverse surface provided with spinning tubes similar to those on the spinnerets; this surface is known as the cribellum. Complementary to the cribellum in function is a row of stiff hairs on each posterior metatarsus, known as the calamistrum. Near

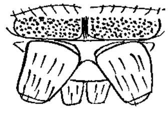


FIG. 4.—Cribellum.

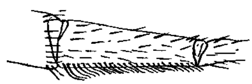


FIG. 4a.—Calamistrum.

the base of the abdominal venter is a transverse slit on each side, these are the lung-slits; in some spiders there are two pairs of these slits. Between these lung-slits is the genital opening; in the female it is conspicious and is known as the epigyrum or vulva. A female spider is not mature till this is exposed.

Table for Families of Indiana Spiders.

1. Two pairs of lung-slits on venter of abdomen; fangs of mandibles moving vertically, parallel to each other.............*Theraphosidæ*

   But one pair of lung-slits on venter of abdomen; fangs of madibles moving more horizontally toward each other..................2

2. With but six eyes; third pair of legs directed forward.....*Dysderidae*

   With eight eyes; third pair of legs directed outward or backward....3

3. Eyes always in three transverse rows; eyes of second row extremely small, and middle eyes of first row very much larger than other eyes; clypeus always vertical; legs rather short; jumping spiders .... *Attidae*

   Eyes in two or three transverse rows; when in three rows, then middle eyes of first row are not greatly larger than other eyes, and those of second row not greatly smaller than other eyes...........4

4. Each tarsus with three claws; legs never laterigrade; spiders making webs 8

   Each tarsus with but two claws, never spinning webs; S. E. rarely contiguous 5

5. P. M. E. large, closer to the small A. S. E. than the latter are to the A. M. E., which are also small; cephalothorax not flattened. *Ctenidae*

   P. M. E. not as close to A. S. E. as latter are to A. M. E., or if so, then eyes of nearly equal size.................................6

6. P. M. E. black; legs I and II laterigrade, that is, articulated so that the anterior surface is directed upward; second pair of legs nearly always as long as the fourth; cephalothorax broad, and rather flattened ....*Thomisidae*

   P. M. E. pale, only A. M. E. dark colored; legs I and II not laterigrade; leg II often shorter than IV............................7

7. Lower spinnerets distinctly separated, rather long and prominent; maxillae with an obliquely transvere furrow or groove; abdomen often depressed ....*Drassidae*

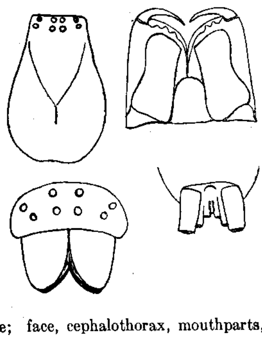


Fig. 5.—Drassidæ; face, cephalothorax, mouthparts, and spinnerets.

   Lower spinnerets contiguous; maxillae usually without the furrow, its outer side convex; abdomen more often cylindrical....*Clubionidae*

8. Eyes in two transverse rows, more or less curved; no scopula to tarsi; P. S. E. never much larger than eyes of front row 9

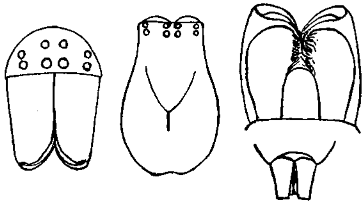


FIG. 6.—Clubionidæ; face, cephalothorax, mouthparts and spinnerets.

Eyes usually in three rows; when in two rows, the P. S. E. are much larger than eyes of the front row, or tarsi are scopulate 15

9. Legs I and II long, with rows of two kinds of spines, one long, the other in between, very short and curved .... *Mimetidae*

No such spine arrangement on the legs 10

10. Upper spinnerets long and two-jointed; the A. M. E. only dark colored .... *Agalenidae*

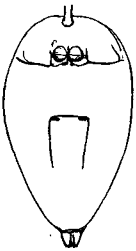


FIG. 7—Venter of Anyphæna.

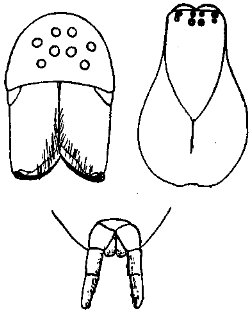


FIG. 8.—Agalenidæ; face, cephalothorax and spinnerets.

Upper spinnerets not long and two-jointed; often other eyes than A. M. E. dark colored; S. E. often contiguous 11

11. Female with cribellum; male with mandibles concave in front and bowed on outside, or else geniculate at base; making irregular webs .... *Dictynidae*

Female without cribellum; male without such mandibles 12

12. A comb on hind tarsus; legs usually without spines; abdomen often globose; maxillae inclined over the tip; clypeus as high as eye-area .... *Theridiidae*

No such comb on tarsus IV; maxillae usually less inclined over lip; spines often present on legs 13

13. At base of mandibles on outer side is a striate or roughened area; clypeus higher than eye-area; no accessory claws to tarsi; male palpal organ with a tarsal hook; making irregular webs .... *Linyphiidae*

At base of mandibles on outer side there is no such striate area, but usually a smooth boss; clypeus not as high as eye-area; accessory claws at tip of tarsi; making orb-webs 14

14. Mandibles large, strongly divergent; abdomen and legs more or less elongate .... *Tetragnathidae*
    Mandibles smaller, not strongly divergent.................. *Epeiridae*
15. Eyes in three rows, those of anterior row very much smaller than the others; clypeus nearly vertical; no spur at tip of tibia of male palpus .... *Lycosidae*
    Eyes in two curved rows; those of anterior row not so much smaller than the others; clypeus sloping; a spur at tip of tibia of male palpus .... *Pisauridae*

Key to Genera of Above Families of Spiders.*

Family Theraphosidae.

Sub-family.

1. Palpus arising from the outer basal side of the maxillae..... *Atypinae*
2. Palpus arising from near or at tip of maxillae.......... Theraphosinae

Sub-family Atypinae.

We have but one genus, *Atypus*, which is rare in the eastern states, with apparently two species. They live in silken tubes which extend some distance above the ground.

Family Dysderidae.

Genera.

1. Leg III directed backward; spines on sides of tibiae IV; tarsi scarcely one-fourth the length of metatarsi; no spines under metatarsi I.. Dysdera
   Leg III directed forward; no spines on sides of tibiae IV; tarsi fully one-third the length of metatarsi; spines under metatarsi I........2
2. The M. E. rather closer to A. S. E. than to P. S. E.......... Segestria
   The M. E. closer to P. S. E. than to A. S. E.................. *Ariadne*

Family Drassidae.

1. Mandibles with a plate or lobe on under side behind the fang; posterior eye-row plainly recurved 2
   Mandibles without such plate, only one or two teeth; posterior eye-row often procurved or straight, rarely a little recurved...........3
2. Posterior eye-row broader than anterior row; P. S. E. not much larger than P. M. E.; head broad............................. Gnaphosa
   Posterior eye-row not broader than anterior row; P. S. E. plainly larger than P. M. E.; head narrow..................... Callilepis
3. No dorsal groove; posterior eye-row slightly recurved; cephalothorax reddish yellow .... *Sergiolus*
   Dorsal groove present; posterior eye-row rarely recurved...........4

*Those genera whose names are printed in italics are represented in the list of spiders taken in Indiana, or are doubtless represented in the State but have not as yet been taken.

4. P. M. E. much nearer to P. S. E. than to each other; cephalothorax and abdomen bivittate ....Cesonia
P. M. E. as near each other as to P. S. E., or at least, abdomen not bivittate 5
5. Upper spinnerets plainly two-jointed, and longer than the lower pair; large dark-colored species; tarsi and metatarsi I, II and III heavily scopulate ....Teminius
Upper spinnerets not plainly two-jointed and not longer than lower pair 6
6. Posterior eye-row slightly recurved; P. M. E. widely separate; no spine above on base of tibia III and IV..........................7
Posterior eye-row straight or procurved...........................8
7. Posterior eye-row plainly broader than anterior row; P. S. E. barely, if any, larger than P. M. E.; S. E. more than diameter apart Pœcilochroa
Posterior eye-row barely longer than anterior row; P. S. E. much larger than P. M. E.; S. E. not diameter apart; smaller spiders Eilica
8. Posterior eye-row plainly procurved, P. M. E. oval................9
Posterior eye-row little if at all procurved, and usually barely longer than anterior row 11
9. Posterior barely longer than anterior row; P. M. E. approximate and larger than P. S. E.............................Megamyrmecion
Posterior row plainly longer than anterior row; P. M. E. rather widely separate 10
10. Two spines above on tibia III and IV...................Drassodes
No spines above on tibiae III and IV.......................*Drassus*
11. P. M. E. large, oval, contiguous or nearly so; no spine above on base of tibiae III and IV; usually with but one or two spines below tibia I...*Zelotes*
P. M. E. smaller, nearly round, and plainly separate; a spine above on base of tibiae III and IV; usually four to six spines below tibia I.. *Herpyllus*
P. M. E. smaller, oval, well separated; no spines above on base of tibiae III and IV; ten spines below on tibia I..........Drassinella

Family Clubionidae.

1. On the venter there is a transverse furrow, remote from spinnerets, representing the openings of the posterior spiracles............10
No such furrow remote from spinnerets..........................2
2. Two rows of large spines under tibiae I and II, more than two in each row 11
Not more than 2-2 spines under tibiae I and II, or else irregularly situate, and banded legs..3
3. Maxillæ impressed with an oblique furrow, as in the Drassidæ, no dorsal groove ....*Micaria*
Maxillæ without furrow, convex; dorsal groove usually present.....4
4. Leg I plainly longer than IV; body and legs pale; spines on legs *Chiracanthium*
Leg I not longer than IV...5

5. No spines on legs, or only a few under tibia I....................6
Spines fairly numerous on legs....................7
6. Posterior eye-row strongly recurved....................*Trachelas*
Posterior eye-row straight ....*Meriola*
7. A. M. E. several times their diameter from clypeal margin; often a horny spot near base of abdomen; legs usually partly dark *Castaniera*
A. M. E. scarcely diameter from clypeal margin; no horny spot on abdomen, legs never dark....................8
8. Lip longer than wide; mandibles long; cephalothorax not mottled. *Clubiona*
Lip broader than long; cephalothorax mottled with brown..........9
9. Anterior eye-row procurved....................*Agroeca*
Anterior eye-row recurved ....Hilke
10. The furrow at or before middle of venter; A. M. E. equal to A. S. E. *Anyphaena*
The furrow behind the middle of venter; A. M. E. smaller than A. S. E....................*Gavenna*
11. Sternum broad, prolonged between hind coxæ; posterior eye-row not recurved, tibia I with five or six pairs of spines below..*Phrurolithus*
Sternum not prolonged between hind coxæ which are nearly contiguous 12
12. Posterior eye-row slightly procurved; five pairs of spines under tibia I Chemmis
Posterior eye-row recurved 13
13. But 3-3 spines under tibia I; two spines above on tibiæ III and IV Syspira
At least 5-5 spines under tibia I....................14
14. Eyes subequal in size; anterior eye-row recurved........Liocranoides
Eyes unequal in size; anterior eye-row not recurved................15
15. A. M. E. smaller than A. S. E.; posterior row weakly recurved Apostenus
A. M. E. larger than A. S. E.; posterior eye-row strongly recurved Zora

Family AGALENIDAE.

1. Spinnerets arranged in one nearly straight transverse row....*Hahnia*

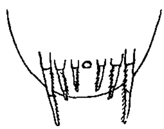


FIG. 9.—Spinnerets of Hahnia.

Spinnerets close together, in two rows....................2
2. But six eyes, the A. M. E. lacking....................Chorizomma
With eight eyes 3
3. Both eye-rows very strongly procurved, so much so that the A. M. E. form a nearly straight line with the P. S. E.; cephalothorax narrow in front....................*Agalena*
Both eye-rows not so strongly procurved....................4

4. A. M. E. much larger than any other eyes; quadrangle of M. E. as broad below as above.......................................*Coras*
   A. M. E. not larger than other eyes; quadrangle usually narrower in front 5
5. Upper spinnerets of but one joint and not longer than lower pair; posterior eye-row straight or even a little recurved; tarsi I plainly more than one-half as long as metatarsus; mandibles geniculate at base *Cybaeus*
   Upper spinnerets of two joints and longer than lower pair...........6
6. Basal spine on outer side under tibiæ I and II not reaching to next spine; larger spiders...7
   Basal spine on outer side under tibiæ I and II reaches to next spine; smaller spiders 8
7. Mandibles plainly geniculate at base; legs less slender........*Coelotes*
   Mandibles not or barely geniculate at base; legs very slender.*Tegenaria*
8. P. M. E. situated fully their diameter apart...............*Cicurina*
   P. M. E. less than diameter apart, and closer to the S. E....Cryphoeca

Family Dictynidae.

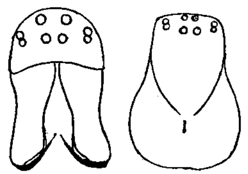


Fig. 10.—Dictynidæ; face and cephalothorax.

