THE PETROLEUM INDUSTRY IN INDIANA.

BY W. S. BLATCHLEY.

CHAPTER I.

DEFINITION OF PETROLEUM—GEOGRAPHICAL DISTRIBUTION OF PETROLEUM—ORIGIN OF PETROLEUM—GEOLOGICAL DISTRIBUTION OF PETROLEUM—PHYSICAL AND CHEMICAL PROPERTIES OF INDIANA PETROLEUM.

The two resources of natural gas and petroleum have, within the past decade, added vastly to the wealth and population of the northern half of Indiana. The former was the first discovered, and millions of dollars have been invested in manufactories in the gas field, and thousands of people from other States and countries have flocked thereto, finding plentiful employment at good wages.

Following fast upon the development of the gas area came the discovery of petroleum in Wells and neighboring counties, and the sinking of bores for the "rock oil" so long stored in the porous reservoirs of the Trenton limestone has gradually developed into a notable industry in at least six counties of the State.

Although constant demands have been and are being made upon the State Geologist for literature and maps relative to the Indiana oil field, hitherto they could not be furnished because none had been prepared. The only paper published by the Department of Geology upon the subject was one of twenty pages in the report for 1891. It was written by A. C. Benedict, then an attache of the Department, and dealt more largely with the history of petroleum, and with areas in Indiana not now producing oil in commercial quantities, than with the present productive field.

In consideration of this lack of literature on the subject, and in accordance with the plan adopted by the present Geologist of taking up the chief resources of the State and treating each in detail, the present paper has been prepared. It is based upon a careful study of the field made by the Geologist in person during the months of June, September

and October, 1896, and has been supplemented by notes and reports rereceived from different persons in the field up to January 1, 1897, so that it may be considered as fairly representative of the developments made to that date.

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 oil field of Indiana, and where the resource in question is contained in a rock formation nowhere exposed to view within the State, the difficulties in the way of a proper presentation of the subject are many. The records of the formations passed through by the bores had to be obtained from drillers and operators, many of whom had little geological knowledge. Moreover, their records were scanty in detail, noting little else than the number of feet of drive pipe and casing used, the depth at which the Trenton rock was found, and the total depth of the bore. However, I found them at all times willing to place at my disposal such knowledge and records as they possessed, and to them I am indebted for such records as are included in the report. To Messrs. L. C. Davenport, of Bluffton; E. J. Little, of Van Buren; Benjamin Fulton, of Portland, and A. T. McDonald and W. S. Morton, of Montpelier, I am under special obligations for services rendered, both in the field and since my return therefrom.

DEFINITION OF PETROLEUM.

Various natural products, called bitumens, have been known to mankind for many centuries. These bitumens comprise a class of minerals, each member of which is made up largely of the nonmetallic elements,* carbon and hydrogen, so combined that the resulting compound will burn readily, with a bright flame and without leaving a residue.

Petroleum a Bitumen.—Like most other kinds of matter, the bitumens occur in three forms, namely, solids, liquids and gases. Each of these forms has many varieties, to which different names are given in different countries, but the typical representatives of each form are as follows:

Solid: Asphalt or Asphaltum.
Liquid: Petroleum.
Gaseous: Natural Gas.

Between these different forms of bitumen a close relationship exists. Especially is this true of petroleum and asphaltum, the one merging into the other through the intermediate varieties known as mineral tar, mineral pitch, etc. It is also well known that when petroleum is freely exposed to the atmosphere for a long time, it loses certain volatile constituents, and gradually passes into asphalt.

While natural gas seems more remotely related to petroleum, the two, in ages past, probably had a common origin. Marsh gas, or light carburetted hydrogen (CH_4) makes up more than ninety per cent. of natural gas. Petroleum, when destructively distilled, yields a large percentage of the inflammable marsh gas. Again, no geological formation is known to yield gas in large amount without in some portion of its area yielding oil as well. Taking these facts into consideration, and at the same time remembering that in nature each form of matter is constantly undergoing change, it is very likely that in the thousands of centuries which have elapsed since the petroleum was formed, much, if not all, of the natural gas has been derived from it by volatilization, or otherwise.

The word "petroleum," like "natural gas," relates to the origin rather than the composition of the substance. It is derived from two Latin words "*petra*," a rock, and "*oleum*," oil, and in many localities the name "rock oil" is given it.

*An *element* is one of the seventy primary forms of matter which make up the universe. It is a substance which has never been separated into anything simpler. Two or more elements united together form a *compound*. There are millions of compounds, but only seventy elements. For example: Wood is a compound, which in the chemical laboratory can be separated into three substances, carbon, hydrogen and oxygen; but no man has as yet been able to separate carbon, hydrogen or oxygen into anything simpler than themselves. Hence, they are elements. The seventy elements bear the same relation to the compounds, as the twenty-six letters of the English language bear to its four hundred thousand words. Or, to state it still differently, the elements form the alphabet of the universe.

GEOGRAPHICAL DISTRIBUTION OF PETROLEUM.

Contrary to common belief, petroleum is widely and abundantly distributed throughout the countries of the world; while its geological horizons include every known formation from the old Archæan rocks up to the later members of the Tertiary period.

New Zealand, Australia, Japan, China and India, all have large known deposits; those of Japan having been put to use for more than a thousand years.

Farther northwest, at Baku, in the Russian province of Apsheron, on the shores of the Caspian Sea, is the richest pool of petroleum known to man. The oil from this district has been used for 2,500 years, and as far back as the thirteenth century Marco Polo wrote of it as follows:

"On the confines toward Georgine there is a fountain from which oil springs in great abundance, inasmuch as a hundred ship-loads might be taken from it at one time. This oil is not good to use with food, but is good to burn, and is also used to anoint camels that have the mange. People come from vast distances to fetch it, for in all countries round there is no other oil."

The Apsheron peninsula proper has a known oil bearing area of 1,200 square miles though but seven square miles are at present developed. The oil is formed in loose sandstone or coarse sand beds of the Eocene age. Since 1875 a number of flowing wells or fountains have been drilled, the yield of some of which is given by Redwood as follows:*

One in 1875, 14,300 barrels daily.
One in 1876, 6,430 barrels daily for 3 months.
One in 1883, 13,700 barrels daily for 1 week.

On September 1, 1883, the famous "Droojba" fountain was drilled in at a depth of 574 feet, and commenced flowing at a rate of 40,000 to 50,000 barrels, valued at over $50,000, daily. This well has been graphically described as follows:

"The fountain was a splendid spectacle—it was the largest ever known in Baku. When the first outburst took place the oil had knocked off the roof and part of the sides of the derrick, but there was a beam left at the top against which the oil burst with a roar in its upward course, and which served in a measure to check its velocity. The derrick itself was seventy feet high, and the oil and the sand, after bursting through the roof and sides, flowed fully three times higher, forming a greyish-black fountain, the column clearly defined on the southern side but merging in a cloud of spray thirty yards broad on the other. A strong southerly wind enabled us to approach within a few yards of the crater on the former side, and to look down into the sandy basin formed round about

*Petroleum and its Products, 1896, 25.

the bottom of the derrick, where the oil was bubbling around the stock of the oil shoot like a geyser. The diameter of the tube up which the oil was rushing was ten inches. On issuing from this the fountain formed a clearly defined stem about eighteen inches thick, and shot up to the top of the derrick, where, in striking against the beam, which was already worn half through by the friction, it got broadened out a little. Thence continuing its course more than two hundred feet high, it curled over and fell in a dense cloud to the ground on the north side, forming a sand bank over which the olive-colored oil ran in innumerable channels toward the lakes of petroleum that had been formed on the surrounding estates. Now and again the sand flowing up with the oil would obstruct the pipe, or a stone would clog the course. Then the column would sink for a few seconds lower than two hundred feet, to rise directly afterward with a burst and a roar to three hundred. Some idea of the mass of matter thrown up from the well could be formed by a glance at the damage done on the southside in twenty-four hours—a vast shoal of sand having been formed, which had buried to the roof some magazines and shops, and had blocked to the height of six or seven feet all the neighboring derricks within a distance of fifty yards. Some of the sand and oil had been carried by the wind nearly one hundred yards from the fountain. Standing on the top of the sand shoal we could see where the oil, after flowing through a score of channels from the ooze, formed in the distance, on lower ground, a whole series of oil lakes, some broad enough and deep enough to float a boat in. Beyond this the oil could be seen flowing away in a broad channel towards the sea. The well was capped on the 29th of December, 1883, after giving an amount of oil estimated at 220,000 to 500,000 tons."*

"The remarkable feature of this well was, that instead of making its owner a millionaire, as would have been the case in America, it both ruined him and broke the heart of the engineer who bored it. The reason was that the fountain belonged to a small Armenian company, which had enough ground for a well but not enough for large reservoirs. The oil flowed over neighboring properties, and was partially caught and sold by those on whose land it trespassed, and the quantity was so great as to reduce the price enormously, while at the same time the deluge of sand did so much damage in swamping the neighboring wells and houses that the amount of compensation claimed from the Droojba company far exceeded the value of the oil recovered by them.†"

The most productive well ever drilled, however, was about one-third of a mile from the Droojba, and began producing in March, 1893, at the rate of 120,000 barrels daily. It will be seen from the above extracts that the spouting wells of the Caspian far outstrip their American competitors in volume and energy.