1. Legs without spines; cribellum usually undivided in middle by a line..3
   Legs with spines; cribellum divided by a line; clypeus very low.....2
2. Maxillæ inclined over the lip; hind legs unspined............*Titanoeca*
   Maxillæ straight; hind legs with spines.................*Amaurobius*
3. With but six eyes; colors pale..........................Neophanes
   With eight eyes, but A. M. E. are sometimes very small............4
4. Cribellum divided by a line in middle......................Dictynina
   Cribellum undivided 5
5. A. M. E. very minute...6
   A. M. E. subequal to others..7
6. A. M. E. higher than A. S. E.........................Dictyolathys
   A. M. E. between A. S. E.................................Prodalia
7. Lip one-third shorter than maxillæ ....Lathys
   Lip nearly as long as maxillæ..............................*Dictyna*

Family Mimetidae.

Clypeus lower than ocular area; hind legs much shorter than front legs; lip much longer than broad.........................*Mimetus*

Clypeus as high as ocular area; hind legs not much shorter than front legs; lip but little longer than broad............................Ero

Family THERIDIIDAE.

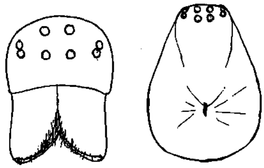


FIG. 11.—Theridiidæ; face and cephalothorax.

1. Abdomen with hard skin and furnished with several humps; small species; sternum truncate behind.......................... *Ulesanis*
   Abdomen without humps and skin soft.......................... 2
2. S. E. widely separate; posterior eye-row recurved................ 3
   S. E. contiguous or nearly so.. 4
3. Leg IV as long as I; abdomen rather flat, and broad behind..Epesinus
   Leg I longer than IV; abdomen globose................*Lathrodectus*
4. P. M. E. fully four times their diameter apart; abdomen prolonged behind; leg IV about as long as I.....................*Spintharus*
   P. M. E. rarely over twice diameter apart........................ 5
5. A. M. E. larger than P. M. E. and much wider apart; clypeus rather high and concave; legs short, IV often as long as I; palpi thick in female 6
   A. M. E. rarely larger than P. M. E., if so then not wider apart..... 7
6. Abdomen pointed behind and somewhat flat................*Euryopis*
   Abdomen more globose, broadly rounded behind............*Dipoena*
7. Cephalothorax with a transverse furrow in the middle; abdomen usually produced above behind, no chitinous pieces at base; leg I longer than IV.. 8
   Cephalothorax with only the ordinary dorsal groove or impression; abdomen not prolonged behind.................................... 9
8. Abdomen very long and slender, vermiform...............Ariamnes
   Abdomen much shorter....................................*Argyrodes*
9. On that part of the abdomen that overhangs the cephalothorax there is a chitinous curved piece each side, in the female not prominent, in the male much more so (they form a stridulating organ); colulus present. Leg I usually but little longer than IV; femur I rarely more than one and one-fourth length of cephalothorax; leg IV usually longer than II.. 10
   No such pieces on base of abdomen, colulus absent; leg I much longer than IV, which is often shorter than II; femur I usually one and one half to twice the length of cephalothorax.................. 17
10. Sternum broadly truncate between coxæ IV; small species..*Crustulina*
    Sternum pointed behind; coxæ IV closer together................ 11
11. S. E. slightly, but distinctly separate, lower eye-row nearly straight; P. M. E. not large, and rather widely separate.......*Lithyphantes*
    S. E. contiguous 12
12. P. M. E. plainly larger than A. M. E.; abdomen not black, with two yellow spots 13
    P. M. E. not larger than A. M. E.............................. 14

13. Leg IV a little longer than I, all short................*Pedanostethus*
Leg IV plainly shorter than I, both long and slender........*Teutana*
14. A. M. E. much larger than A. S. E.; leg I longer than IV...*Steatoda*
A. M. E. not larger than A. S. E...............................15
15. Leg IV plainly longer than I; sternum granulate.............*Asagena*
Leg I a trifle longer than IV....................................16
16. Femur I not one and one-fourth as long as cephalothorax; abdomen rather depressed ....*Enoplognatha*
Femur I nearly twice as long as cephalothorax; abdomen more slender, and in male, constricted near middle...................Coleosoma
17. Sternum truncate between hind coxæ; tarsal claws with few or no teeth; leg I not much longer than IV..........................18
Sternum pointed behind; hind coxæ more approximate; tarsal claws pectinate; abdomen usually globose; leg I often much longer than IV 23
18. No shields or sigillæ on the abdomen..........................19
Shields or sigillæ on abdomen.......................................21
19. Abdomen globose; cephalothorax short and high, narrow in front..20
Abdomen elongate; cephalothorax broad in front; legs banded Ceratinops
20. Tibia I not as long as cephalothorax; cephalothorax very broad; male eyes elevated ....Microdipoena
Tibia I longer than cephalothorax, which is more elongate than preceding .... *Mysmena*
21. Abdomen with shield across base...........................Idionella
Shield not across base 22
22. Abdomen of both sexes with dorsal shield; male with horn from eye-region; no stiff bristles under femur I.................*Histiagonia*
Abdomen of female without dorsal shield, only sigillæ; male without frontal horn; a row of stiff bristles under femur I....Ancylorrhanis
23. Anterior eye-row procurved; tibia of male palpus large; female with abdomen swollen in middle each side....................*Theridula*
Anterior eye-row straight or recurved; tibia of male palpus not enlarged; female not with swollen sides.................*Theridium*

Family LINYPHIIDAE.

1. Cave spiders; no claw at tip of palpus of female..................2
Not cave spiders 4
2. Without eyes; sternum broad..............................*Antrobia*
With eyes 3
3. P. M. E. about as close to P. S. E. as to each other; A. M. E. barely diameter apart ....*Phanetta*
P. M. E. much closer to each other than to P. S. E.; A. M. E. several diameters apart ....*Troglohyphantes*
4. No claw to tarsus of female palpus; epigynum without a finger or hook; male palpus with a tibial apophysis, usually but one spine above on tibia IV..............................(Erigoninæ) 16
A claw to palpus in female; epigynum with a finger or hook; male palpus without a tibial apophysis, although sometimes enlarged or a tooth at tip; usually two spines or erect bristles above on tibia IV (Linyphinæ) 5

5. Legs without spines; mandibles long, and their lower anterior border provided with several long, slender teeth; A. M. E. larger than P. M. E. ....Tapinopa
   Legs with at least a few spines, or not agreeing with above..........6
6. Mandibles long, slender, divergent, in front with 3 pairs of long spines, abdomen depressed and rather broad; P. M. E. less than diameter apart ....Drapetisca
   Mandibles without the 3 pairs of spines in front..................7
7. Tibiæ without lateral spines; metatarsus I not longer than tibia I; usually small spiders 8
   Tibiæ with lateral spines; metatarsus I usually as long as, often longer than, tibia I; larger spiders..........................9
8. Posterior eyes closer together; S. E. on slight tubercles; legs long and very slender ....*Microneta*
   Posterior eyes farther apart; S. E. not on tubercles; legs less slender *Tmeticus*
9. P. M. E. plainly closer to P. S. E. than to each other, and larger than S. E.; femora with few if any spines..................*Neriene*
   P. M. E. not closer to P. S. E. than to each other.................10
10. No spines on metatarsi; P. M. E. rather close together..*Bathyphantes*
   Spines on metatarsi, at least one.................................11
11. P. M. E. very much larger than S. E., two or three times larger, about one diameter apart, and as far from very small S. E., which are no larger than A. M. E.; abdomen slender...............*Linyphiella*
   P. M. E. not much larger than other eyes..........................12
12. P. M. E. at least two diameters apart, or else plainly farther from S. E. than from each other; quadrangle of M. E. plainly wider above than below ....*Linyphia*
   P. M. E. scarcely more than diameter apart, and about as close to P. S. E. 13
13. All femora with some distinct spines.........................14
   All femora not with distinct spines..............................15
14. Tarsus I two-thirds of metatarsus I; quadrangle of M. E. rather narrower below ....*Bolyphantes*
   Tarsus I only one-half of metatarsus I; quadrangle of M. E. as wide below as above ....Labulla
15. Abdomen high and broad at base, tapering to a point behind *Lepthyphantes*
   Abdomen elliptical or even broader beyond middle, not tapering behind ....*Frontinella*
16. Tarsus I only about one-half as long as metatarsus I, male with lobate head ....*Hypselistes*
   Tarsus I two-thirds or more of length of the metatarsus I.........17
17.* Dorsum of male abdomen with a corneous shield; often present also in female 18
   Dorsum of abdomen in both sexes without shield.................20
18. Sternum broadly truncate and slightly concave behind between hind coxæ; usually some corneous pieces on venter; tarsi I but little shorter than metatarsi I................................*Ceratinella*

*Beyond this the table is based on males, although females will frequently run to proper place.

Sternum less broad and somewhat convex behind between hind coxæ; no corneous pieces on venter....19

19. Tarsi I plainly shorter than metatarsi; no hole in side of male head; P. M. E. but little higher than A. M. E....Exechophysis

Tarsi I about as long as metatarsi; a hole in side of head of male; P. M. E. much higher than A. M. E....Lophocarenum

20. Head of male with a horn from middle of eye-region; sternum rather elongate; posterior eye-row strongly procurved....*Cornicularia*

Head of male without such horn; sternum often broad, triangular...21

21. Head of male plainly lobed, or at least with a hole in side behind S. E. 22

Head of male not lobed, nor with a hole in side....26

22. Metatarsus I of male swollen in middle....Caracladus

Metatarsus I normal....23

23. Male with two large and two small tufts of bristles in middle of eye-region; posterior eye-row very strongly procurved....Panamonops

Male without such tufts; posterior eye-row but little procurved....24

24. P. M. E. situate upon top of lobe of male....25

Lobe of male not bearing eyes....Dismodicus

25. Sternum broad, triangular....*Diplocephalus*

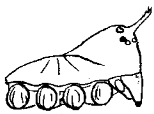


FIG. 11a.—Cephalothorax of Cornicularia

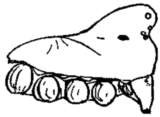


FIG. 11b.—Cephalothorax of Diplocephalus.

Sternum more slender....Walckenæra

26. Male having a horn from middle of clypeus....Delorrhipis

Male without such horn 27

27. Male palpus with enlarged femur; head of male elevated; posterior eye-row slightly recurved; legs slender....Gonatium

Male palpus with femur normal....28

28. A projection below at tip of tibia of male palpus; sides of cephalothorax often with teeth; posterior eye-row slightly recurved..*Erigone*

No such projection to tibia of male palpus....29

29. S. E. situate on a slight elevation, making head broad in front; sternum rather broadly truncate behind between hind coxæ; tibia I shorter than the cephalothorax 30

S. E. not on elevation; sternum narrowly, if at all, produced between hind coxæ 31

30. Two rows of spines under metatarsus IV; female with large lateral spines under tibiæ and metatarsi I and II....Maso

No rows of spines under metatarsus IV, nor under tibiæ and metatarsi I and II ....*Ceratinopsis*

31. Tibia I longer than cephalothorax; legs very slender; sternum narrowly truncate between hind coxæ; head of male elevated..*Notionella*

Tibia I shorter than cephalothorax....32

32. Two rows of spines under tibiæ and metatarsi I and II....Satilatlas

No such spines under these joints....33

33. P. M. E. closer to each other than to P. S. E.; a hump behind eye-region in male .... *Grammonota*
Eyes of posterior row about equidistant; no hump behind eye-region...34
34. Distance between eyes of posterior row not much greater than diameter of an eye 35
Distance between eyes of posterior row more than two diameters of an eye .... Acartauchenius
35. Head of male elevated................................Tiso
Head of male not elevated................................*Gonglydium*

Family Tetragnathidae.

1. Abdomen with a transverse ventral furrow near middle; abdomen not twice as long as broad................................Glenognatha
Abdomen without such furrow................................2
2. Abdomen not twice (or barely) as long as broad, not much longer than cephalothorax ....*Pachygnatha*
Abdomen three or four times as long as broad................................3
3. S. E. as close or closer than M. E................................*Tetragnatha*

Fig. 12.—Cephalothorax of Tetragnatha.

S. E. farther apart than M. E................................4
4. Abdomen projecting beyond spinnerets in a tail................*Eucta*
Abdomen not projecting beyond spinnerets in a distinct tail..*Eugnatha*

Family Epeiridae.

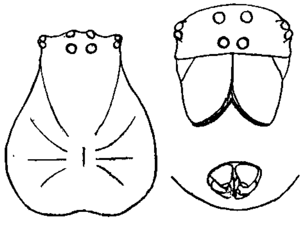


Fig. 13—Epeiridæ; cephalothorax, face and spinnerets.

1. Abdomen with a horny shield, or at least with sigillæ; leg IV longer than I................................2
Abdomen without shield or sigillæ; leg IV shorter than I..........4
2. Spinnerets enclosed at base by a horny ring; abdomen with spines...3
Spinnerets not enclosed by horny ring; abdomen without spines Cercidia
3. Cephalothorax as broad as long; abdomen broader than long Gasteracantha
Cephalothorax and abdomen longer than broad...........*Acrosoma*

4. Cephalothorax bearing spines or tubercles.................*Ordgarius*
   Cephalothorax without spines or tubercles.........................5
5. Posterior eye-row strongly procurved; metatarsus plus tarsus I plainly longer than tibia plus patella I; cephalothorax rather flat.........6
   Posterior eye-row barely, if at all, procurved.....................7
6. A. M. E. nearer to each other than to A. S. E., large species..*Argiope*
   A. M. E. as near to A. S. E. as to each other; small species......*Gea*
7. All metatarsi longer than tibia plus patella; abdomen subcylindric; maxillæ longer than broad; S. E. separate by fully two diameters; legs often with bands of erect hair.......................Nephila
   Metatarsi shorter than tibia plus patella, rarely equal in fore legs; when so, then maxillæ shorter than broad; S. E. approximate, and no bands of erect hair on legs...8
8. Hind femora with a fringe of curved hairs at base; abdomen subcylindric; S. E. approximate; P. M. E. only about twice as far from P. S. E. as from each other; legs very slender and with only a few slender spines ....*Leucauge*
   Hind femora without such fringe of erect, curving hairs at base.....9
9. Cephalothorax much elevated behind, sloping forward to eye-region.10
   Cephalothorax not prominently elevated behind...................11
10. Legs with long spines; P. M. E. less than diameter apart; no tubercles on abdomen ....*Mangora*
    Legs without spines, or very weak ones; P. M. E. fully two diameters apart; abdomen with tubercles.........................Carepalxis
11. Abdomen with a median hump or cone at base, as well as lateral projections; sternum rather long; clypeus high..............*Plectana*
    Abdomen without median together with lateral projections.........12
12. S. E. separated by fully diameter and on separate tubercles.........13
    S. E. contiguous or nearly so, at least upon the same eminence......14
13. P. M. E. small and close together; mandibles slender....Dolichognatha
    P. M. E. equal to others and widely separate ....Azilia
14. P. M. E. scarcely more than one and a half diameter apart, and as close to the P. S. E. as to each other; S. E. slightly separate; all eyes subequal in size; epigynum without a finger.....................15
    P. M. E. much closer to each other than to P. S. E................18
15. Tarsus IV with many serrated bristles beneath; small spider with globose abdomen ....*Theridiosoma*
    Tarsus IV without serrate bristles beneath; larger species; abdomen not globose 16
16. Maxillæ twice as long as broad; mandibles long and slender; abdomen convex above..*Meta*
    Maxillæ not twice as long as broad.................................17
17. Abdomen elliptical, rather depressed, without humps at base....*Zilla*
    Abdomen subcylindric, with two small humps at base.........Hentzia
18. No spines above on tibiæ I and II.................................19
    With some spines, at least one, above on tibiæ I and II............20
19. Abdomen with spines or humps; cephalothorax broad and tumid in front ....Wagneriana
    Abdomen without spines or humps.........................Metazygia

20. Legs very slender, especially leg I, almost destitute of spines; cephalothorax very slender; posterior eye-row strongly recurved....*Acacesia*
Legs less slender and with a number of distinct spines, or else the posterior eye-row not strongly recurved............................21
21. Abdomen pointed at base, elongate, sternum one and one half longer than broad; P. M. E. scarcely diameter apart..............*Larinia*
Abdomen not pointed in middle at base..........................22
22. Abdomen as high behind middle as at base, and elliptical in outline or broader behind middle; P. M. E. about diameter apart; epigynum without finger; small species, with short legs..............*Singa*
Abdomen highest toward base, and usually broadest near base.....23
23. Cephalothorax with a broad transverse furrow (at least in female); abdomen usually prolonged above behind; A. S. E. never twice as far from A. M. E. as latter from each other; quadrangle of M. E. plainly wider below than above; legs more hairy.................*Cyclosa*
Cephalothorax without such furrow; abdomen rarely prolonged above behind; legs more spiny..................................*Epeira*

Family THOMISIDAE.

1. Legs III and IV not or scarcely shorter than legs I and II; tarsi I and II scopulate (at least in females); hairs of body usually branched, prone not erect..............................(Philodrominæ) 2
Legs III and IV much smaller than I and II; tarsi I and II not scopulate; hairs of body, simple, scattered, and erect..(Misumeninæ) 7
2. Leg II very much longer than I; posterior eye-row almost straight; cephalothorax broad ....*Ebo*

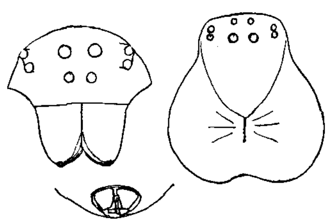


FIG. 14.—Thomisidæ; face, cephalothorax and spinnerets.

Leg II but little longer than I; posterior eye-row very plainly recurved 3
3. Five pairs of spines under tibiæ I and II; P. M. E. nearer to P. S. E. than to each other..............................Philodromoides
Less than 5-5 spines under tibiæ I and II........................4
4. P. M. E. farther apart than from P. S. E.; abdomen not very slender; leg IV shorter than leg I...........................*Philodromus*
P. M. E. not nearer P. S. E. than to each other, or if barely so then leg IV is longer than I......................................5

5. P. M. E. much nearer to each other than to P. S. E.; abdomen long and slender; leg IV longer than I........................*Tibellus*
   P. M. E. about as near P. S. E. as to each other..................6
6. Leg IV shorter than leg I............................*Apollophanes*
   Leg IV longer than leg I.................................*Thanatus*
7. Legs I and II with spines only under tibiæ and metatarsi, at most with one or two very minute ones elsewhere............................8
   Legs I and II with distinct spines elsewhere.....................10
8. Abdomen furnished behind with two prominent conical projections ....Thomisus
   Abdomen without two projections behind..........................9
9. A ridge between eye-rows.................................*Runcinia*
   No ridge between eye-rows...............................*Misumena*
10. Abdomen high and pointed behind; clypeus sloping; tubercle at P. S. E. much larger than at A. S. E..............................*Tmarus*
    Abdomen broadly rounded behind; clypeus more vertical; tubercles of S. E. subequal in size.......................................11
11. Cephalothorax very flat; dark colored species...........*Coriarachne*
    Cephalothorax moderately high...................................12
12. Abdomen, cephalothorax, and legs pale whitish or yellowish, but little marked except bands on legs of males.................*Misumessus*
    Abdomen, or cephalothorax and legs, dark, or heavily marked with dark 13
13. Quadrangle of M. E. higher than broad; tibiæ I and II with 2-2 spines ....*Ozyptila*
    Quadrangle of M. E. not higher than broad.......................14
14. Eyes of lower row equidistant; A. M. E. larger than P. M. E.; tibiæ I and II with 3-3 spines..................................*Synœma*
    A. M. E. nearer to A. S. E. than to each other, and not larger than P. M. E.; tibiæ I and II with 4-4 or 5-5 spines.............*Xysticus*

Family PISAURIDÆ.

Anterior eye-row recurved; quadrangle of M. E. broader behind than high; clypeus about as high as quadrangle of M. E........*Dolomedes*

Anterior eye-row straight; quadrangle of M. E. not broader behind than high; clypeus not as high as quadrangle of M. E....*Pisaurina*

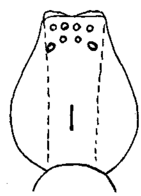


FIG. 15.—Cephalothorax of Pisaurina.

Family Lycosidæ.

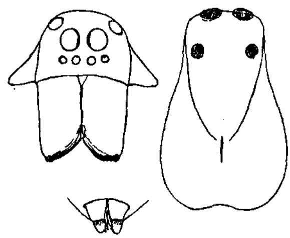


Fig. 16.—Lycosidæ; face, cephalothorax and spinnerets.

1. Tibiæ III and IV with a stout spine at base above..................4
   Tibiæ III and IV without spine at base above, although there may be one near middle above..2
2. No spines above on tibiæ III and IV; long hair above on these joints, head large and high.................................*Geolycosa*
   A spine near middle above on tibiæ III and IV.......................3
3. Upper spinnerets not longer than lower; anterior eye-row not wider than the second.......................................*Trochosa*
   Upper spinnerets longer than lower; anterior eye-row wider than second row; tarsi heavily scopulate.........................Sosippus
4. Cephalic region with a wedge-shaped mark, containing a central stripe; posterior spinnerets longer than others; eyes of second row scarcely their diameter apart, small species.................*Pirata*
   No such mark on cephalic region; spinnerets subequal in length......5
5. Tibia I with 4-4 imbricated spines, the basal ones reaching beyond base of second ones beyond; very small species; eyes of second row not their diameter apart...*Trabea*
   Basal spines on tibia I not reaching beyond base of the third pair, usually but 3-3 spines below.....................................6
6. Cephalothorax without median mark of any kind; spines under tibia I very short, 3-3...*Allocosa*
   Cephalothorax with a paler median stripe or mark.................7
7. Head with sloping sides; eyes of second row usually scarcely diameter apart; usually 3-3 short spines under tibia I, the basal pair rarely reaching next pair; lip longer than broad; larger spiders....*Lycosa*
   Head with more vertical sides; eyes of second row more than diameter apart; 3-3 long spines under tibia I, the basal pair usually reaching next pair; lip not longer than broad; smaller spiders........*Pardosa*

Family Ctenidæ.

A. S. E. nearer to A. M. E. than to either P. S. E. or P. M. E...Titiotus
A. S. E. nearer to P. M. E. or to P. S. E. than to A. M. E......*Ctenus*

Family ATTIDÆ.

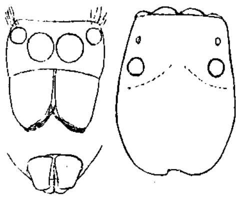


FIG. 17.—Attidæ; face, cephalothorax and spinnerets.

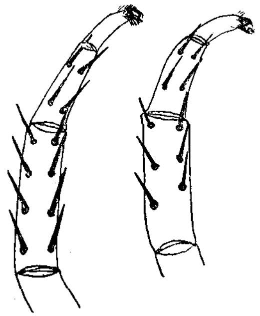


FIG. 18.—Attidæ; two types of spine-arrangement under tibia I.

1. Abdomen more or less constricted; cephalothorax usually constricted; pedicel distinctly chitinized....................................2
   Neither cephalothorax nor abdomen constricted; pedicel soft.........4
2. Leg I plainly thicker than the other legs; cephalothorax only slightly constricted ....*Peckhamia*
   Leg I as slender as others.......................................3
3. Cephalothorax and abdomen very strongly constricted; apical joints of female palpus slender.............................*Synemosyna*
   Cephalothorax and abdomen but little constricted; apical joints of female palpus enlarged.............................*Myrmarachne*
4. Eyes in four rows; pale green spiders..................Lyssomanes
   Eyes in three rows...5
5. No spines under tibia I, or at most with one or two small ones.......6
   Several spines under tibia I.....................................9
6. Cephalic part very long, reaching almost to base of abdomen; leg I plainly thickened.......................................*Homalattus*
   Cephalothorax slopes from before middle to base.................7
7. Leg I plainly heavier than others................................8
   Leg I slender, as the others............................*Salticus*
8. No spines on hind legs...................................*Admestina*
   A few distinct spines on hind legs......................Erematus
9. Leg III as long as or longer than IV, at least in males; usually spines on sides of patellæ III and IV; coxæ I separate by more than width of lip; 2-2 or 3-3 spines under tibia I; legs usually quite hairy.....30
   Leg III plainly shorter than IV.................................10
10. Ocular area occupying fully one half of the cephalothorax, the dorsal eyes situated at its greatest width, and projecting laterally.*Zygoballus*
    Ocular area occupying less than one half of the cephalothorax; or if so, then the cephalothorax is not plainly broader at dorsal eyes than elsewhere 11
11. Tibia I with 4-4 spines below (or less), the basal one of inner series is nearer to base than the first third of tibial length.................12
    Tibia I with 3-3 spines (or less), the basal one of inner series situate one third of tibial length (or greater distance) from base; coxæ I usually widely separate......................................22

12. Metatarsus IV heavily spined near base and middle, both below and on sides; cephalothorax never very low, nor very broad; usually spines on patellæ III and IV....................................17
Metatarsus IV spined only at tip, or with one or two weak spines on sides; never a basal and middle circle of spines.................13
13. Coxæ I approximate; leg I plainly thickened; sternum usually long; usually large species..15
Coxæ I widely separate; leg I barely thickened; sternum short; very small species, with a narrow cephalothorax.....................14
14. Ocular area occupying nearly one half of cephalothorax; as wide in front as behind, dorsal eyes as large as laterals of first row; no spines below on tarsus IV..................................*Neon*
Ocular area less than one half of cephalothorax, rather wider behind; dorsal eyes smaller than laterals of first row; spines below on tarsus IV ....Attidops
15. Abdomen about four times as long as broad; tibia I with 4-4 spines below ....Hyctia
Abdomen much shorter..16
16. Eye-region occupying two-fifths of cephalothorax; the sternum nearly as broad as long, smaller species..........................*Fuentes*
Eye-region occupies about one-third of cephalothorax; the sternum much longer than broad; larger species.................*Marpissa*
17. Tibia I with 4-4 spines below......................................18
Tibia I with less than 4-4 spines below...........................19
18. Ocular area slightly narrower behind than in front; leg IV plainly longer than I..*Mœvia*
Ocular area barely narrower behind; leg I as long as IV....*Plexippus*
19. Cephalothorax rather long; eye-area occupying scarcely one-third of length; tibia I with 3-3 spines..................................20
Cephalothorax shorter; eye-area occupying fully two-fifths of length; coxæ I widely separate..21
20. Basal spine of femora III and IV about one-half as long as the joint; abdomen vittate ....*Phlegra*
Basal spine of femora III and IV much shorter; abdomen not vittate ....Sidusa
21. Patella III as long as IV, no patellar spines...............Euophrys
Patella III shorter than IV, patellar spine present.............*Attus*
22. Cephalic part about two-thirds of cephalothorax, reaching almost to abdomen; legs short, leg I thickened; hind metatarsi spined only at tip ....*Homalattus*
Cephalic part far shorter...23
23. Cephalothorax high, and rather broad; quadrangle of eyes wider behind than in front; large species, rarely under 7 mm.; leg I heavy and very hairy, often with fringes of hair, mandibles often iridescent; often a group of stout bristles near lateral eyes..........*Phidippus*
Cephalothorax not as high and heavy, leg I not so hairy; smaller species, rarely over 6 mm.......................................24
24. A spine above before middle on tibia III and IV, and above on base of metatarsus IV; leg I not thickened; small species..........Attinella
No spines above on tibia III and IV, nor on base of metatarsus IV..25