* Petroleum and its Products, 1896, 25.
† H. M. Cadell, Trans. Edinb. Geol. Soc., VII, 1894, 63.

Westward from Baku oil is found in numerous countries of continental Europe, the most important deposits being in Galicia, Roumania and Denmark.

In the New World deposits of petroleum are known in Mexico, Peru, Venezuela, Alaska, and Ontario, Canada; but its most important oil field occupies a broad zone about 750 miles in length, extending from New York State south and west through western Pennsylvania, West Virginia, Ohio and part of northern Indiana. Outside of this area the most important oil fields in the United States are near Los Angeles, California, where 1,200,000 barrels were produced in 1895; and in Colorado, which produced 530,000 barrels the same year. Small fields are also developed in Wyoming, Kansas, Kentucky and Tennessee.

The following table gives the production of petroleum in the United States from 1859 to 1895, inclusive, together with the average yearly price per barrel:

Production of Crude Petroleum in the United States from 1859 to 1895 (Barrels).

YEAR.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	Total United States.	Average Yearly Prices per Barrel.
1859	2 000													2.000	
1860	500,000													500,000	$9 59
1861	2,113,609													2,113,609	49
1862	3,056,690													a3,056,690	1 05
1863	2,611,309													2,611,309	3 15
1864	2,116,109													2,116,109	8 06
1865	2,497,700													2,497,700	6 59
1866	3,597,700													3,597,700	3 74
1867	3,347,300													3.347,300	2 41
1868	3,646,117													3,646,117	3 62½
1869	4,215,000													4.215.000	5 63¾
1870	5,260,745													5,260.745	3 84
1871	5,205,234													5.205,234	4 34
1872	6,293,194													6,293,194	3 63
1873	9.893,786													9,893,786	1 87
1874	10,926,945													10.926.945	1 15
1875	8,787,514	b200,000	b3,000,000		b175,000									b12.162,514	1 36
1876	8.968,906	31,763	120,000		12.000									9,132,669	2 56¼
1877	13,135,475	29,888	172.000		13.000									13,350.363	2 42
1878	15,163,462	38,179	180,000		15,227									15.396,868	1 19
1879	19,685,176	29,112	180.000		19,858									19.914,146	85⅞
1880	26,027,631	38,940	179,000		40,552									26,286,123	94⅛
1881	27,376,509	33,867	151,000		99,862									27,661,238	85⅞
1882	30,053,500	39,761	128,000		128,636		c160,933							30,510,830	78½
1883	23,128,389	47,632	126,000		142,857		4,755							23,449,633	1 05¾
1884	23,772,209	90,081	90,000		262,000		4,148							24,218,438	83⅛
1885	20,776,041	650.000	91,000		325,000		5,164							21,847,205	87⅞
1886	25,798,000	1,782,970	102,000		377,145		4,726							28.064,841	71¼
1887	22,356,193	5,018,015	145,000	76,295	678,572		4,791							28,278,866	66¾
1888	16,488,668	10,010,868	119,448	297,612	690,333		5,096							27,612,025	87⅝
1889	21,487,435	12,471,466	544,113	316,476	303,220	33,375	5,400	1,460	500	48	20			35.163,513	94⅛
1890	28,458,208	16,124,656	492,578	368,842	307,360	63,496	6,000		1,200	54	278			45,322,672	86¾
1891	33,009,236	17,740,301	2,406,218	665,482	323,600	136,634	9,000		1,400	54	25	30		54,291,980	67
1892	28,422,377	16,362,921	3,810,086	824,000	385.049	698,068	6,500			45	10	80		50,509,136	55⅝
1893	20,314,513	16.249,769	8,445,412	594,390	470,179	2,335,293	3,000			50	50	10		48,412,666	64
1894	19,019,990	16,792,154	8.587,624	515,746	705,969	3,688,666	1,500	300	40,000	60	8	130	2,369	49,344,516	72
1895	19,144,390	19,545,233	8,120,125	529,482	1,208,482	4,386,132	1,500	200	44,340	50	10	37	3,455	52,983,526	1 09
Total	516,657,260	133,343,773	37,179,604	4,188,325	6,683,901	11,341,664	222,513	1,960	87,530	361	401	287	5,824	709,713,403	

a In addition to this amount it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee. b Including all production prior to 1876 in Ohio, West Virginia and California. c This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

THE ORIGIN OF PETROLEUM.

How and from what source did petroleum and natural gas originate? The answer to this question has been sought, especially in recent years, by the most eminent chemists and geologists of the world. Many laboratory experiments have been made with a view to answering it, and from the results thus obtained numerous theories have been advanced, but no one of them has, as yet, found universal acceptance. The more important of these theories will be taken up and briefly discussed in the present paper. For convenience they will be separated into two groups, viz.: *inorganic* and *organic* theories.

INORGANIC THEORIES.

While the theories which ascribe the origin of petroleum to inorganic objects have few adherents among the geologists and scientists of the present day, among the masses of the people who think of such subjects it is perhaps the prevailing opinion that in some mysterious manner oil and gas have been and are being formed in the depths of the earth by the action of water upon rocks or metals. Such an opinion probably had its origin in a theory advanced in 1866 by Berthelot, a distinguished French chemist. He expressed the view that the interior of the earth contains large quantities of the alkali metals, potassium and sodium, in a free or uncombined state, and that water, charged with carbonic acid, finds its way to these metals, and, assisted by the high temperature and great pressure necessarily existing at such depths, combines with them to form both liquid and gaseous bitumens.

Berthelot's Theory.

It is needless to say that such a theory finds little credence among scientists and others acquainted with the many conditions under which petroleum exists in the rocks of the earth. The theory is based wholly upon remote possibilities, and is incapable of the slightest verification by the geologist. Not a particle of evidence exists tending to prove that either sodium or potassium occurs uncombined in the interior of the earth. Even if they should so occur, neither of the two is a constituent of petroleum, and the latter, according to the theory, would have to be wholly formed from the water charged with carbonic acid, which, in itself, is impossible.

Another inorganic theory which has gained wide circulation is that of Mendeljeff, proposed in 1877. He refers to the great density of the earth and to the well-known presence of iron in meteorites and the solar system, as shown by the spectroscope.

Mendeljeff's Theory.

Assuming the commonly accepted theory of La Place, that the earth has been formed from incandescent matter thrown off from the sun, he asserts that, according to well-known physical laws, the vapors making up the incandescent matter arranged themselves according to their specific gravities, the heavier being nearer the center of the earth, and the lighter nearer its surface. In this manner *iron*, either pure or in the form of a carbide, was collected in large quantities at great depths in the earth. Afterwards, by internal forces, the cooler crust of the earth has been broken and allows the water which has collected thereon to run through the fissures to the hot masses of iron carbide. The iron forms an oxide with the oxygen of the water. The hydrogen of the water unites with the carbon from the iron to form a light hydrocarbon, which in time is condensed into the heavier petroleum. In this way he claims that not only the deposits of bitumens already existing have been formed but new ones are continually being formed at great depths in the earth and are gradually forced upward into cracks and fissures nearer its surface and there stored. As for the proofs of his theory, he asserts that the largest deposits of petroleum are found in the neighborhood of mountain ranges, where fissures leading to the depths of the earth are most likely to occur, and that he and other chemists have obtained petroleum-like hydrocarbons by the action of boiling water or dilute hydrochloric acid upon spiegeleisen (carbide of iron and manganese).

The theory of Mendeljeff, like that of Berthelot, has few facts to bear it out. In America, at least, every field in which oil has been found controverts its leading assumptions. The larger oil fields of this country are *not* found along mountain ranges, but over level areas. There are within their bounds no fissures or cracks leading to the inner depths of the earth. The oil is found in pores of minute size between the grains of sandstone or limestone rock in which it occurs, and not in fissures and rents of the rock. Again, there is not a particle of known evidence tending to prove the presence of iron carbide in quantity at great depths in the earth; and even though a few of the simpler members of the series of hydrocarbons to which petroleum belongs have been formed artificially in the chemical laboratory from inorganic substances, all attempts to thus form such complex compounds, as is petroleum itself, have proven fruitless.

Such theories as those of Berthelot and Mendeljeff are, to say the least, not only crude and unscientific, but are productive of much harm, in that they tend to cause the masses to believe that natural gas and petroleum are being formed as fast as they are used. Such a belief is responsible for much of the reckless waste which has taken place in the gas fields of Indiana in the past; a waste which has already brought the stored supply down close to the limit at which the natural rock pressure of the gas is overcome by salt water.

ORGANIC THEORIES.

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, already mentioned as being the chief constituent of natural gas, bubbles up from every stagnant pool which contains rotting vegetable or animal 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.

However, two distinct views prevail among geologists as to the manner in which the decomposition has been brought about. One of these views, known as the *secondary* decomposition theory, was first set forth by Prof. John S. Newberry, formerly State Geologist of Ohio. He claims 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. As a proof of this theory, Professor Newberry says:

Secondary Decomposition Theory.

"We have in the Huron shale a vast repository of solid hydrocarbonaceous matter, which may be made to yield 10 to 20 gallons of oil to the ton by artificial distillation. Like all other organic matter, this is constantly undergoing *spontaneous distillation*, except where hermetically sealed deep under rock and water. This results in the formation of oil and gas closely resembling those which we make artificially from the same substance, the manufactured differing from the natural products only because we can not imitate accurately the processes of nature.

"*Second.* A line of oil and gas springs marks the outcrop of the Huron shale from New York to Tennessee. The rock itself is frequently found saturated with petroleum, and the overlying strata, if porous, are sure to be more or less impregnated with it.

"*Third.* The wells on Oil Creek penetrate the strata immediately overlying the Huron shale, and the oil is obtained from the fissured and porous sheets of sandstone of the Portage and Chemung groups, which lie just above the Huron, and offer convenient reservoirs for the oil it furnishes."*

Of Prof. Newberry's theory it may be said that, while it is true that the shales contain oil in large quantities, which may be separated from them by distillation, there is no direct proof that this oil is wholly indigenous to the shale, *i. e.*, derived from the remains of organic life

*Geol. of Ohio, I, 158.

which was buried in it. Few, if any, traces of animal life are found in shales. In some places, however, remains of plant life are fairly abundant,* but not enough so to have furnished the source for as large an amount of oil as the shales contain. Yet, at the time the shales were deposited, algæ and the simpler forms of plant life, whose decomposition would leave no residue or fossils, were undoubtedly abundant and may have supplied a large proportion of the petroleum which the shales contain.

On the other hand, all shale beds are sedimentary in their origin, being composed of particles of clay (an inorganic material) 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 may thus have been derived from organic matter undergoing decomposition in *other* and remote strata.

At the time that the "secondary decomposition 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 occurs in a series of sandstone strata which contain few, if any, organic remains, and could not, therefore, have furnished the original source of the oil. These sandstone strata overlie the bituminous shales, and, from their porous nature, have served as reservoirs into which the oil, oozing from the shale, has passed and accumulated in large quantities.

The second organic theory, known as the "primary decomposition theory," was first promulgated by Dr. T. Sterry Hunt about 1862, and, better than any other, accounts for the origin of the oil in the Trenton limestone rocks wherever found. Dr. Hunt asserted that petroleum has been formed from the remains of animals or plants in the 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.

Primary Decomposition Theory.

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

*Notably in the Genesee shale at New Albany, Ind., where many remains of fucoids and allied plants have been recently discovered by Mr. Hans Duden.

with dirt, formed a tarry coating upon the exposed surfaces; and adds, "With such sources ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to search elsewhere for the origin of petroleum, and to suppose it to be derived, by some unexplained process, from rocks which are destitute of the substance."

Dr. Hunt also stated that one of the principal proofs of the truth of his theory lay in the statement of Mr. G. P. Wall, who, in 1860, published a report on the Asphalt Lake of Trinidad,* in which the following passage occurs:

"When *in situ*, it (the asphalt) is confined to particular strata which were originally shales containing a certain proportion of vegetable *debris*. *The organic matter has undergone a special mineralization, producing bituminous in place of ordinary anthraciferous substances. This operation is not attributable to heat, nor to the nature of distillation, but is due to chemical reaction at the ordinary temperature and under the normal conditions of the climate.* The proofs that this is the true mode of the generation of the asphalt repose not only on the partial manner in which it is distributed in the strata, but also on numerous specimens of the vegetable matter in process of transformation, and with the organic structure more or less obliterated. After the removal by solution of the bituminous material under the microscope, a remarkable alteration and corrosion of the vegetable cells becomes apparent, which is not presented in any other form of the mineralization of wood. Sometimes the emission is in the form of a dense, oily liquid, from which the volatile elements gradually evaporate, leaving a solid residue."

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 those 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.

Coal Theory.

The theory that petroleum had its origin in coal, or that the two are closely related, is held by many people. While it is true that both coal and oil are undoubtedly the remains of past existing organisms, the main petroleum field of Indiana is one hundred and fifty miles distant from the main coal area. Moreover, the Trenton rock containing the oil belongs to an entirely different forma-

*Quarterly Journal Geol. Soc., XVI, 1862, 467.

tion, and was in existence thousands of years before the plants from which the coal is derived flourished. Even where the Trenton rock directly underlies the coal strata there are several impervious strata between them which neither gas nor oil could penetrate. These facts show conclusively that, in Indiana at least, there has been no connection whatever between the origin of the coal and petroleum.

Life of the Trenton Period.

It is a well known geological fact that most if not all limestones owe their origin to the presence of minute organisms in the water in which the limestones were formed. 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 eighty 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; remains of these earliest known vertebrates having been discovered in the Trenton of Colorado by Walcott, in 1891.†

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.

Formation of the Trenton Limestone.

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 time the waters containing these beds of limestone, with their enclosed accumulations of undecayed plants and animals, became turbid, and, instead of calcareous sediment, deposited mud and clayey sediment in thick beds on

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* *Vide* Ulrich, Rep. on L. Sil. Bry. Minnesota (Vol. III, Geol. and Nat. Hist. Surv. Minn, 1893, 96.

† Bull. Geol. Soc. III, 1892, 153.

top of the limestone strata. These deposits of mud and silt were afterward, by later deposits, compressed into the fine-grained, impervious Utica shale, 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 gas was probably not formed in a short time, but is the result of a slow decomposition, carried on through hundreds and thousands of centuries. The primary product of such decomposition 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.

Not only Trenton limestones, but every other limestone, as well as most shales, have in the past produced petroleum in greater or less quantities. Distributed in minute proportions through the substances of the rocks, it easily escapes notice, but when intelligently looked for its presence is revealed, and, though the percentage is small, the aggregate is often vast. If, for example, a stratum carries but one-tenth of 1 per cent. of petroleum and is 500 feet in thickness, it contains more than 2,500,000 barrels to the square mile. Indeed, so common is the occurrence of petroleum in stratified rocks that wherever a close-grained shale occurs there is almost always a small accumulation of oil directly underneath it. The same thing is found when an impervious stratum of any other composition than shale occurs in the geological series.

In concluding these remarks on the origin of petroleum, I can not do better than to add as a summary the following opinions of Dr. Edward Orton, which, slightly modified, are as follows:

1. Petroleum is derived from organic matter.
2. Petroleum of the Pennsylvania type is derived from the organic matter of bituminous shales, and is probably of vegetable origin.
3. Petroleum of the Ohio-Indiana type is derived from limestones, and is probably of animal origin.
4. Petroleum has been produced at normal rock temperature, and is not a product of destructive distillation of bituminous shales.
5. The stock of petroleum in the rocks is already practically complete.*

GEOLOGICAL DISTRIBUTION OF PETROLEUM.

If petroleum has been thus generally formed throughout the Trenton limestone, why do not all parts of that geological 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

*Report on the Occurrence of Petroleum, Natural Gas and Asphalt Rock in Western Kentucky, 1891, 60.

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 is originally formed it is wholly without value. Like all other forms of mineral wealth, it must be concentrated into reservoirs, the so-called "pools" of the oil fields, before it can be utilized by man. The conditions necessary to these accumulations are (1) a porous stratum of rock to serve as 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. Each of these necessary conditions will now be briefly considered.

The rock formations which best furnish the necessary porosity for the accumulation of oil are (a) sandstones; (b) conglomerates, and (c) limestones which have undergone a certain chemical change since their formation.

The Porous Reservoir.

In the case of the sandstones and conglomerates a natural porosity exists between the particles composing the rocks. The greater the degree of porosity, the greater the amount of oil contained in the reservoir, or "pool." In most, if not all cases, the oil in sandstone reservoirs has been derived from the underlying strata, which are usually fossiliferous and highly compacted shales.

The Trenton rock, when first formed, was a true limestone or calcium carbonate ($CaCO_3$), in some places very pure (94 to 98 per cent. carbonate of lime); in others, more or less mixed with silicious and other impurities.

In time, as a result of the oscillations ever taking place in the sea level, certain large areas of the Trenton limestone became raised into great, shallow basins or lagoons, partially or almost wholly shut off from the main ocean. In these basins the sea waters were in an unusually briny condition, owing to large quantities of salts of magnesium which they held in solution. These magnesium salts, especially the chlorides, in the course of time, acted upon the *purer* areas of calcium carbonate, one-half of the calcium being removed by the chlorine and replaced by magnesium, as shown in the equation ($2CaCO_3 + MgCl_2 = CaMg2CO_3 + CaCl_2$), the change resulting in dolomite or calcium-magnesium carbonate ($CaMg2CO_3$). This change took place only in the purer Trenton limestone after the Trenton rock had been formed and consolidated, and before the Utica shale had been deposited over it.