25. Tibia I with 2-2 large spines, and toward base are two pairs of large bristles with enlarged bases, not obscured by other hairs; metatarsi IV spined throughout, patellæ III and IV with spines; leg I not much thickened .... *Thiodina*
Tibia I without such bristles, distinct from all else, 3-3 spines below ..26
26. Legs with few hairs (except sometimes a brush under tibia I in male), tibia I about three times as long as broad, with very small spines; legs lineate with dark.................................. *Tutelina*
Legs more hairy, tibia I much stouter; legs not lineate (or rarely) with dark 27
27. Cephalothorax much broader than width of dorsal eye-line; tibia and metatarsus I in male elongate; abdomen quite slender; leg I not very heavy; legs III and IV not plainly banded.................. *Wala*
Cephalothorax narrower at dorsal eyes; tibia and metatarsus I not elongate in male...28
28. Cephalothorax plainly depressed; leg I very much thickened, male with horny shield on base of abdomen...................... *Metacyrba*
Cephalothorax higher; male without shield at base...............29
29. Tibia I plainly convex below; legs less hairy; cephalothorax longer *Icius*
Tibia I barely convex below; legs more hairy; cephalothorax shorter *Dendryphantes*
30. Very few spines on hind legs, none above on bases of tibæ III or IV, nor on base above of metatarsus III; quadrangle of eyes wider in front; smaller, less hairy species.................... *Habrocestum*
Hind legs with many spines, often one above on base of either tibia III or IV or both, and a spine above on metatarsus III; quadrangle of eyes usually wider behind........................... *Pellenes*

A List of the Arachnida of Indiana, With Localities.

Order ARANEIDA (Spiders).

Family Theraphosidæ.

1. *Atypus milberti* Walck., Ins. Apt., I, 249, 1837.
From Wyandotte, September 8; New Harmony (Dransfield).

Family Dysderidæ.

2. *Ariadne bicolor* Htz., Spid. U. S., 21, 1875.
From Wyandotte, April 17; Mitchell, April 2; Mecca, April 27.

Family Drassidæ.

3. *Herpyllus ecclesasticus* Htz., Spid. U. S., 90, 1875.
From Greencastle.
4. *Zelotes atra* Htz., Spid. U. S., 91, 1875.
From Wyandotte, April 17.
5. *Sergiolus variegatus* Htz., Spid. U. S., 94, 1875.
From Tippecanoe Lake, June 6.

Family CLUBIONIDÆ.

6. *Agroeca pratensis* Emer., Trans. Conn. Acad., VIII, 190, 1890.
One from Arlington, Marshall County.
7. *Anyphaena gracilis* Htz., Spid. U. S., 86, 1875.
From Hammond, June 16; Veedersburg, May 12 (young).
8. *Chiracanthium inclusum* Htz., Spid. U. S., 85, 1875.
From Vincennes, August 23.
9. *Clubiona abbotii* Koch. Die Arachn. fam. Drassiden, 303, 1867.
One from Arlington, Marshall County, June 10.
10. *Clubiona triloba* n. sp.
Pale yellowish, slightly infuscated with brown on the head, mandibles red-brown. Eye region broad, nearly as broad as in *C. tibialis*, P. M. E. more than two diameters apart and a trfle closer to the

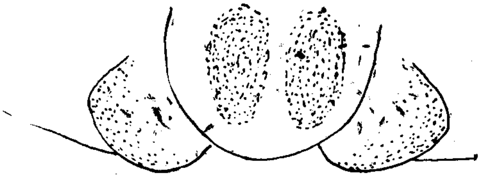


FIG. 19.—Clubiona triloba, vulva.

equal P. S. E.; A. M. E. less than their diameter apart, and a little farther from the nearly equal A. S. E. Legs long and slender, metatarsi I and II scopulate to near base, tibia I and II with 2-2 spines below, tibiæ III and IV with 1-1 spines below, a patch of dense brown hair at tips of metatarsi III and IV below. Abdomen rather slender, pointed at tip; vulva is not as broad as in *C. tibialis*, and shows three lobes behind, the lateral projecting more behind than the median one. Length, 9 mm.
One female from Wyandotte, Indiana; also a female from near Charleston, West Virginia.
11. *Castaneira descripta* Hentz., Spid. U. S., 92, 1875.
From Greencastle.
12. *Castaneira longipalpis* Hentz., Spid., U. S., 93, 1875.
From Tippecanoe Lake, August 17; Knox County, July 2.
13. *Trachelas tranquilla* Htz., Spid. U. S., 89, 1875.
From Tippecanoe Lake, June 8; Greencastle; Huntingburgh.
14. *Phrurolithus alarius* Htz., Spid. U. S., 98, 1875.
From Grand Chain, Posey County, May 12.

Family AGALENIDÆ.

15. *Agalena naevia* Htz., Spid. U. S., 102, 1875.
From Tippecanoe Lake, August 17; Vincennes, August 31; North Vernon, September 14; New Albany, September 11; Clear Lake, August 13; Marion County, May 30 (young); Greencastle; Huntingburgh.
16. *Tegenaria cavicola* Banks, Rept. Ind. State Geol. 1896, 202.
From Salt Petre Cave, Crawford County.

17. *Tegenaria derhami* Scop., Emer., Trans. Conn. Acad., VIII, 29, 1890.
From Wyandotte, September 9; Greencastle, Twin Cave (Banta).

18. *Cicurina arcuata* Keys, Verh. zool. bot. Ges. Wien, 1887, 460.
From Bass Lake, April 9.

19. *Cicurina pallida* Keys, Verh. zool. bot., Ges. Wien, 1887, 462.
From Wyandotte, August 17; Bass Lake, April 9; Putnam County, April 22.

20. *Cicurina brevis* Emer., Trans. Conn. Acad. VIII, 30, 1890.
From Bass Lake, April 9.

21. *Coelotes longitarsis* Emer., Trans. Conn. Acad., VIII, 28, 1890.
From New Harmony, September 3.

21a. *Coras medicinalis* Htz., Spid. U. S., ———, 1875.
Putnam County, April 22.

Family DICTYNIDÆ.

22. *Amaurobius bennetti* Blk., Emer., Trans. Conn. Acad., VII, 451, 1888.
From Truitt's Cave (Banta).

23. *Dictyna sublata* Htz., Spid. U. S., 147, 1875.
From Tippecanoe Lake, June 8; Grand Chain, June 3; Vawter Park, June 1.

24. *Dictyna frondea* Emer., Trans. Conn. Acad., VII, 449, 1888.
From Hammond, May 29; Arlington, Marshall Co., June 10.

Family MIMETIDÆ.

25. *Mimetus interfector* Htz., Spid. U. S., 138, 1875.
From Shoals, May 16 (young).

Family THERIDIIDÆ.

26. *Theridium tepidariorum* Koch., Emer., Trans. Conn. Acad., VI, 13, 1882.
From Kosciusko County; Greencastle.

27. *Theridium porteri* Banks, Rept. State Geol. Ind., 1896, 203.
From Porter's and Truitt's caves; have also seen this species from caves in Texas.

28. *Theridium kentuckyense* Keys, Die Spinn. Amer., II (1), 78, 1884.
From Mayfield's Cave and Twin Cave (Banta).

29. *Theridium spirale* Emer., Trans. Conn. Acad., VI, 10, 1882.
From Pine, Lake County, May 25.

30. *Theridium frondeum* Htz., Spid. U. S., 146, 1875.
From Vincennes, July 10; Grand Chain, June 3.

31. *Theridium differens* Emer., Trans. Conn. Acad., VI, 9, 1882.
From Arlington, June 10; Bass Lake, June 17.

32. *Theridium murarium* Emer., Trans. Conn. Acad., VI, 11, 1882.
From Hammond, June 16; Arlington, June 10.

33. *Lathrodectus mactans* Fabr., Keys, Die Spinn. Amer., II (1), 145, 1884.
From Wyandotte, September 9; Mitchell, July 15; North Vernon, September 14; Shoals, April 22 (young); New Albany, May 5; Greencastle; Huntingburgh.

34. *Steatoda borealis* Htz., Spid. U. S., 145, 1875.
From Greencastle.

34a. *Euryopis funebris* Htz., Spid. U. S., ———, 1875.
New Harmony, June 4.

35. *Pedanostethus riparius* Keys, Die Spinn. Amer., II (2), 126, 1886.
From Knox County, May 26.

36. *Asagena americana* Emer., Trans. Conn. Acad., VI, 23, 1882.
From Wyandotte, April 17.

37. *Argyrodes trigonum* Htz., Spid. U. S., 152, 1875.
From Twin Cave, April (Banta).

Family LINYPHIIDÆ.

38. *Gonglydium tridentatus* Emer., Trans. Conn. Acad., VI, 53, 1882.
From Porter Cave, Owen County.

39. *Erigone infernalis* Keys, Die Spinn. Amer., II (2), 180, 1886.
From Twin Cave, November 9 (Banta).

40. *Erigone longipalpus* Emer., Trans. Conn. Acad., VI, 59, 1882.
From Arlington, June 10.

41. *Bolyphantes lineata* Keys, Die Spinn. Amer., II (2), 64, 1886.
From Greencastle.

42. *Linyphia phrygiana* Koch, Die Arachn., III, 83, 1836.
From Culver, June 29.

43. *Linyphia marginata* Koch, Emer., Trans. Conn. Acad., VI, 61, 1882.
From Arlington, June 10; Wyandotte, April 17; Greencastle.

44. *Willibaldia cavernicola* Keys, Die Spinn. Amer., II (2), 123, 1886.
From Donnelson's Cave, November 9 (Banta).

45. *Phanetta subterranea* Emer., Amer. Nat., IX, 279, 1875.
Described from Wyandotte Cave; from Truitt's Cave, April 1 (Banta).

46. *Nesticus carteri* Emer., Amer. Nat., IX, 279, 1875.
From Bradford Cave (Emerton); Marengo Cave (Banta); Porter, Coon and Marengo caves (Blatchley).

Family TETRAGNATHIDÆ.

46a. *Pachygnatha tristriata* Koch.
New Harmony, June 4.

47. *Tetragnatha extensa* Linn., Emer., Trans. Conn. Acad., VI, 333, 1884.
From Tippecanoe Lake, June 6, 8; Vincennes, July 10; Grand Chain, July 8; Culver, June 29; Knox County, July 2.

48. *Tetragnatha grallator* Htz., Spid. U. S., 131, 1875.
From Tippecanoe Lake, June 6, 8; Arlington, June 10; Kosciusko County; Huntingburgh.

49. *Tetragnatha laboriosa* Htz., Spid. U. S., 131, 1875.
From Tippecanoe Lake, June 6; Hammond, June 16; May 29; July 30; Arlington, June 10; Wyandotte, June 25; Mitchell, April 2 (young); Grand Chain, June 3; Attica, June 20; Vawter Park, June 1; Pine. Lake County, May 25; Wilders, July 25; Greencastle.

50. *Eugnatha straminea* Emer., Trans. Conn. Acad., VI, 335, 1884.
From Tippecanoe Lake, June 6.

Family EPEIRIDÆ.

51. *Theridiosoma gemmosum* Cambr., Emer., Trans. Conn. Acad., VI, 320, 1884.
From Mayfield's Cave (Banta).

52. *Leucauge hortorum* Htz., Spid. U. S., 118, 1875.
From Arlington, June 10; Grand Chain, May 12; Greencastle.

53. *Meta menardi* Latr., Emer., Trans. Conn. Acad., VI, 328, 1884.
From Mitchell, July 15; Greencastle; Strong's Cave (Banta); Twin Cave, April 2 (Banta); Mayfield's, Strong's, Donnehue's, Donnelson's, Clifty, Wyandotte and Salt Petre caves (Blatchley).

54. *Cyclosa caudata* Htz., Spid. U. S., 126, 1875.
From Greencastle.

55. *Argiope transversa* Emer., Trans. Conn. Acad., VI, 330, 1884.
From Greencastle.

56. *Argiope aurantia* Lucas, Emer., Trans. Conn. Acad., VI, 329, 1884.
From Lake Maxinkuckee, August 7; Greencastle.

57. *Mangora placida* Htz., Spid. U. S., 115, 1875.
From Wyandotte, June 26; New Harmony, May 6.

58. *Acacesia foliata* Htz., Spid. U. S., 116, 1875.
From Grand Chain, July 8 (young); Greencastle.

59. *Singa hentzi n. sp.*

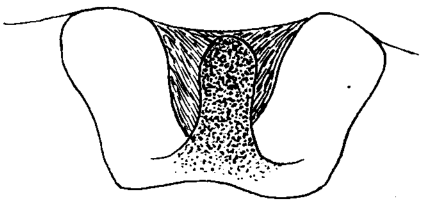


FIG. 20.—Singa hentzi, vulva.