As a result of the change into dolomite, the rock became reduced in bulk about one-eighth of one per cent., and at the same time more or less porous, the porosity resulting from the fact that the new crystals of dolomite never entirely filled the spaces from which the crystals of lime had been removed.* *The larger areas of the Trenton limestone were either too*

*In the change into dolomite small cavities in great numbers were left between the interlocking points of the replacing crystals, equaling, or even greatly exceeding, the spaces between grains of sand or pebbles.—*Orton, Geol. Survey of Ohio, 1890, 69.*

impure to admit of the change into dolomite, or the conditions of sea level were never such that the change could take place in them; hence, they are found destitute 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 fifty feet of the Trenton. The upper one of these has a thickness of three to ten, or sometimes fifteen feet, and usually occurs within twenty 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 fifteen to twenty feet below the first and is separated from it by a bed of unchanged, non-porous limestone. This alternation of dolomite and limestone strata is probably due to alternations in the sea levels at the time the limestone was undergoing the change 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.

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 the oil nor its volatile constituents will pass or can be forced by the enormous pressure behind it. Such a cover is usually a fine-grained shale, and wherever such a stratum covers a porous rock, petroleum in greater or less quantities is usually found. In the Indiana oil field the Trenton rock is covered by an average thickness of 250 feet of that dark brown, close-grained deposit known as the Utica shale, which possesses every quality of a typical impervious cover. The driller recognizes this stratum as soon as he strikes it, by its color, its comparative freedom from fossils, and the ease with which it is drilled and mixed with water. No free oil is found in the Utica shale, though by distilling portions of it an amount equal to three per cent.* of the shale has been obtained.

The Anticlinal Structure.

Owing to the contractile movements of the cooling crust of the earth, it has become in many places creased or raised into folds, which often extend for long distances with great regularity. Sometimes these contractions have been violent, resulting in a pushing upwards or protrusion of the crust into chains of mountains. More often they have resulted in the formation of a series of broad, low curves, whose arches are known as anticlines and whose troughs are called synclines. These changes in level took place in an early part of the earth's history and affected mainly the older

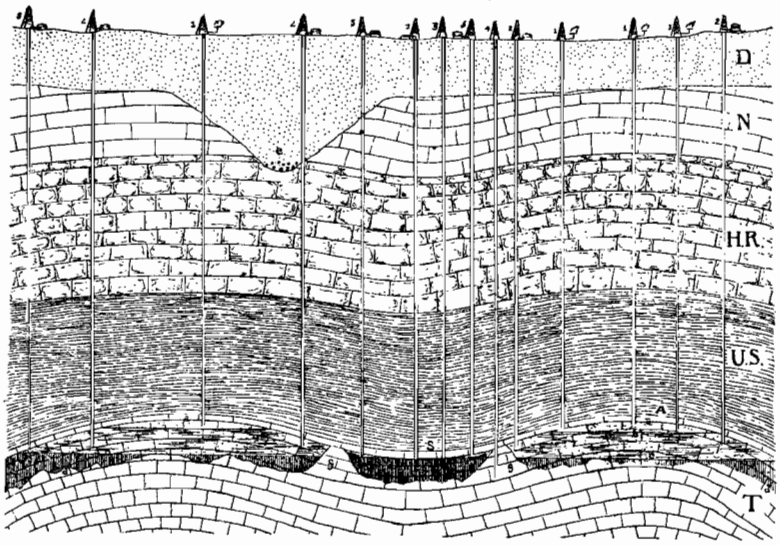
*Dana, Manual of Geology, 4th Ed., 522.

formations. Since then other formations have been deposited, filling up the depressions and leveling the surface, so that the existence of these wavelike folds in deep-lying strata is revealed only by the bore or shaft sunk to them.

The records of the numerous bores put down in recent years for oil and gas in Ohio and Indiana show that the surface area of the Trenton rock is not, as many people think, a level plane, but that numerous rather broad arches and troughs, or anticlines and synclines, exist in it. Experience has proven that the anticlines in the Trenton are important factors in the geological distribution and accumulation of oil and gas. Where the anticlines occur the wells drilled along their crests yield at first gas and after a time oil. Those drilled into the troughs yield only salt water, while in those put down in the intermediate territory, or slope of the anticline, there is most probability of finding oil. The explanation is obvious. The original brine in the Trenton, being heavier than either gas or oil, sank to the lowest position it could reach; the lighter oil assumed an intermediate position, and the still lighter gas was forced or found its way upward to the crown of the arch, where it has remained under great pressure, imprisoned by the impervious stratum of Utica shale covering the porous reservoir.

In the Indiana oil field the production of a new well can usually be foretold by the depth at which the top of the Trenton rock is found. If it is from five to ten feet higher than the average in the nearby productive wells, the chances are that it will yield much gas and little oil. On the other hand, if the Trenton is struck ten to fifteen feet lower than the average, the bore has pierced a trough or syncline, and a salt water well usually results. Sometimes, however, there are apparent exceptions. Of two wells in which the Trenton is found at the same depth, one will be a "gusher," and the other, but a short distance away, a "dry hole." The only explanation which can be given in such a case is that the latter has pierced a close-grained or non-porous area of the Trenton, through which no fluid can find its way. Again, there may be secondary or subsidiary flexures or anticlines which influence the distribution of the oil in local areas. Finally, it may be said that the anticlinal structure has, by numerous tests and observations, been proven to be of the greatest importance in the accumulation of oil in all the great productive fields at present known to man.

The following illustration will, perhaps, lead to a better understanding of the facts mentioned in the last few pages:



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

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

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.

The Rock Pressure.

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. This rock pressure has in the past eventually had much to do with the accumulation of oil in the porous reservoirs, and it will, therefore, be briefly considered in this connection.

Several theories have been proposed as to the cause of the pressure, but the one which is upheld by the most facts, especially in the Trenton limestone field of Ohio and Indiana, is that it is nothing more nor less than water pressure, as in artesian wells, the water entering the porous stratum at some point where the latter outcrops and so forming the "head" or "source." Dr. Orton has calculated the pressure which should be found in certain wells at certain depths, if produced by a head of water equal to the depth of the well below tide level, and has found a remarkable agreement with the actually-measured pressures in many wells of Ohio. He concludes, therefore, that "the rock pressure of

Trenton limestone gas or oil is due to a salt water column measured from about 600 feet above tide to the level of the porous stratum holding the gas or oil.*

The outcrops of the porous Trenton rock which allow the water to enter and so serve as a head, are probably located on the shores of Lakes Superior and Huron at approximately the same elevation as that which the salt water reaches in the oil wells.

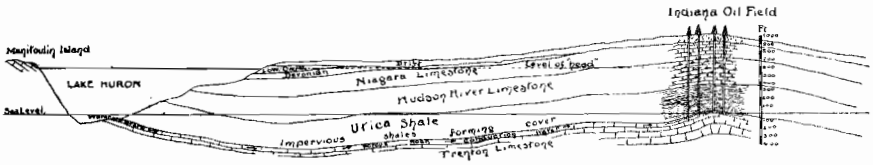


FIGURE ILLUSTRATING ARTESIAN ACTION IN INDIANA OIL FIELD.

The Trenton limestone, being porous, and covered by the impervious Utica shale, serves as a channel for water. This water enters the Trenton at its outcrops along the margins of Lake Huron. In the Indiana oil field the water is, therefore, under a "head" equal to the difference in depth between the Trenton at that point and the level of Lake Huron. It is this "head" which gives the pressure to the oil and gas in Indiana.

The water when it first passed into the Trenton rock gathered the particles of disseminated oil upon its surface and pushed them ahead into the higher and limited areas in which the great accumulations are now found. It has since remained below these accumulations, and so served as a seal on the lower side in like manner as has the Utica shale on the upper. When the driller passes below the second "pay-streak" or layer of porous rock, he always finds the salt water, which rises in the well several hundred feet, and sometimes flows out at the surface. As the supply of oil is diminished the water takes its place in the pores which the former occupied. "Salt water makes the normal and well-nigh universal contents of the porous rocks. The rare exceptions, in localities favored by the accidents of structure, are the stocks of gas and oil, which in reality are very scanty, but which, by comparison with each other, we sometimes call great. Their total volume is insignificant when compared with the other elements with which they are associated. We have no reason to believe that all the accumulations of petroleum contained in the crust of the globe would exceed a few cubic miles in volume, but the salt water contained there would make a sea."—(*Orton.*)

If the above theory is the correct one, and all the facts tend to prove that it is beyond a reasonable doubt, it will be seen that the rock pressure is no indication of either abundance of the oil or permanence of its supply. The porous rock holds a limited amount; the salt water is behind this amount ever pressing it forward into the vent furnished by the drill

*Geol. Surv. Ohio, 1890, 102.

hole. When the supply 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 pores which formerly held the oil, and it will come to stay.

THE PHYSICAL AND CHEMICAL PROPERTIES OF INDIANA PETROLEUM.

The crude petroleum obtained in Indiana is a brownish black liquid with a specific gravity of about .853.* It possesses a rank and disagreeable odor, due to the sulphur compounds which it contains. The elements composing it are carbon, hydrogen, oxygen, nitrogen and sulphur, the last two being present in small amounts. The first three are so combined that the petroleum burns readily, and yields but a small amount of residue.

Two samples of crude petroleum, one furnished by Mr. E. J. Little, from the Van Buren, Grant County, field, and the other obtained by Dr. W. A. Noyes, from one of the wells at Terre Haute, Vigo County, were examined by Dr. Noyes, who reported on them as follows:

	Terre Haute.				Van Buren.			
	Per Cent.	Specific Gravity.	Degrees, Beaume.	Flashing Point.	Per Cent.	Specific Gravity.	Degrees, Beaume.	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 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

*By specific gravity is meant its weight as compared with an exactly equal volume of distilled water, the temperature of the two being the same.

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%

The Terre Haute oil is derived from a different formation than the Trenton.* It is darker colored, more ill-smelling (though, according to the report of Dr. Noyes, the percentage of sulphur is less) and of a greater density and weight than that from Van Buren. At the present time it is used in the manufacture of illuminating gas and as a fuel.

Almost all of the petroleum from the main Indiana field is transported by pipe line to the refinery at Whiting, Indiana, and there manufactured into various commercial products. Within recent years a process has been put into use by which the injurious sulphur compounds are removed by means of iron filings, while the oil is in a state of vapor, so that kerosene almost equal in quality to that derived from the Pennsylvania oil is now obtained from the once despised and little-valued Trenton limestone oil of the Lima-Indiana field.

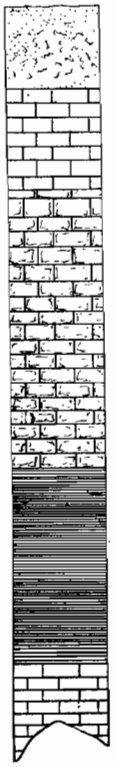
*See Report on Geology of Vigo County, by Dr. J. T. Scovell, in this volume.

CHAPTER II.

THE INDIANA OIL FIELD.

The area of Indiana at present producing petroleum in commercial quantities occupies a portion of six counties northeast of the center of the State, viz.: Adams, Jay, Blackford, Wells, Grant and Huntington. As shown on the accompanying map it comprises about 400 square miles, being included within a strip of territory thirty-three miles long and twelve miles wide, extending from a short distance northeast of Bryant, Jay County, to near Landessville, Grant County. This territory comprises all or a part of each of the following civil townships: Wabash and Hartford, Adams County; Bear Creek, Jackson and Penn, Jay County; Harrison and Washington, Blackford County; Nottingham, Chester and Jackson, Wells County; Van Buren and Washington, Grant County; Salamonie and Jefferson, Huntington County. Outside of this field, as limited on the map, no oil is at present being produced in Indiana, except at Terre Haute, Vigo County, where three wells have been yielding since 1889.

Area.



The surface of the area now yielding oil was originally one great plain, with only occasional small undulations to break its monotony. This 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 bowlder clay, everywhere covering the oil territory from a depth of 50 to 250 feet. These outcrops belong to the Niagara group of the Upper Silurian period.

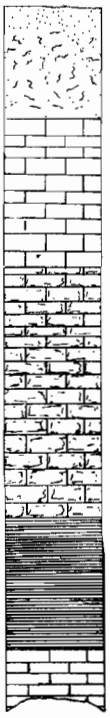
Topography.

The formations passed through by the drill in all parts of the field before the Trenton limestone is reached are, therefore, as follows: Drift; Niagara limestone; Hudson River limestone; Utica shale. In the eastern half of the field an average section showing the thickness of each formation passed through would be about as follows:

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

In the western half the average shows:

5. Drift.....175 feet.
6. Niagara limestone.....225 feet.
7. Hudson River limestone.....380 feet.
8. Utica shale.....200 feet.



The average depth at which the Trenton rock is found below the surface is very close to 1,000 feet, and the first stratum of porous rock or first "pay streak" is usually between seventeen and thirty feet below the surface of the Trenton, the upper crust of the Trenton being a very pure, hard, non-porous limestone, often containing as high as 95 per cent. of carbonate of lime.

The Indiana oil field is, without doubt, a westward extension of the Ohio field, though as yet the connecting area between the two has not been located. From the easternmost Indiana wells, at Bryant, it is but seventeen miles in a southeasterly direction to the wells at Fort Recovery, Ohio; twenty-three miles due east to those at Selma, Ohio, and twenty miles northeast to those at Wiltshire, Ohio.

Throughout the Indiana field what is known as the drive pipe, an iron tube 8 to 10 inches in diameter, is forced down through the drift and boulder clay to the solid Niagara limestone. In this stone is always found more or less salt water; hence, a casing tube $5\frac{5}{8}$ or $6\frac{1}{4}$ inches in diameter is used through the full thickness of the Niagara to shut out the water. Below the Niagara no water is usually found until the Trenton rock is struck. 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 gas or oil is found the salt water is usually below them, at a depth of sixty or more feet in the Trenton; and the operator is usually careful to see that the drilling is stopped before that depth is reached. In some cases, however, the 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, after having been in operation for a year or more. It costs much more to operate such a well, as it has to be pumped with a beam and, therefore, requires a separate power. 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.

Salt Water.

WELLS COUNTY.

Wells County, in which petroleum in paying quantities was first discovered, comprises an area of 372 square miles, 106 of which are included within the known productive oil territory. The surface of the county is level or gently rolling. The average altitude above sea level is about 850 feet. The Wabash River flows diagonally across the county, entering it on the eastern side, a little below the center, and flowing in a northwesterly direction. The Salamonie flows across the southwestern corner in the same direction, and these streams with their numerous smaller tributaries furnish an abundance of running water and in most townships an ample system of drainage.

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

Two railways, the Toledo, St. Louis & Kansas City ("Clover Leaf") and the Ft. Wayne, Cincinnati & Louisville, pass entirely through the county, while the Chicago & Erie touches its northern border; so that the means for transportation of the resources of the county are excellent.

Three townships of Wells County lie largely or wholly within the oil field proper, and in a fourth, Liberty Township, two or three productive wells have been put down. Of these

NOTTINGHAM TOWNSHIP

is by far the largest producer, some of the richest pools in the State having been found within its bounds. This township comprises forty-eight square miles, being eight miles long by six wide; two tiers of sections on the west side of Congressional township 25 north, range 13 east, having been added to township 25 north, range 12 east, in its formation.

The first well in the township and the second in the present field was put down on the Nathan Cory farm in the southeastern quarter of section 28 (25 north, 12 east), by Mr. E. J. Little, in June, 1891. The following record of this well has been kindly furnished me by Mr. Little:

Drive pipe	68 feet.
Casing	306 feet.
Trenton struck at	1,026 feet.
Gas found	1,036 feet.
Oil found	1,038 feet.
Total depth	1,051 feet.

It began to yield at the rate of 250 barrels daily. This was kept up for some time, but gradually fell, until in June, 1896, it was yielding but three barrels daily.

The boring of this well and its success led immediately to the leasing of the surrounding territory, and the rapid opening of the rich deposits in the southern half of the township. The field took on a new lease of life, and there has been no time since that drilling for oil has not been going on in Indiana.

Of the forty-eight sections in Nottingham Township ten at present produce no oil These are sections 5, 6, 7 and 8, in township 25 north, range 13 east, and sections 1, 2, 3, 10, 11 and 12 in township 25 north, range 12 east. No drilling has been done in these sections except in the southeast quarters of sections 3, 7 and 10, in each of which one dry hole has been put down

In the northwest corner of the township no drilling has been done in the north half of sections 4, 5 and 6, nor in the southwest quarters of sections 4 and 6. The southeast quarters of each of these sections have light wells on them, while the southwest quarter of section 5 contains one dry hole.

Sections 7 and 8 and the northeast and southwest quarters of section 9 are proving to be good territory. In section 8 Sharpe & Hittman have nine wells which in June, 1896, were producing fifty barrels daily. One of these started in June, 1895, at two hundred and fifty barrels, averaged one hundred and fifty barrels for fifteen days, but by June, 1896, was down to ten barrels. In these wells the Trenton rock was struck at a depth of 998 to 1,003 feet, and the first porous stratum at seven feet lower. The northwest and southeast quarters of section 9 yield little oil, several dry holes having been drilled on them. A pumping station of the Buckeye Pipe Line is located at Ruth, in the southwest quarter of this section. Two twelve-thousand barrel tanks are located at the station, and much of the oil produced in Nottingham and Chester Townships is forced from there through a four-inch main to Preble, Ohio, where it enters the main leading to the refinery at Whiting, Indiana.