Cephalothorax blackish brown, with a pale median stripe, narrowed behind, and in its middle an elongate white spot; median eyes surrounded by black; mandibles pale, with a blackish spot at base; sternum and mouth parts black, but the tips of the labium and maxillae whitish. Coxæ pale, legs pale, a narrow black band on extreme base of femora, a broad, black band almost reaching to tip of femora, a black band covering the apex of patellæ and base of tibiæ, a broad, black band on middle of tibiæ, basal and median bands on the metatarsi, and a basal band on tarsi; palpi banded with black. Abdomen with a large black mark above, with irregular edges, and margined with silvery white; venter with a broad, black field in the middle, a whitish stripe each side and lower sides with a black stripe. Both M. E. closer to each other than to S. E., quadrangle of M. E. as broad behind as long, and plainly narrower in front. Length, 4.2 mm.

One female from Cannelton, Indiana, May 31. Differs from *S. modesta* Bks., by black sternum and more banded legs; from *S. singaeformis* Sch., by colors of cephalothorax and abdomen above.

60. *Singa nigripes* Keys, Verh. zool. bot. Ges. Wien, 1883, 655.
From Grand Chain, May 12.

61. *Singa variabilis* Emer., Trans. Conn. Acad., VI, 322, 1884.
From Tippecanoe Lake.

62. *Epeira angulata* Clerck., Emer., Trans. Conn. Acad., VI, 299, 1884.
From Greencastle.

63. *Epeira displicata* Htz., Spid. U. S., 117, 1875.
From Tippecanoe Lake, June 6; Grand Chain, June 3; Attica, June 20; Shoals, May 16; Vawter Park, June 1.

64. *Epeira domiciliorum* Htz., Spid. U. S., 108, 1875.
From Grand Chain, July 8; Greencastle; Huntingburgh.

65. *Epeira globosa* Keys, Verh, zool.-bot. Ges. Wien, 1865, 820.
From Greencastle.

66. *Epeira infumata* Htz., Spid. U. S., 122, 1875.
From Grand Chain, June 3 (young).

67. *Epeira insularis* Htz., Spid. U. S., 109, 1875.
From Vincennes, August 23; Mitchell, July 13; Montezuma, August 12; Marion County, May 30; Greencastle.

68. *Epeira labyrinthea* Htz., Spid. U. S., 111, 1875.
From Greencastle.

69. *Epeira prompta* Htz., Spid. U. S., 115, 1875.
From Tippecanoe Lake, June 6; Hammond, June 16; Vincennes, July 10, August 23; Arlington, June 10; Wyandotte, June 25; Bass Lake, June 22, 20; Grand Chain, July 8, June 3 (young); Attica, June 20; Vawter Park, June 1; Pine, June 29; Culver, June 29; Knox County, July 2.

70. *Epeira sclopetaria* Clerck., Emer., Trans. Conn. Acad., VI, 303, 1884.
From Greencastle.

71. *Epeira strix* Htz., Spid. U. S., 112, 1875.
From Tippecanoe Lake, August 17; Vincennes, November 26; Arlington, June 10; Grand Chain, July 8; Vawter Park, June 1; Culver, June 29; Knox County, July 2; Jeffersonville, June 23; Greencastle.

72. *Epeira thaddeus* Htz., Spid. U. S., 113, 1875.
From Greencastle.

73. *Epeira trifolium* Htz., Spid. U. S., 110, 1875.
From Culver, August 22; Greencastle.

74. *Epeira trivittata* Keys, Sitz. Ibis, Dresden, 1864, 95.
From Tippecanoe Lake, June 6, 8; Hammond, July 30, May 29; Vincennes, August 23; Arlington, June 10; Wyandotte, June 26; Bass Lake, June 17, 22, 20; Culver, June 29, August 22; Wilders, July 25; Greencastle.

75. *Epeira verrucosa* Htz., Spid. U. S., 121, 1875.
From Vincennes, July 10; Wyandotte, September 9; Montezuma, August 12; Knox County, July 2 (young); Greencastle.

76. *Plectana stellata* Htz., Spid. U. S., 125, 1875.
From Vincennes, July 10; Bass Lake, June 20; Grand Chain, July 8; North Vernon, September 14; Greencastle.

77. *Ordgarius cornigerus* Htz., Spid. U. S., 123, 1875.
From Greencastle.

78. *Acrosoma rugosa* Htz., Spid. U. S., 124, 1875.
From Wyandotte, September 9; Greencastle.

79. *Acrosoma mitrata* Htz., Spid. U. S., 125, 1875.
From Greencastle.

80. *Acrosoma spinea* Htz., Spid. U. S., 123, 1875.
From Vincennes, July 10; Wyandotte, July 25, June 26; Mitchell. July 15; Greencastle.

Family THOMISIDÆ.

81. *Tibellus duttoni* Htz., Spid. U. S., 81, 1875.
From Pine, Lake County, October 29 (young); Kosciusko County.

82. *Tibellus oblongus* Walck., Keys, Die Spinn. Amer., I, 196, 1880.
From Wilders, July 25; Greencastle.

83. *Philodromus vulgaris* Htz., Spid. U. S., 76, 1875.
From Tippecanoe Lake; Bass Lake, June 17, April 9 (young); Grand Chain, July 8, June 3; Pine, October 29 (young); Knox County, July 2; Greencastle.

84. *Philodromus ornatus* Banks, Proc. Acad. Nat. Sci. Phil., 1892, 61.
From Arlington, June 10; Wilders, July 25.

85. *Philodromus aureolus* Clerck. Keys., Die Spinn. Amer., I, 217, 1880.
From Hammond, June 16; Vincennes, August 23; Knox County, July 2.

86. *Philodromus rufus* Walck., Keys., Die Spinn. Amer., I, 217, 1880.
From Tippecanoe Lake, June 6; Arlington, June 10.

87. *Philodromus placidus* Banks, Proc. Acad. Nat. Sci. Phil., 1892, 62.
From Vincennes, July 10; Arlington, June 10; Grand Chain, July 8, May 12; Pine, June 29; Culver, June 29.

88. *Misumessus oblongus* Keys., Die Spinn. Amer., I, 79, 1880.
From Veedersburg, May 12 (young); Vawter Park, June 1; Greencastle.

89. *Misumessus asperatus* Htz., Spid. U. S., 79, 1875.
From Wyandotte, April 17, June 23, September 20; New Harmony, May 6; Pine, May 25; Huntingburgh.

90. *Misumena americana* Keys., Die Spinn. Amer., I, 85, 1880.
From Bass Lake, June 17; Grand Chain, June 3; Attica, June 20; Culver, June 29; Knox County, July 2; Greencastle.

91. *Runcinia aleatoria* Htz., Spid. U. S., 77, 1875.
From Lake James, May 8; Hammond, July 30; Grand Chain, September 5; Greencastle.

92. *Coriarachne versicolor* Keys., Die Spinn. Amer., I, 53, 1880.
From Wyandotte, April 17; Grand Chain, April 19; Mecca, April 27; New Albany, May 4; Greencastle.

93. *Ozyptila conspurcata* Thor., Bull. Geol. Surv. Terr., III, No. 2, 496, 1877.
From Cypress Swamp, September 25; Pine, October 29; Knox County, May 26.

94. *Synœma parvula* Htz., Spid. U. S., 80, 1875.
From Arlington, June 10; Grand Chain, May 12; Veedersburg, May 12; Culver, June 29.

95. *Xysticus triguttatus* Keys., Die Spinn. Amer., I, 12, 1880.
From Hammond, July 30; Wilders, July 25.

96. *Xysticus transversus* Bks., Proc. Acad. Nat. Sci. Phil., 1892, 54.
From New Harmony, February 23 (not quite adult).

97. *Xysticus stomachosus* Keys., Die Spinn. Amer., I, 28, 1880.
From Vincennes, August 23; Arlington, June 10 (young); Wyandotte, July 25 (young); Bass Lake, June 22 (young); Culver, June 29; Greencastle.

98. *Xysticus gulosus* Keys., Die Spinn. Amer., I, 43, 1880.
From Wilders, July 25; Greencastle.

99. *Xysticus nervosus* Banks, Proc. Acad. Sci. Phil., 1892, 55.
From Tippecanoe Lake, June 6; Culver, June 29; Greencastle.

100. *Xysticus quadrilineatus* Keys., Die Spinn. Amer., I, 42, 1880.
From Kosciusko County.

Family Pisauridæ.

101. *Pisaurina undata* Htz., Spid. U. S., 42, 1875.
From Arlington, June 10; Bass Lake, June 20; Shoals, July 13 (young); Culver, June 29; Greencastle; Huntingburgh.

102. *Pisaurina subinflata* Htz., Spid. U. S., 161, 1875.
From New Harmony, September 3; North Vernon, April 14 (young).

103. *Dolomedes urinator* Htz., Spid. U. S., 40, 1875.
From Mitchell, April 2 (young); Donnelson's Cave.

104. *Dolomedes tenebrosus* Htz., Spid. U. S., 38, 1875.
From Wyandotte, July 25 (young); Bass Lake, October 10 (half grown), April 9; Mitchell, July 15; Medora, September 24; Cypress Swamp, September 25 (young); Knox County, May 26 (young); Lake Maxinkuckee, August 7 (young); Gibson County, September 1; Wilders, July 25; Greencastle.

105. *Dolomedes sexpunctatus* Htz., Spid. U. S., 41, 1875.
From Tippecanoe Lake, June 6; Greencastle.

Family Lycosidæ.

106. *Lycosa avara* Keys., Vehr. zool.-bot. Ges. Wien, 1876, 661.
From North Vernon, May 7.

107. *Lycosa carolinensis* Walck., Emer. Trans. Conn. Acad., VI, 486, 1885.
From Wyandotte, July 25; North Vernon, September 14; Laporte County, August 26.

108. *Lycosa erratica* Htz., Spid. U. S., 29, 1875.
From Hammond, May 7 (young).

109. *Lycosa fatifera* Htz., Spid. U. S., 26, 1875.
From Wyandotte, September 8, May 27 (with cocoon); Bass Lake, October 10; New Harmony, September 3; Culver, August 22; Marion County, May 30.

110. *Lycosa frondicola* Emer., Trans. Conn. Acad., VI, 484, 1885.
From Mitchell, August 28; North Vernon, April 14 (young); New Albany, May 4; Huntingburgh.

111. *Lycosa gracilis* Banks, Proc. Acad. Nat. Sci. Phil., 1892, 70.
From Wyandotte, April 17.

112. *Lycosa helluo* Walck., Emer., Trans. Conn. Acad. Sci., VI, 482, 1885.
From Tippecanoe Lake, June 6; Arlington, June 10; Bass Lake, April 9; Mitchell, August 28 (young); Grand Chain, May 12, June 3; Medora, September 24; Mecca, April 27; Jeffersonville, June 23 (young); Marion County, May 30; Huntingburgh.

113. *Lycosa kochi* Keys., Verh. zool.-bot. Ges. Wien, 1876, 636.
From Tippecanoe Lake, August 17; Wyandotte, September 8 (young), 9; Bass Lake, October 10; Grand Chain, September 5; Medora, September 24; Huntingburgh.

114. *Lycosa ocreata* Htz., Spid. U. S., 33, 1875.
From Tippecanoe Lake, June 8, August 17; Mitchell, July 15; Vawter Park, June 1; Laporte County, August 26.

115. *Lycosa pratensis* Emer., Trans. Conn. Acad., VI, 483, 1885.
From Vincennes, April 25 (young); Wyandotte, August 17 (young); Bass Lake, April 10; Medora, September 24; Pine, October 29.

116. *Lycosa punctulata* Htz., Spid. U. S., 31, 1875.
From North Vernon, September 14; Greencastle.

117. *Lycosa scutulata* Htz., Spid. U. S., 32, 1875.
From Mitchell, August 28; Greencastle; Huntingburgh.

118. *Pardosa lapidicina* Emer., Trans. Conn. Acad., VI, 494, 1885.
From Kosciusko County.

119. *Pardosa flavipes* Keys., Verh. zool.-bot. Ges. Wien, 1876, 616.
From Bass Lake, April 10 (young); Jeffersonville, June 23 (young); Huntingburgh.

120. *Pirata insularis* Emer., Trans. Conn. Acad., VI, 492, 1885.
From Hammond, May 7.

121. *Pirata piratica* Clerck., Emer., Trans. Conn. Acad., VI, 492, 1885.
From Clear Lake, August 13; Knox County, May 26.

122. *Allocosa funera* Htz., Spid. U. S., 34, 1875.
From Knox County, July 2.

123. *Trochosa cinerea* Fabr., Emer., Trans. Conn. Acad., VI., 488, 1885.
From Hammond, June 16; Grand Chain, September 5; Pine, May 25; Greencastle.

Family Ctenidæ.

124. *Ctenus punctulatus* Htz., Spid. U. S., 35, 1875.
From Wyandotte, April 17 (young); September 8.

Family Attidæ.

125. *Phidippus putnami* Peck, Att. N. A., 35, 1888.
From Knox County, July 2; Grand Chain.

126. *Phidippus cardinalis* Htz., Spid. U. S., 51, 1875.
From North Vernon, September 14.

127. *Phidippus multicolor* Htz., Spid. U. S., 53, 1875.
From Vincennes, July 10; Wyandotte, June 25, 26; Grand Chain, July 8; Shoals, July 13; Greencastle.

128. *Phidippus audax* Htz., Spid. U. S., 50, 1875.