Beginning on the east side of the next lower tier of sections, we find that section 17 (25 N. 13 E.) produces some oil in its northern half, while its southern half may be classed as good territory. Section 18 has scarcely been tested, and its southern half may in time become productive. The north halves of sections 13 and 14, and the northeast quarter of section 15 (township 25 north, range 12 east) are as yet undrilled. The south halves of 13 and 15 are good producers, while that of 14 has so far proven light. Sections 16, 17 and 18 comprise good producing territory, section 17 being one of the best in the entire field. In the "Abshire" pool, in the south half of section 16 and the north half of section 21, forty wells have been put down by the American Oil Company. The first one was drilled in June, 1893, and the others at inter-

vals of about one month thereafter. The average production of the forty in September, 1896, was ten barrels each. The Trenton rock was found at an average depth of 1,001 feet.

In the next tier of sections, Nos. 19, 20, 21, 22, 23 and 24 (25 north, 12 east) have all yielded good wells, those of the south half, section 23, being the best. Pumping stations of the Buckeye Pipe Line are located in the southwest quarter, section 19, and the southeast quarter, section 23. Two dry holes had been put down in the southeast quarter, section 24, prior to 1896, and the greater portion of the quarter section thereby condemned. W. H. Dye, of Indianapolis, re-leased the territory, and in the autumn of that year put down two wells, the first of which started at 200 and the second at fifty barrels, thus furnishing proof that one or two dry holes on a quarter section are no evidence of its non-productiveness.

Sections 19, 20, 29 and 30 (township 25 north, range 13 east) have proven good territory, except the northeast quarter of 19, where two dry holes have been drilled. On the Peter Schott farm, in the southeast quarter of 19, a well was drilled thirty feet into the Trenton in 1894, and yielded nothing but salt water. It was abandoned and partly filled with sand. In May, 1896, a new derrick was put up, the sand and water pumped out, and the bore put down twenty feet deeper and then shot. A hundred-barrel well resulted, which is still keeping up a good yield.

Of the two remaining sections in 25 north, 13 east, No. 32 has a fair yield, while 31 ranks among the best in the township.

The Cudahy Bros., of Chicago, have recently erected in the northwest quarter of section 32 a pumping station and a 38,000-barrel tank. The Northern Indiana Oil Company, which operates a large amount of territory in this portion of the Indiana field, is controlled by them, and the oil will from January 1, 1897, be pumped directly to Chicago through some large mains put down in 1896.

The farm of Geo. W. Brookhart, occupying the northeast quarter of section 31, has been one of the best producers in the Indiana field. The first well was drilled in May, 1893, the second in June, and the third and fourth in the last half of the same year. Five additional wells were put down in 1894, and four in 1895. Up to September 1, 1896, Mr. Brookhart's one-eighth royalty had amounted to over $12,800 for the thirteen wells, so that more than $100,000 worth of oil had been produced from the 160 acres. The depth at which the Trenton limestone was found ranged between 997 and 1,011 feet for the thirteen wells.

The No. 11 well on this farm was thought at first to be a dry hole. "If it had been outside of the farm," said Mr. Brookhart, "it would have been abandoned." The company finally concluded to shoot it with 200 quarts of nitroglycerine. After the shot it yielded only salt water

for a week. Then it began yielding oil at the rate of thirty barrels a day. This rapidly increased, and when the well was fifty-six days old it had produced fifty-four tanks of oil, proving itself by far the best well on the farm. In September, 1896, it was yielding forty barrels of oil and 125 barrels of water a day. Like other large water wells, it has to be pumped alone; whereas the remaining twelve wells, together with fourteen on adjoining farms which are operated by the same company, are pumped by one power. The Geo. Updegraff farm and the Wolff farm, in the quarter section just south of that of Brookhart, have yielded proportionally as much as the Brookhart farm.

Sections 25 to 32, inclusive (township 25 north, range 12 east), have proven good oil territory. On the Harshman and Templin farms, in the northwest quarter of section 26, Davenport, Simmons & Co. put down several wells in 1894 and 1895. The average record of these wells, as given me by Mr. L. C. Davenport, was as follows:

Drift	108 feet.
Niagara limestone	164 feet.
Hudson River limestone	443 feet.
Utica shale	300 feet.
Trenton struck at	1,015 feet.
First oil struck at	1,028 feet.

In the best well on the quarter section the Trenton was found at a depth of 1,010 feet; the well starting at 160 barrels per day in March, 1894, and being down to ten barrels in June, 1896. In the poorest well the Trenton was found at 1,023 feet. The well started at twenty barrels and was down to three in a short time. Eighteen thousand dollars was spent on the lease. Oil equal to that amount in value was produced, and the property was then sold for $18,000. Since then five bores have been put down on the quarter section, four of which have proven dry holes.

As an example of what may be done with a fairly good producing small lease, when properly managed, we may mention that of the 40-acre farm of Margaret Yeager, in the northeast quarter, section 28, operated by L. C. Davenport, of Bluffton. It has on it four wells, the first of which was put down in 1893, and the last in 1894. The average of the well records, as kept by Mr. Davenport, are as follows:

Drive pipe	54 feet.
Casing	294 feet.
Trenton struck at	1,031 feet.
Oil found at	1,046 feet.
Total depth	1,073 feet.

Average initial product, 55 barrels.

Up to September, 1896, $5,500 had been expended on the lease; $6,000 worth of oil had been sold; and the property was valued at $4,000,

based on the market price of oil, 57 cents per barrel. The four wells were then yielding about 18 barrels of oil daily. The only expense for operating was the salary of the pumper, $45 a month; gas and oil, yielded by the wells, being used as fuel.

In the northwest quarter section 29, the Schooley farm has proven excellent territory, more than $80,000 worth of oil having been produced by the 11 wells drilled on it.

Sections 33 and 34 are rather lighter in their yield than those of the remaining sections of the lower tier; while sections 35 and 36 (25 north, 12 east) are both counted as good territory. On the J. Brown farm, in the northwest quarter, section 36, the average record of four wells is as follows:

Drive pipe	128 feet.
Casing set at	264 feet.
Trenton struck at	1,010 feet.
Oil found at	1,025 feet.
Total depth	1,060 feet.

Average initial output, 80 barrels.
Average output in June, 1896, 6 barrels.

An average of the township will probably show 280 feet as the amount of casing put in, and 1,020 feet as the depth at which Trenton is found.

Up to the present, Nottingham Township has probably yielded more oil than any other two townships in the Indiana field. The wells, while not starting in with as large a flow as in some other parts of the field, have held up better. But few, even of the older wells, have as yet been abandoned. While most of the territory has been tested, there is undoubtedly some which has been condemned by one or two dry holes, which will yet be found to be productive. Examples of such territory have already been noted as occurring on the H. Brooks farm in section 24 and the Peter Schott farm in section 19 (25 north, 13 east).

Again, some of the sections in the northern half of the township, as yet undrilled, will probably be found to yield oil in fair amounts, while in much of the territory now producing there is still room for additional wells, so that the output of oil from the township bids fair to be a good one for a number of years to come.

CHESTER TOWNSHIP

comprises thirty-six square miles, corresponding in its civil boundaries to the Congressional township, 25 north, range 11 east. Although a number of good wells have been found within its bounds, the township as a whole contains much light oil territory and has proven a disappointment to those interested in the development of the Indiana field.

The first well to show oil in any quantities in the State was put down by the Northern Indiana Oil Co., on the D. A. Bryson farm, near Keystone (southwest quarter of section 26), in June, 1890. The Trenton limestone was found at a depth of 986 feet, oil at 1,012 feet and salt water at 1,023 feet. The well flowed naturally sixty barrels the first twenty-four hours, but in three months had declined to twenty-five barrels. It was then shot with forty quarts of nitroglycerine, and the flow increased to 100 barrels, but in nine months was down once more to twenty-five barrels. Once again it was shot, this time with 100 quarts, and the flow again increased to 125 barrels, but in two weeks was down to seventy barrels; in three months, to fifty barrels; and in 1896, when six years old, was still yielding eight barrels daily.

Several other wells were put down in 1890 by the Northern Indiana Co. in the vicinity of the first one, but, as none of them showed oil in paying quantities, the company gave up the idea of getting oil there, and no further drilling was done in Wells County until Mr. E. J. Little put down the Cory well in Nottingham Township.

Taking up the sections of the township in detail, we find that Nos. 1 to 4, inclusive, have had but one well drilled in them. This was on the southeast quarter of section 3, and came in in July, 1896, as a very light producer. The Trenton rock was struck at a depth of 998 feet.

Section 5 contains three very light wells on its south half, and one dry hole on its northwest quarter, where the rock was found low—1,020 feet.

In the north half of section 6 a number of wells were put down in 1896, but the yield was light. The Trenton was found almost level, ranging from 1,011 to 1,016 feet. The south half of section 6 and sections 7 and 8, comprise good territory. It was in this locality that one of the principal extensions of the Indiana field was made in 1896, the line of the known producing territory being extended south and east of Mt. Zion, through sections 7 and 8. A number of the wells put down in these sections started out at 100 to 250 barrels daily.