From Arlington, June 10; Bass Lake, June 22; New Harmony, May 6; September 3; Grand Chain, May 12, June 3; Attica, June 20; North Vernon, May 7; Culver, June 29; Greencastle; Huntingburgh.

129. *Phidippus rufus* Htz., Spid. U. S., 60, 1875.
From Vincennes, July 10; Wyandotte, September 9; Bass Lake, June 17; Grand Chain, July 8; Wilders, July 25; Huntingburgh.

130. *Phidippus insigniarius* Koch., Die. Arachn., XIII, 150, 1846.
From Hammond, June 16; Arlington, June 10.

131. *Philaeus rimator* Peck, Att. N. Amer., 32, 1888.
From Greencastle.

132. *Dendryphantes rarus* Htz., Spid. U. S., 62, 1875.
From Greencastle.

133. *Dendryphantes militaris* Htz., Spid. U. S., 62, 1875.
From Wyandotte, June 25; Mitchell, July 15.

134. *Dendryphantes octavus* Htz., Spid. U. S., 70, 1875.
From Hammond, June 16, May 29, July 30; Arlington, June 10; Wyandotte, June 25, 26; Bass Lake, June 22; Grand Chain, May 12, June 3; Attica, June 20; Shoals, May 16; Veedersburg, May 12; Vawter Park, June 1; Pine, June 29; New Albany; Culver, June 29.

135. *Phlegra leopardus* Htz., Spid. U. S., 63, 1875.
From New Harmony, September 3.

136. *Habrocestum pulex* Htz., Spid. U. S., 65, 1875.
From Wyandotte, September 8.

137. *Thiodina retarius* Htz., Spid. U. S., 161, 1875.
From Wyandotte, June 25, July 25; Grand Chain, June 3; New Albany; Huntingburgh.

138. *Mævia vittata* Htz., Spid. U. S., 64, 1875.
From Arlington, June 10; New Albany.

139. *Marpissa undata* De Geer, Peck, Att. N. Am., 80, 1888.
From Greencastle; Huntingburgh.

140. *Wala mitrata* Htz., Spid. U. S., 68, 1875.
From Arlington, June 10; Grand Chain, July 8, May 12, June 3; Shoals, May 16; Veedersburg, May 12; Vawter Park, June 1; Shoals, July 13.

141. *Wala palmarum* Htz., Spid. U. S., 71, 1875.
From Hammond, June 16, May 29, July 30; Arlington, June 10; Pine, May 25.

142. *Tutelina elegans* Htz., Spid. U. S., 56, 1875.
From Hammond, May 29; Arlington, June 10; Bass Lake, June 22; Shoals, May 16; Culver, June 29; Knox County, July 2.

143. *Zygoballus bettini* Peck, Att. N. Amer., 89, 1888.
From Knox County, July 2.

144. *Homalattus cyaneus* Htz., Spid. U. S., 69, 1875.
From Hammond, June 16.

145. *Synemosyna formica* Htz., Spid. U. S., 73, 1875.
From Arlington, June 10; Culver, June 29.

Order PHALANGIDA. (Harvestmen or "Daddy Long-legs.")

146. *Oligolophus pictus* Wood., Comm. Essex Inst., VI, 21, 1869.
From Tippecanoe Lake, June (young), August 19; Vincennes, August 23 (young); Knox County, July 2.

147. *Hadrobunus grande* Say, Wood, Comm. Essex Inst., VI, 25, 1869.
From Tippecanoe Lake, August 19; Wyandotte, September 8; Bass Lake, June 20 (young); Mitchell, August 28; New Harmony, September 5; Culver, June 29; Knox County, May 26 (young).

148. *Liobunum ventricosum* Wood, Comm. Essex Inst., VI, 23, 1869.
From Clear Lake, August 13.

149. *Liobunum calcar* Wood, Comm. Essex Inst., VI, 17, 1869.
From Bass Lake, June 17; Arlington, June 26.

150. *Liobunum vittatum* Say, Wood, Comm. Essex Inst., VI, 11, 1869.
Tippecanoe Lake, August 19; Wyandotte, June 25 (young), September 8; New Harmony, September 3; Grand Chain, July 8; Montezuma, July 22; New Albany, June 23; Arlington, June 26; Knox County, July 2; Culver, August 22.

151. *Liobunum formosum* Wood, Comm. Essex Inst., VI, 21, 1869.
From New Harmony, April 23 (young); Grand Chain, April 19 (young); Putnam County, April 22 (young).

152. *Liobunum politum* Weed, Bull. Ill. St. Lab. Nat. Hist., III, 89, 1889.
From Tippecanoe Lake, August 19; Wyandotte, September 8.

153. *Liobunum nigripes* Weed, Trans. Amer. Ent. Soc., XIX, 190, 1892.
From New Harmony, September 3; Arlington, June 26.

154. *Cynorta sayi* Simon., Ann. Soc. Ent. Belg., XXII, 200, 1879.
From Wyandotte, September 8, August 17; Cannelton, May 31; New Albany, May 4.

155. *Scotolemon flavescens* Cope, Amer. Nat., VI, 420, 1872.
From Clifty Cave; recorded also from Wyandotte Cave.

Order PSEUDOSCORPIONIDA. (Chelifers.)

156. *Chthonius packardi* Hag., Zool. Anzeiger, July, 1879, II, 399.
From Wyandotte Cave.

157. *Chelanops oblongus* Say, Ed. Lec., II, 12.
Wells County, April 10; Marion County, March 14.

158. *Chelanops sanborni* Hagen., Amer. Ent., 1868, 51.
Marion County, April 17.

158a. *Chelanops pallidus* Banks.
Lawrence County, May 9.

Order ACARINA. (Mites.)

159. *Rhagidia cavicola* Banks, Amer. Nat., 1897, 382.
From Twin Cave (Banta).

160. *Cheyletus clavispinus* Banks, Canad. Entom., 1902, 172.
From Indianapolis.

161. *Trombidium locustarum* Riley, Banks, Trans. Amer. Ent. Soc., XXI, 213, 1894.
From Wyandotte, April 17; Putnam County, April 22.

162. *Trombidium sericeum* Say, Banks, Trans. Amer. Ent. Soc., XXI, 212, 1894.
From Hammond, May 7; New Harmony, February 23; Mecca, April 27.

162a. *Bryobia pratensis* Garman, Insect Life, III, 45.
Indianapolis, April 14.

163. *Rhyncholophus longipes* Banks, Trans. Amer. Ent. Soc., XXI, 215, 1894.
From Bass Lake, April 9.

163a. *Caeculus clavatus* Banks.
Lawrence County, May 9.

164. *Celaenopsis americana* Banks, Proc. Ent. Soc. Wash., VII, 137, 1906.
From Indianapolis.

165. *Ixodes scapularis* Say, Compl. Writ., Leconte Ed., II, 21, 1859.
One male from Indianapolis.

166. *Galumna imperfecta* Banks, Proc. Phil. Acad. Nat. Sci., 1906.
Marion County.

167. *Galumna emarginata* Banks.
Putnam County, April 22.

168. *Liacarus nitidus* Banks.
Putnam County, April 22.

169. *Phthiracarus arctatus* Riley, Sixth Mo. Rept., 1874, 52.
Lake County, June 11.

Literature on Spiders.

The best book for a beginning student of spiders is Emerton's "Our Common Spiders," published by Ginn & Company, Boston. Other papers on the classification of American spiders are as follows:

Banks, N.
'92. A Classification of the North American Spiders. *Can. Entom.*, vol. 24, pp. 88-98.

Cambridge, F. O. P.
'97-: '05. Arachnida-Araneida, vol. 2. *Biologia Centrali-Americana*, London.

Comstock, J. H.
:'03. A Classification of North American Spiders. Ithaca, N. Y.; 55 pp.

Peckham, G. W. and E. G.
'88. Attidæ of North America. *Trans. Wisc. Acad Sci.*, vol. 7, 104 pp.

NOTES ON THE CRAYFISH OF WELLS COUNTY, INDIANA, WITH DESCRIPTION OF A NEW SPECIES.

By E. B. Williamson.

The purpose of this brief paper is to make a permanent record of the species of crays at present to be found in this county and to note some facts in their life histories under local conditions. Some habits hitherto unmentioned or at variance with published statements have been observed and it is believed that these are to be explained by the present environment. The desirability of making record of the present members of the fauna is evident, when the certain ultimate effect of draining and clearing, of stream pollution and diminution is considered.

Some streams in this locality where crays formerly abounded have been so changed that they no longer afford a home for these crustaceans. Undrained fields where burrows formerly existed by hundreds have been drained and pastured, and the burrows have disappeared. Crays formerly occurred commonly in the town of Bluffton in localities where cement walks, asphalt pavements and storm and sanitary sewers now cheer the cultured and refined. The certain decline of the fauna in the future, if it has not already been marked in the past, is too evident to call for remark, however. This is a very level county, practically every square foot of which is tillable. The few permanent streams have had the constituents of their waters vastly altered by drainage of swamps, clearing of forests, and by direct pollution.

The six species occurring in the county fall into three of the five subgenera proposed by Ortmann (Proc. Amer. Phil. Soc., vol. XLIV, 1905, and Annals of the Carnegie Museum, vol. III, No. 3, 1905.)

These three subgenera, with their Wells County species, are: *Cambarus acutus* Girard, *Faxonius rusticus* (Girard), *Faxonius immunis* (Hagen), *Bartonius ortmanni* n. sp., *Bartonius diogenes* (Girard), and *Bartonius argillicola* (Faxon).

Cambarus acutus Girard. In Wells County this species finds its most congenial environment in woodland swamps, though it has been taken frequently from ditches and creeks and one female was taken in the Wabash River on September 26, 1905. Its habits early in the spring make it a ready victim of raccoons. At a swamp on the farm of Hiram Vanemon, south of Bluffton, the feces of raccoons, found in large quantities about two or three stumps, were composed almost entirely of hard bits of this cray. On March 26, 1906, the species was taken in swamps near Craigville and abundantly in the Vanemon swamp, mentioned above, where specimens of all sizes were associated. On this date and on March 28 females were carrying recently hatched young. In Blackford County is a large swamp near the nitro-glycerine factory just north of Hartford City. This old swamp, formerly surrounded by forests, lies now in a wilderness of sedges, bidens, and button-bushes. Here *acutus* is abundant. On June 11, 1905, they fled in numbers before the intruder who waded the swamp. On June 25, two weeks later, but few were seen and most of these were recently moulted. On September 9 not an individual was to be found in open water, but about 60 specimens were collected from burrows. About this swamp the burrows of this species are short and of large diameter, usually closed with a small flattened mound of homogeneous earth. Their direction is usually oblique or nearly horizontal for a short distance, then descending vertically. The terminal pocket is scarcely evident. They average about two feet in length, though some are half this length and others reach a length of three or four feet, the increase above the ordinary length being usually in the horzontal portion of the burrow. The burrows are placed usually near the water's edge and always in land which is overflowed earlier in the season. Water fills the burrow to within a few inches of the opening. This water contains many dragonfly larvae and other food suitable for the occupants, and the earth at the mouths of the burrows indicates that they are opened rarely if at all. Most of the burrows contained a pair; two of the same sex were never found together. One female on this date (September 9) was carrying eggs, and the largest female taken measured 98. The largest specimens seen were females.

Though *Bartonius diogenes* also occurs about this swamp there is no doubt that the burrows are the work of *acutus*. In their great diameter they are distinct from the burrows of the true burrowing crays of the subgenus *Bartonius*. I have also taken this species from burrows along Six-Mile Creek, May 20 and May 27, 1906, two females, 81 and 82 in length, and from a burrow in a creek bank in Robinson Park, Ft. Wayne, June 17, 1906, a female 96 in length. These burrows were in clay, were deep and vertical, and may have been the work of *diogenes.* In any case it is not the disappearance of water which drives *acutus* to burrows, for the swamp near Hartford City and Six-Mile Creek contains water the year round. It seems a provision entirely for mating and spawning. The burrows mentioned above along creeks contained only females. These were wandering individuals, which, true to their instincts, sought burrows unaccompanied by mates. About the swamp, under more congenial environment, each burrow usually sheltered a pair.

In pools along the C. B. and C. R. R. near the Muncie Interurban crossing this species was very common on April 11, 1906. In wading about the edges of these pools in search of toads, *Chlorophilus,* which were calling by hundreds, I frightened these crays from cover and they then swam almost as rapidly as though they were fish to some distance, resting only when they had reached other concealment.

In addition to localities and dates mentioned above, the following may be recorded:

Six-Mile Creek, from one mile above Bethel Church to Six-Mile Church, May 16, 1906, 1 male (I), length 79.5, 7 males (II) 72 to 89, 9 females, 80-104.

Ditch on Alex Fisher farm south of Craigsville, April 12, 1906, one or two taken in open ditch, others at end of tile ditch discussed under *Faxonius immunis.*

Craven ditch, L. R. Vanemon farm, April 13 and 18, 1906.

Pools along C. B. and C. R. R., mentioned above, April 27, 1906, moulting, recently moulted males are of both I and II forms.

Nitro-glycerine swamp, near Hartford City, April 29, 1906, casts very abundant, many individuals recently moulted; fragments of many dead ones lying about; great number of burrows already dug around the edge of the swamp.

Faxonius immunis (Hagen). This species occurs commonly in Wells County, especially in early spring, when they may be expected in almost every ditch and pool, especially the small pools usually formed by the discharge of tile ditches. On April 12, 1906, in a ditch on the Alex Fisher farm, one and one-half miles south of Craigville, a few were taken, and along the same ditch many were found where a tile drain emptied into the ditch. The tile opened about three feet above the water in the ditch and back in the bank about two feet from the ditch. The water fell from the tile in a miniature cataract into a pocket or basin in the clay soil. This clay was almost as resistant to the water as solid rock. The overflow from this basin into the ditch was blocked by a mass of grass stems and similar rubbish through which the water permeated. In this rubbish were about a dozen dead crays, all females of *argillicola*, excepting a single male of *acutus*. Nearly all of the *argillicola* had eggs or egg cases clinging to the swimmerets, and all but two or three of them had the rostrum broken squarely off, no other injury being apparent. The small basin into which the water from the tile fell was nearly circular, about a foot in diameter and six or eight inches deep. In the sides of this basin were a few short burrows or pockets an inch or two in depth. Just at the edge of the basin was a burrow upward into the bank. This burrow was about two inches in diameter and six inches long. The basin, the short burrows in its sides and the burrow upward from its edge were literally packed with *immunis* in the densest crayfish society I have ever seen. Most of the specimens were females and fully one-half of them carried small black eggs. Altogether at the end of this tile ditch more than 100 individuals were taken; a few were *argillicola*, a still smaller number were *acutus* and the remainder were *immunis*. Dr. Ortmann suggests that the breaking of the rostrum of the dead female *argillicola* may have occurred during fights among themselves.

The eggs of this species are small and black, very different from the large pale eggs of *argillicola*, with which species it is often associated in wet-weather pools or ditches. Females carrying eggs have been taken from March 29 to April 12. On April 29 females were observed with young.

This species, occuring as it does, with one or two exceptions, in wet-weather pools and streams, of necessity becomes a burrower. With the disappearance of water I have no doubt that the crayfish passes into a state of aestivation in most cases. In the case of some this begins comparatively early in the season, while others, because of the greater permanency of the pools or streams which they frequent, have this quiescent period greatly reduced. On October 1, 1905, I took 3 small females and a small second form male from burrows in a swamp four miles north of Bluffton. These burrows were under logs, the opening of the burrow being just at the side of the log. The burrows were of small diameter, simple, nearly vertical, about 18 inches deep, contained several inches of water, and had but little or no earth heaped up about the mouth. But such burrows I believe are not usual and the great abundance of this species and the fact that I have never found burrows of larger individuals lead me to think that the dry season must be spent in a quiescent state.

During the collecting of 1905, males and females were taken in about equal numbers. On March 26, 1905, individuals taken varied from 25 to 65 in length, the smallest female carrying eggs measuring 55.

The species has been taken as early as March 26th and has been found in ditches generally in Lancaster Township from this date to April 2. The following dates and localities may be recorded:

Craven ditch on L. R. Vanemon farm April 8, 1906, females with eggs; a small male had a large leech attached to it; April 13, 1906, males I and II, females with eggs; April 18, 1906.

Six-Mile Creek, May 16, 1906, taken in seine near Bethel Church, two females, 63 and 65.5.

Wet-weather ditch just west of A. R. Vanemon's house, May 18, 1906, abundant, very active, 2 males (II) 62 and 62.5, and one female, 62.

Small wet-weather ditch on James Glasgow farm, May 18, 1906, three males (I) 57, 59 and 61, and one male (II) 47.

Ditch one and one-half miles east of Vera Cruz on the south side of the Wabash, June 10, 1906, 2 males (I) 58 and 66.5.

Eight-Mile Creek, west of Ossian, June 7, 1906, one male (I) 59.

St. Mary's River, Fort Wayne, at Broadway bridge, May 13, 1906, one female, taken in seine.

Faxonius rusticus (Girard). This is the only species in Wells County which occurs at all seasons in streams or permanent pools and nowhere else. Though both *immunis* and *acutus* have also been taken in permanent streams there are reasons to think their presence there is accidental. Because of its habitat this is therefore the best known and to many the only known crayfish. Specimens collected in June, 1905, in Six-Mile Creek were all in the second form. At this time many large individuals were taken, some measuring as much as 90 in length, and specimens 85 in length were common. On September 20, 1905, the species was in first form and collections were made in Six-Mile Creek in the identical spots where seining had been done in June. But on this date the largest male taken measured 70 in length and the largest female 68, and these were exceptional, the other large males in the collection measuring between 55 and 65 in length. The only conclusion possible is that the larger individuals perish during the summer. The largest specimens seen of this species have been males.

The following dates and localities may be recorded:

Gravel pit along Croven ditch, east of L. R. Vanemon's house, April 8, 1906, males in first form, females with eggs.

Six-Mile Creek, from one mile above Bethel Church to Six-Mile Church, May 16, 1906, males all second form, 59 to 86.

Eight-Mile Creek, five miles north and one mile west of Uniondale, May 22, 1906, very abundant, males (II), 54 to 84.5 and one specimen 99, females 50 to 72, females in short burrows in creek bed, young about ready to leave females, in color pale, carapace light green, antennæ, apical half of large chelæ and elbows bright cherry red.

Eight-Mile Creek, west of Ossian, June 7, 1906, males all second form, 64 to 102, only one specimen maximum size, females 50-80.5; June 23, 1906, 13 males (I), 62 to 88, all with old shells, 4 males (II), 52 to 84, 6 females, 67 to 81.

In ditch 1½ miles east of Vera Cruz on south side of the Wabash, June 10, 1906, males all second form.

St. Mary's, St. Joseph and Maumee rivers at Fort Wayne, May 13, 1906, generally abundant, rarest in the St. Joseph, largest males not moulted and sluggish, most individuals recently moulted, only a few females with eggs.

In Pine Creek and Kickapoo Creek, tributaries of the Wabash, in Warren County, on July 1, 1906, males (II) and females of *propinquus* were taken. The occurrence of *rusticus* in Eight-Mile Creek, in the drainage of the Ft. Wayne outlet of glacial Lake Maumee, indicates that the boundary between these two species in the Wabash River must be looked for between Huntington and Delphi, since Hay has recorded *propinquus* for the latter locality. Both species are recorded by Hay from Waterloo, De Kalb County, but exact localities are not given. The distribution of these two species, and in fact of all the species of the State, is a matter that could readily be determined with the co-operation of the high school science teachers of the State. The crayfish in the dissecting pan is common to all high schools. I submit the proposition that the species of crays of a locality, the characters by which they may be recognized, their habits, life-histories, and distribution in the State, are facts more easily learned, of more general interest, and more immediately attractive to the high school student than the rather exhaustive discussion of the anatomy of a crustacean, commonly called crawdad, genus?, species?, related to the lobster, but otherwise uninteresting.

Cambarus ortmanni n. sp.—Named for Dr. A. E. Ortmann, on whose time and energy and broad fund of information it has been the privilege of the author to draw freely during the course of this study of local crays.

Belonging to Faxon's Third Group, subgenus *Bartonius* and section *diogenes* as defined by Ortmann, Proc. Am. Phil. Soc., XLIV, 1905, pp. 117 and 119.

Carapace compressed, with sides and dorsum strikingly flattened, punctate, slightly roughened on the sides and without trace of spines throughout; its greatest width greater than one-half its length. Areola for a part of its length reduced to a line; in length of carapace about 2.3 times. Rostrum concave above, short, triangular, margins convergent; acumen short, triangular. Postorbital ridges short and low; suborbital angle low. Antennæ not reaching beyond the second abdominal segment.

Chela ovate, coarsely granulate without definite pattern; carpopodite with a large inner, subapical, knob-like spine, and a smaller more acute, sub-basal one; lower side of meropodite generally with reduced and obtuse spines on the inner side only.

Abdomen robust, shorter than the carapace. First appendages of the male suggesting those of *bartonii* but sufficiently distinct; seen in profile from the outside the lower tooth almost reaches the upper tooth (as in *argillicola,* which has the lower tooth proportionately smaller), the two not widely separated as in *bartonii;* the lower edge of the lower tooth passes behind the shoulder of the upper tooth at an angle of about 45° to the long axis of the appendage, and not at right angles as in *bartonii;* so viewed from the side the lower tooth is not a symmetrical tubercle as is the case in *monongalensis,* for example; with the two first appendages side by side the apices of the lower teeth are divergent, more so than in *bartonii,* and not nearly parallel as in *monongalensis, diogenes, argillicola* and *uhleri,* for example. Annulus ventralis much as in *bartonii* and *monongalensis,* but with the posterior angle more developed and more angulate.

Largest male, 94; largest female, 92. The type male is 90; length of carapace, 48, width 26; areola 21; length of large chela 40, width 20. The type female is 92; length of carapace 48; areola, 21. The largest male has the large chela 46 long and 21.5 wide.

Color in life olive brown without decided markings. Chelæ have plumbeous shades, the ends of the fingers are pinkish and the tubercles whitish; rostrum with very narrow, pale yellowish margin; on the rostrum and just back of it the olive color is clearest; abdominal segments russet-brown basally; tail-fin fringe of hairs black; beneath paler, swimmerets black. The above description was made from the type female during life. A female 63 in length, taken April 18, 1906, was light olive brown, abdomen paler, beneath almost white, dorsum of abdomen with two rows of brown spots on each side; legs thickly spotted with russet-brown; apices of chelæ pale yellow. A male (II), 43 in length, taken on the same date, was paler and greener; the dorsum of abdomen, between the two most dorsal rows of spots, pale green.

Wells County, Indiana, March 26 to May 22, from drainage of Six-Mile Creek and Bills Creek, tributaries of the Wabash from the south, and Eight-Mile Creek and Johns Creek, tributaries of the Wabash from the north, very rare, 23 specimens altogether; the type of each sex is in the Carnegie Museum.

A summary of localities and dates of captures follows:

1. Ditch near Craigville (Johns Creek drainage), one female, length 47, April 2, 1905.

2. Eight-Mile Creek, five miles north and one mile west of Uniondale, burrow in spring in creek bank, one male, May 22, 1906.

3. Craven ditch, on L. R. Vanemon farm (Bills Creek drainage), one male (I), length 83, March 26, 1905; type female, length 92, April 8, 1906; one female, length 48, and fragments of a male, carapace 42, April 13, 1906; three males (II), length 43, 53 and 69, and one female, length 63, April 18, 1906.

4. Six-Mile Creek from Bethel Church to Six-Mile Church, one male (I), length 94, three females, length 35, 60 and 70, May 20, 1906; three females, length 31, 42 and 84, May 27, 1906; type male (I), length 90 and one male (II), length 50, May 29, 1906.

On April 1, 1906, a male (II), 47.5 length, was taken from a spring near the house on the W. Cover farm northwest of Bluffton, and three small specimens, one male (II), 24 in length, and two females, 26 and 45 in length, were taken from a spring near the house on the Walter Snyder farm north of Bluffton. Both localities are north of the Wabash.

Eight-Mile Creek is a tributary of a stream now occupying the valley of the Ft. Wayne outlet of old Lake Maumee of glacial times. Johns Creek, Bills Creek and Six-Mile Creek are all small tributaries of the Wabash above Bluffton, within a distance of three miles from town. The exact localities for these captures are given because of the apparent rarity of the species in Wells County, the fact that it will probably become rarer here, and that nothing is known of its occurrence elsewhere.

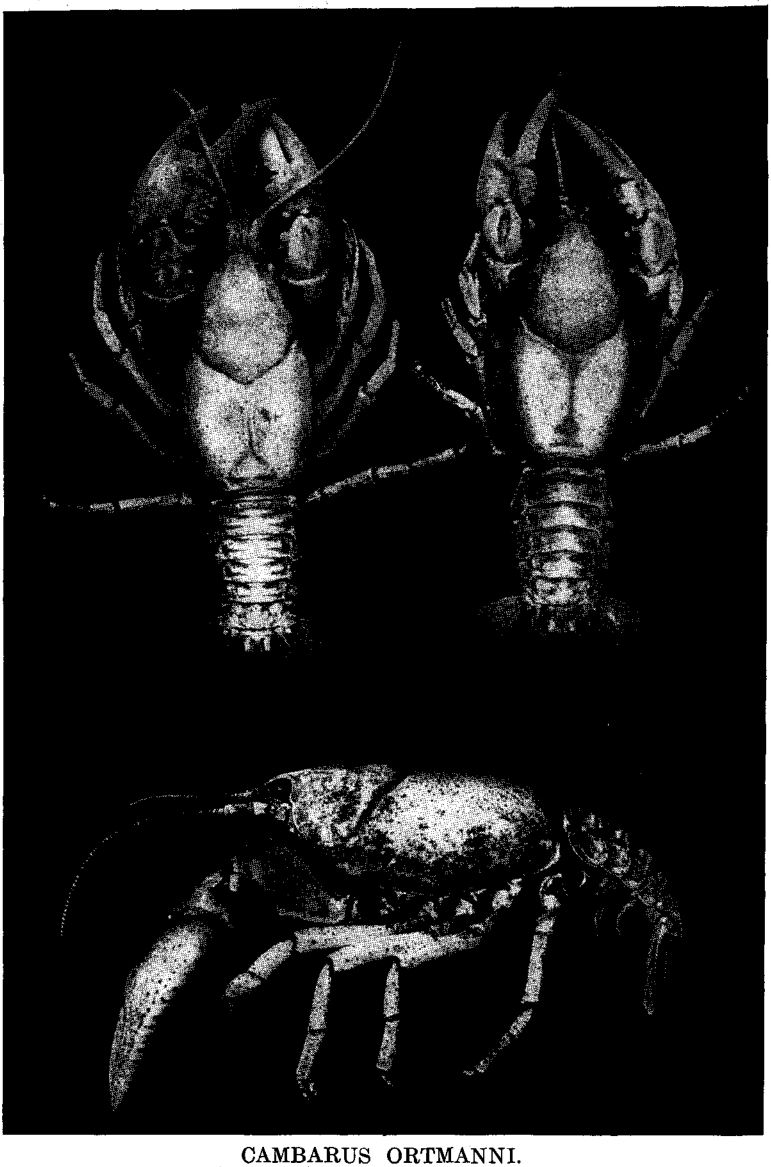
Like all burrowing species in Wells County, this one may be expected in wet-weather ditches from the last of March till at least late in April. The earliest date of capture in ditches is March 26 and the latest April 18. In early April between periods of

Plate XXXV.