Sections 9, 10, 11 and 12 have practically no production. Dry holes have been put down in the northwest and southeast quarters of section 9, the southwest quarter of section 11, and the northeast quarter of section 12 The remaining parts of the sections have not been tested, except the northeast quarter of section 11 and the southeast quarter of section 12, where one or two light wells are located.

A light production only has so far been obtained in sections 13, 14, 15 and 16. On the John Kennedy farm in the northwest quarter of section 16, A. L. Sharpe drilled in a well in July, 1896, which produced much gas, the Trenton being found at 984 feet, and a small amount of oil. Gas was first struck at 12 feet in the Trenton and oil at 27 feet. Three-fourths of a mile west, on the T. J. Callahan farm (northwest quarter of section 16) the Trenton was found to be 44 feet lower down, and no gas, oil or

water was found until a depth of 1,051 feet was reached where "Blue Lick" water occurred. Between the two wells above mentioned, a bore on the farm of John McKey (northeast quarter of section 16) developed the Trenton at 1,014 feet, and a good production of oil. Such facts are strong proofs of the truth of the anticlinal structure of the Trenton having much to do with the distribution of the petroleum; the gas on the Kennedy farm being found in the crest of an anticline; the water on the Callahan farm in a syncline, and the oil on the McKey farm in intermediate territory.*

Sections 17 and 18 may be classed as good territory, the south half of section 17 being lighter than the north half

Of the next lower tier of sections, Nos. 19 to 22, inclusive, are light producers, the Trenton being found rather low. On the William Bennett farm in the northwest quarter of section 23 are a number of fairly good wells, and from there eastward through section 24 the Trenton rises and the production becomes better. The east half of section 24, and sections 25 and 26 may be classed as good producing territory, while Nos. 27 to 34, inclusive, are light, the four in the southwest corner of the township, viz., 29, 30, 31 and 32 being especially so. No drilling has, however, been done in section 28. In the south half of section 34 the Trenton is found 1,000 to 1,005 feet. Nearer Montpelier, in the township south, it rises to 970 feet, and the bores show much gas and a better production of oil.

Coming back to the southeast corner, we find sections 35 and 36 to be like the ones above them—good producers. These four sections evidently form a natural portion of an area of rich territory found to the eastward in Nottingham Township, and to the south and southeast in the corners of Harrison Township, Blackford County, and Penn Township, Jay County.

On the eighty-acre farm of Jane Howard, in the northeast quarter of the northeast quarter, section 36, seven wells were put down in the spring of 1896 by F. E. Alexander. In six of them the Trenton rock was found at a depth of 1,024 feet, and in the seventh at 1,039 feet, the oil being found at seventeen to twenty feet lower in each case. All were productive, the initial output ranging from one hundred and fifty down to thirty barrels. In three weeks the one hundred and fifty barrel well was down to thirty barrels, while the thirty barrel well, when six weeks old, was still yielding eighteen barrels. A dry hole was put down on the farm immediately west, the Trenton being struck at 1,024 feet.

From what has been written concerning the production in Chester Township, it will be seen that the southeastern and northwestern corners only can be classed as good territory, the remainder having, as yet, shown a small production. A large portion of the southern half of the township

*See page 43.

seems to have the surface of the Trenton in a syncline which gradually rises to the westward, resulting in some good producing territory in the southern half of Jackson Township.

JACKSON TOWNSHIP

contains thirty-six square miles, and corresponds to the Congressional township (25 north, range 10 east).

Of this area about ten square miles may be classed as good oil producing territory. The remainder has, up to the present, yielded but little oil.

In the northeast corner, sections 1, 2, 12 and 13, and the north half of 11 seem to form the western half of what may be termed the Mt. Zion pool, inasmuch as they have proven themselves highly productive. Section 1 has probably produced more oil than any other section in the township.

On the G. W. Huffman farm, in the west half of the section, eleven wells were put down in 1894–5, in which the Trenton rock was found between 997 and 1,003 feet. For the month of May, 1896, the wells yielded 3,354 barrels, and for June 3,018 barrels, an average of ten barrels each daily.

No drilling has been done in sections 3 to 7, inclusive, except in the northeast quarter of 3 and the south half of 4, where some fairly productive wells have been put down. Section 8 has one dry hole in the northwest quarter, the remainder being untested. In section 9 two holes were put down in the south half in which a show of oil was found, but not enough, the operators thought, to warrant the expense of shooting the wells. The northwest quarter of the section contains fair and the northeast quarter good producing wells. The west half of section 10 contains some light wells, the east half being undrilled. A pumping station of the Buckeye Pipe Line is located on the northeast quarter of this section.

The south half of 11 and the east half of 14 include light producing territory, being seemingly on the southwestern edge of the Mt. Zion pool.

The west half of 14 and the north half of 15 are undrilled, while in the south half of 15 three bores have been put down, which resulted in a dry hole, a salt water well and a heavy gas well, the last two showing oil in small quantities.

A dry hole in the southwest quarter of 16, and one in the northwest quarter of 17, are the results of the only bores in those sections. Section 18 has had two wells put down on the east half which were so light that they are no longer pumping. The west half, and section 19 except the southwest quarter, are undrilled. On that quarter section several fair producing wells are located.

Section 20 has had several very light wells drilled upon it. On the Mercer farm, in the east half of the southeast quarter, the No. 1 bore put down by W. B. Little & Co. showed the following section:

Drift	121 feet.
Niagara limestone	259 feet.
Hudson River limestone	287 feet.
Utica shale	300 feet.
Trenton found at	967 feet.
Total depth	1,025 feet.

Result, dry hole.

Twelve hundred feet east a gas well was put down in 1891, which is now pumping about six barrels of oil daily, the supply of gas having gradually dwindled to practically nothing.

Section 21 and the southwest quarter of section 22 contain a number of fair producing wells. The Mercer No. 2, put down by W. B. Little, in the north half of the southwest quarter of section 21, in May, 1895, has the following record:

Drift	231 feet.
Niagara limestone	154 feet.
Hudson River limestone	296 feet.
Utica shale	300 feet.
Trenton found at	981 feet.
Total depth	1,020 feet.

Average initial product, 75 barrels.
Daily product in June, 1896, 8 barrels.

The great discrepancy in the relative thickness of the drift and Niagara in this bore and Mercer No. 1, suggests the presence of a preglacial channel in the Niagara, at the point where No. 2 was put down. In the north half of 22 and in section 23 a number of holes have been put down, but the yield of oil has been very light. Section 24 is undrilled, except in the northeast quarter, where a few light wells are found.

The sections of the next tier, 25 to 30 inclusive, are all light producers, except Nos. 27 and 28, which may be classed as good. The south half of 30 has not, as yet, been tested.

In the lower tier no drilling has been done in 31. The south half of 32 has a few light wells, and the north half two bores which yielded oil for a while, but are no longer pumped. Farther east the production becomes much better, and sections 33, 34 and 35 each have a number of good wells, while 36 is less productive. On the Byall farm in the southeast quarter of 34 is a large salt water well, which is also noted for its production of oil. It was finished in March, 1892, and in September, 1896, when four and one-half years old, was producing forty barrels of oil and 700 barrels of water daily. Two similar wells are located on the T. J. Banter farm in the southwest quarter of section 35. One of them,

finished in June, 1895, was producing forty barrels of oil and 1,000 barrels of water in September, 1896. The other, finished a month later, yielded 210 barrels of oil and no water for several days before shooting. In a short time it began yielding water, and in September, 1896, was producing thirty barrels of oil and 500 of water daily. In such instances, it is believed that the water flows or is forced through the porous stratum and brings in with it oil from other territory.

While on the map the whole of Jackson Township is included in the productive area of the Indiana field, the good production, it will be seen, has been in spots, with much intervening territory, either undrilled or with a very light yield. In the center of the township, as well as in its northwestern fourth, there is much territory which has been condemned by dry holes, which, with a fair test, might prove productive. It is the writer's opinion, based on a careful study of the Indiana field, that there are greater chances of striking oil in the undrilled portions of such a township as Jackson, which lies within the limits of known productive territory, than by "wild catting," outside of such limits.

LIBERTY TOWNSHIP (26 NORTH, 11 EAST)

lies north of Chester Township, and east of Salamonie Township, Huntington County. But little drilling has as yet been done within its bounds. A bore in section 22 resulted in a salt water well A dry hole was put down in the southeast quarter section 34; and, in 1896, two light producing wells and one dry hole in the south half of section 31. One of the wells, located on the William Dalby farm, had an initial product of 50 barrels. The Trenton is found comparatively low in the section, being struck at a depth of 1,023 feet. A number of good wells have been drilled immediately west in sections 25 and 36, Salamonie Township, where the Trenton occurs between 990 and 1,000 feet.

* * *

Outside of the productive area shown on the map oil has been found at one or two other localities in Wells County, but not in paying quantities. At Kingsland, Jefferson Township, in the southwest quarter, section 33 (28 north, 12 east), Judge E. R. Wilson put down a well in 1890 for gas. It yielded but a small amount of gas and six barrels of oil daily. The well was capped in and 800 feet east a second bore was put down seventy-three feet into the Trenton, without finding either water, gas or oil.