1

3

2



CAMBARUS ORTMANNI.

Figs. 1 and 2, type male; fig. 3. type female; from photographs by Prof. W P. Hay.

high water Craven's ditch through L. R. Vanemon's farm is a clear stream two or three feet wide and four or five inches deep. In this ditch I have taken on one date five of the six species of crays occurring in the county; and the sixth species, *rusticus,* is found in Bills Creek, into which the waters from Cravens Ditch pass. Later in the summer this ditch carries no water and the few shallow pools are completely dried up. The actions of *ortmanni* and other burrowers (*diogenes* and *argillicola*) are distinctly different from those of other species. The burrowers move heavily and slowly, rarely swimming when threatened with capture, make little effort at hiding, and are as often found in the middle of the current at a distance from all means of concealment as elsewhere. Of course the young of the burrowers are more active, but they do not approach *acutus* and *immunis* in agility. Of the burrowers *argillicola* is most alert and active. On April 18, 1906, three small males and one female of *ortmanni* were taken under rubbish which had accumulated at the water's edge, beneath the bridge over Cravens Ditch. The single male taken along Eight-Mile Creek was in a short burrow, situated a foot or two from the water's edge, where a little spring oozed from the creek bank. Six-Mile Creek has probably more springs along its course and in its bed than any stream of its size in Wells County, though springs are not abundant even here. Many tile ditches open into the creek's banks. About the end of one of these ditches, carrying a slight amount of cool water, three females were taken on May 20, 1906. The burrows were back under the first tile, were short and but little dirt was piled up. On the same date at another ditch, flowing cool spring water, a slight amount of dirt was observed thrown out about the end of the tile. The tile was pulled from its place in the bank, revealing a large burrow. At a depth of about 18 inches in this burrow the largest male, 94 in length, was taken. All specimens taken along Six-Mile Creek were under tiles from which flowed more or less cool water. On May 16, 1906, Six-Mile Creek was carefully seined from one mile above Bethel Church to Six-Mile Church, but no *ortmanni* were found in the stream. The female, 84 in length, taken May 27, 1906, was in a very intricate winding burrow, with many pockets, in one of which the cray was found. This burrow was horizontal or nearly so in much of its course, with a small quantity of homogeneous earth heaped up at its mouth. None of the females taken have carried eggs or young and in no case has more than one specimen been taken from a single burrow. The burrows themselves may be the work of other species, but I believe not. I have taken *acutus* in burrows which I opened hoping to get *ortmanni,* but this has happened only a few times. The burrows where I took the largest male on May 20, 1906, was subsequently cleaned up and extended and occupied by a large male *diogenes,* which I captured on May 29, 1906.

The four specimens captured April 18, 1906, in Cravens Ditch were taken home alive and placed in a basin of water. The two largest, a male, 69, and a female, 63, fought viciously whenever they met. One of them killed the male, measuring 53, tore off a leg, and mutilated the abdomen. The smallest one, a male, 43, escaped their attacks by its activity.

The relationship of the species is not altogether certain. In a letter of January 23, 1906, Dr. Ortmann writes: "Your specimens are markedly different from the typical *bartonii* (which I had labeled them) not only in the very narrow and longer areola, but also in other characters, chief of which is the carapace, which is depressed in *bartonii,* while here it is rather compressed. The relation of height at gastrical region (G) to width at hepatical (H) and branchial (B) is as follows for species mentioned: *bartonii,* G—H—B=1—1.4—1.6; your specimens, G—H—B=1—1.06—1.3; *carolinus, monongalensis, diogenes,* G—H—B=1—1—1.1. Thus your specimens are nearer the burrowing forms and I believe that they actually belong to the *diogenes* group, being closer to *carolinus* and *monongalensis* than to *diogenes.*" The type male and females were sent to Prof. Hay, who very kindly made the photographs for the plate accompanying this description. At the U. S. Natl. Mus. he compared these types with the extensive series of *bartonii* there. Under date of November 18, 1906, he writes: "Your specimens represent a form with the areola obliterated, with the carapace compressed or cylindrical, the fingers not very strongly ribbed, and the rostrum more decurved and slightly differing in form from any of the specimens which I have identified as *C. bartonii.* At the same time it resembles *C. bartonii* much more closely than it does anything else. We have here one female specimen collected by me at Irvington which has a very narrow areola and which may be regarded as truly intermediate between your specimens and those of southern Indiana. These grade in turn into the Kentucky and eastern Indiana forms." In the reduction of the areola *ortmanni* most nearly approaches the burrowing species of the subgenus, though in robustness and form of carapace it is unique, none of them having the carapace dorsally flattened and with the width greater than one-half the length. In color and size it suggests *bartonii,* the maximum size known for *monongalensis* and *carolinus* being respectively 76 and 80, while the maximum for *ortmanni* is 94, and specimens of the southern Indiana form of *bartonii,* collected for me by Mr. Newton Miller, exceed 100. Also in the reduction of spines in adults *ortmanni* is unique, the two inner spines on the carpopodite especially losing the character of spines and becoming knob-like structures. In younger individuals these are spine-like, as they are in the largest adults I have seen of *bartonii, monongalensis* and *carolinus.* In the spines of the meropodite there is great variation, largely dependent, though not altogether, on age. There may be low spines on both the inner and outer lower edges or both may be practically smooth. In the general form of the carapace *ortmanni* suggests *C. latimanus striatus* Hay of which I collected the type and of which I have specimens from the type locality. These specimens were all collected in a wet-weather ditch and I believe that burrows are certainly dug as the water disappears. In *striatus* the areola is proportionately shorter, the rostrum has the sides more convergent, and the acumen is less abrupt than in *ortmanni. Striatus* also differs in sculpturing of hands and spines on the carpopodite, and decidedly in the form of the first abdominal appendages of the male. In *striatus* the upper tooth is long, slender and recurved, longer than the lower tooth, the two teeth widely separated; in *ortmanni* the teeth are shorter, heavier, closely approximated and about equal in length.

Bartonius diogenes (Girard). This, the largest of our crays, is freely distributed over the county. In early spring the largest and oldest males come from their burrows to wander about in ditches, over fields and across highways. I have found them as early as March 26 and as late as the latter part of April. Along some swift flowing ditch, fed by the clear water discharged from tile ditches one can certainly expect to find a large male or two in early April. There he walks heavily and slowly on the bottom. He seeks no concealment. A little eddy catches him and turns him over and over. He slowly rights himself and goes blindly on over a little waterfall. The great pincers are still strong, but they are a burden now. The death instinct is on him. His life of burrowing and concealment has preserved him for this and he now fares forth to become food for raccoon or pig or crow or to be crushed under the hoofs of farm animals. The burrows of this species occur in open fields, usually in low land. Burrows placed in higher and drier locations often lack the chimneys, which are often so conspicuous about some swamp, or have them lower and less perfectly constructed. In this species the most elaborate chimneys I have seen were those built by smaller individuals over short burrows where the land level was near the water level. Frequently the beginning of the burrow is a horizontal shaft back in some creek bank on a level with the water. Through this shaft the dirt excavated in driving the vertical burrow upward and downward is carried and dumped into the creek. With the completion of the vertical burrow to the surface, much or all of the soil excavated at the bottom of the burrow is carried to the surface. Hence the chimney may be composed entirely of light yellow clay brought from a depth of two feet or more.

This species occurs about two small glacial lakes in Jackson Township. On May 25, 1905, a large female taken from her burrow was carrying nearly hatched eggs. The largest male seen was taken in a ditch near Craigville, April 2, 1905, and measured 124 in length. On April 1, 1906, 22 males and 11 females were taken in a small ditch on the Ed Ware farm north of Liberty Center. All were large, males all first form and the smallest 85 in length. None of the females carried eggs; the largest was 124.5. Dr. Ortmann thinks all of this lot of 33 specimens were at the end of their lives. The male 124 and female 124.5, mentioned above, are the maximum recorded sizes for this species, the largest hitherto being 115 by Hagen.

The following dates and localities may be recorded:

Springs north of Wabash River, northwest of Bluffton, April 1, 1906, three males (I) 80, 82 and 83, one male (II) 25, two females, 21 and 40.

Craven ditch, Vanemon farm, April 8, 1906, and April 18, 1906, all old males; June 9, 1906, one female, 112, with young, 10 in length.

Eight-Mile Creek, five miles north and one mile west of Uniondale, May 22, 1906, from burrows in creek bank, male (I) 110, female, 98, with eggs.

Six-Mile Creek at Six-Mile Church, May 29, 1906, males and females from burrows in creek bank.

Ditch near Craigville, April 29, 1906, two large females without eggs, one dead in the water without sign of any injury.

Along ditch 1½ miles east of Vera Cruz on south side of Wabash, June 10, 1906, three large females, one with exuviæ on abdominal feet, two carrying recently hatched young, measuring about 7.5; one female was carrying 215 young, the other 87. These two females were taken at the surface near burrows. Their presence out of their burrows is to be explained I believe by an attempt on their part to regulate the temperature of water for their young. Following heavy rains the temperature of the water in burrows would be considerably lowered by the intake of subterranean water, while the water of the conveniently adjacent ditch would change but little in temperature, remaining appreciably warmer than the cooled water of the burrows.

Swamp near nitro-glycerine factory, north of Hartford City, April 29, 1906, many fragments of large individuals, one male (I) 83, dug from a burrow.

Bartonius argillicola (Faxon). While *diogenes* is the burrowing species of open fields and swamps, this species prefers thickets or woodland. In the spring I have taken a few specimens in pools in woods, and in tramping through woodland in search of hawks' nests I have found many large pincers of males. In April, 1905, this species was very numerous in ditches near Craigville. On April 2d, females were carrying eggs which were beginning to hatch and in ditches females were eight or ten times more numerous than males. The average size of females with eggs was about 65 and the smallest female with eggs was about 53. Specimens about 25 in length were taken March 26, 1905.

The following dates and localities may be recorded:

Small ditch on Ed Ware farm north of Liberty Center, April 1, 1906, one male and eleven females, females with eggs.

Ditch northeast of Bluffton, south of Wabash, April 1, 1906, a large female with eggs; a large leach was attached to the cray, which was lying on its back in the water apparently helpless.

Craven ditch, L. R. Vanemon farm, April 8, 1906, large and small individuals, two females with eggs; April 13, 1906; April 18, 1906, female with young.

Ditch 1½ miles south of Craigville, on Alex Fisher farm, see discussion under *immunis*.

Woods east of swamp on H. Vanemon farm, April 13, 1906. In 1905 several unsuccessful attempts were made to determine the species of cray in this colony of burrows. The burrows pass in and out among the interlaced tree roots making their excavation very difficult. April 13, 1906, at a depth of about 3½ feet a male and female of *argillicola* were taken from a burrow. On this date water completely filled the burrows.

Pools along the C. B. and C. R. R. near the Muncie interurban crossing, April 25, 1906, several specimens, one large male without apparent injury found dead; April 11, 1906.

Fred Reppert farm east of Vera Cruz in Adams County, from burrow in yellow clay on hillside, one male, burrow about four feet deep.

To summarize, it may be said that on a favorable day in early April the six species of crays occurring in the county may all be taken without digging in an area covered by a walk of a quarter of a mile. In all western Pennsylvania, including the lake and Mississippi drainage, an area having great range in altitude, Dr. Ortmann has found only five species and one variety, and there is no reason to believe others will be found there. The six species of Wells County occur at the same level and in all parts of the county, their distribution determined entirely by the water supply. *Rusticus* has a continuous habitat determined by the course of streams in which all its life is spent; *immunis* during its period of activity is an inhabitant of mud-bottomed streams and pools from which the water disappears early in the season; *acutus* is an inhabitant of more permanent marshes, especially in woodland; *ortmanni* digs its burrows in the vicinity of cool running water; *diogenes* is an inhabitant of the warm subterranean waters of fields and marshes; and *argillicola* prefers the cooler subterranean water of forests and thickets. Of course the high waters of spring render marsh, ditch, creek and river one continuous, unbroken water-way and greater or less mingling of species at this season, when all waters are practically the same temperature, is inevitable.

In the preparation of this paper I have had the invaluable help of Dr. Ortmann, through whose hands nearly all my specimens have passed, thus securing an accuracy of determination of which I am not capable. To Professor Hay I am indebted for the excellent photographs reproduced in the halftone plate which accompanies this article, and for a careful comparison of the types of *ortmanni* with the large material in his collection and in the U. S. Nat. Mus. To several friends in Wells County I am indebted for specimens.