Two bores were put down in Lancaster Township in 1894 by W. B. Little, one of which contained a small amount of oil. It was located on the east half section 11 (27 north, 12 east) and showed the following section:

Drift	80 feet.
Niagara	420 feet.
Hudson River limestone	300 feet.
Utica shale	347 feet.
Trenton at	1,147 feet.
Showing of oil at	1,168 feet.
Blue Lick (sulphur) water	1,187 feet.
Total depth	1,200 feet.

The second bore in section 1 (27 north, 12 east) found Trenton at 1,120 feet, and produced a small flow of gas.

ADAMS COUNTY.

This county lies east of Wells County and is bordered on the east by the Ohio State line. It is twenty-four miles in length from north to south and fourteen miles in breadth, comprising, therefore, an area of 336 square miles. Like Wells County, the surface is comparatively level, but well drained by the St. Mary's and its tributaries in the northern half and the Wabash and its tributaries in the south. The soil is rather more retentive of moisture than that of Wells County, but the materials composing it are essentially the same, and its fertility, where properly drained, has proven excellent.

Three railways pass through the county, the G. R. & I. from north to south, and the T., St. L. & K. C. and Chicago & Erie from east to west; Decatur, the flourishing county seat, being a junction point of the three.

Petroleum has so far been found in paying quantities only in the two townships of Hartford and Wabash, in the southwestern part of the county.

HARTFORD TOWNSHIP

comprises an area of only twenty-four square miles, the two western tiers of the Congressional township (25 north, range 13 east) being included in the civil township of Nottingham, Wells County. Of this area about one half is at present producing oil in paying quantities.

The first productive well in Adams County was put down by the Bolds Brothers on the George Shoemaker farm, east half of northeast quarter of section 26 (25 north, 13 east), in February, 1892. It started at 110 barrels a day and proved an incentive to much drilling in the neighborhood. The second well on the same farm was drilled in May, 1893, with an initial production of 100 barrels, and the third in July, 1892, started at sixty barrels. The lease was then sold for $8,000, much less than its actual value.

The most northern production in Hartford Township, at the present time, is in section 13, where there are several light producing wells.

Bores have been put down in sections 2, 4, 10, 11, 14, 15, 16 and 21, all of which resulted in dry holes or salt water wells.

Some good producing wells are found in the southeast quarter of section 22, but the remaining portions of the section have been condemned by bores resulting in salt water, or nothing. Sections 23 and 24 both comprise good territory; the former has one dry hole near its center, but several wells starting at 150 to 180 barrels have been located within its bounds. The southeast quarter of 24 has in the past yielded much gas, but has recently changed into productive oil territory.

The remaining sections of the township are all noted as good producers. On the C. Herschey farm, in the northeast quarter section 25, thirteen wells have been bored, the average depth of the Trenton being 1,004 feet, and the average initial production one hundred barrels. On the J. A. Martin farm in the southwest quarter of the same section, the record of a well put down in 1892 is as follows:

Drive pipe ..... 110 feet.
Casing ..... 230 feet.
Trenton struck at ..... 996 feet.
Initial production, 150 barrels.
Production in October, 1896, 2 barrels.

On the northeast quarter of section 28 the drift was found to be fifty-seven feet thick, the Niagara 173 feet thick, and the Trenton at a depth of 1,002 feet. A number of the first wells in this portion of the township were drilled only about twenty feet into the Trenton, and so missed the second porous stratum, which lies deeper. The yield of oil from them has been much less on this account than what it otherwise would have been.

In section 33 the Trenton lies at about 1,003 feet below the surface. In section 34 a bore put down in 1893, and resulting in a dry hole, condemned 320 acres of land belonging to Joseph Watson. In 1895 it was re-leased, and has resulted in one of the most productive farms in the township.

In the south halves of sections 35 and 36 the Niagara limestone seems to have been cut out by spurs or tributaries of a great preglacial river, which will be mentioned more fully hereafter. As a result 350 to 400 feet of drive pipe must be used, and the expense of drilling is thereby much increased.

In the area of Hartford township in which oil has been found, the initial production has been above the average for the Indiana field, and the wells have held up better than those in the western part of that field. The large number of dry holes and salt water wells already down in the north part of the township are a strong proof that the northern boundary of the productive area has been practically determined, and that but few, if any, good wells will be found outside of the line shown on the map.

WABASH TOWNSHIP.

But four square miles of this township have up to the present yielded oil in commercial quantities. They comprise sections 18, 19, 30 and 31 along the western edge.

Along the northern border of section 18, Jones, Good & Co. have five light producing wells, the first of which was put down in 1892. Each of the five had a good initial production, but it gradually dwindled until in November, 1896, the total yield was but about ten barrels a day. The south half of section 18 and the north half of 19 have each been tested by several bores, which yielded salt water and but little oil.

The south half of 19 and the west half of 30 have each a number of good wells located on them. On the I. Wheeler farm, in the northeast quarter of 30, the Trenton was found at 1,030 feet and a dry hole resulted. On the J. Bucher farm, in the southwest quarter of the same section, two wells were put down in 1896, which started at 150 and 120 barrels respectively. In these the Trenton was found at 1,012 feet.

The wells on section 31 have been light producers. The drift is here found 400 feet deep, as also in the northwest quarter of the northwest quarter of section 32, where a single light well has been bored.

Wells in which more or less oil was found have been put down in Adams County at several points outside of the present producing area. In Wabash Township, on the southeast quarter of section 10, the Standard Oil Co., in 1893, drilled a well which started at fifty barrels. Much of the surrounding territory was immediately leased and a pipe line laid to the well mentioned, but the production rapidly dwindled and no further developments were made.

In the outskirts of Geneva, in the northeast quarter of the northeast quarter of section 29 (25 north, 14 east), a bore resulted in salt water with a showing of oil. The drift was here found to be 400 feet thick. A two barrel well was also developed in the northwest quarter of section 28.

In the south halves of sections 31 and 32 (township 26 north, range 15 east), Blue Creek Township, several bores have been put down. One, by the Superior Oil Co., resulted in a fifteen barrel well, which will still yield five barrels daily. The others were dry holes or salt water wells, which stopped further operations. The Trenton is here found at a depth of 1,092 feet, while seventy-seven feet of drive pipe and 300 feet of casing are necessary.

These isolated wells go to prove that oil occurs in the Trenton of the southeast corner of Adams County. There is little doubt, as already mentioned, but that the Indiana field is connected with that of Ohio by a strip of territory in southeastern Adams and northeastern Jay—the limits of which have not as yet been defined by the drill.

JAY COUNTY

comprises an area of 387 square miles, lying south of Adams and the eastern half of Wells counties and west of Mercer and Darke counties, Ohio. The surface of the county is gently rolling or nearly level, and the soil of most portions proves very fertile where properly drained and tilled. The Salamonie River flows through the county from southeast to northwest and drains its western and southern halves. The Wabash River touches its northeastern corner and through its tributaries drains the townships of Wabash, Bear Creek and Jackson.

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

In the Indiana field, Jay County ranks next to Wells as a producer of petroleum. The area at present productive of oil in commercial quantities lies for the most part west of the G. R. & I. Railway, in the northern tier of townships, though a few light wells are producing east of that line.

BEAR CREEK TOWNSHIP (24 NORTH, 14 EAST).

Of the thirty-six square miles embraced in the civil township of Bear Creek seven produce oil in sufficient quantities to pay for operating the wells. Those seven are sections 6, 7, 8, 9, 16, 17 and 18.

The west half of section 6 contains some good wells. On the farm of Dr. C. S. Arthur, in the northwest quarter, two bores struck the Trenton at 1,002 feet, one yielding 280 barrels the first day, the other being a dry hole.

The east half of the section is untested, except the extreme southeast corner, where a dry hole has prevented the drilling of adjacent territory in section 5. Section 7, and the southwest quarter of section 8 may also be called good territory. Bolds Bros., in 1892, held leases on 480 acres in section 7, and put down a bore which developed a dry hole. They gave up the leases, and the territory was re-leased and a second dry hole put down. Again abandoned, Bold Bros. took it up a second time and developed sixteen producing wells, which were yielding 110 barrels daily in 1896, when the property was sold for $30,000 to the Warren Oil Company. An average section of these wells shows:

Drive pipe	75 feet.
Casing	235 feet.
Trenton at	993 feet.

East of the G. R. & I. Railway, and northeast of Bryant, thirteen bores were put down in 1896, in sections 9, 10, 15 and 16 The first one, in the south half of section 9, started in June with a yield of 125 barrels, but by October had dropped to four barrels daily. The large initial product of this well caused the drilling of the remaining twelve, five of which were dry holes, and the remainder only light producers. The one farthest northeast in the northeast quarter of section 10 was yielding ten barrels a day when the engine was moved and the well plugged. Dry holes have been bored in the northwest quarter of section 14 and the southeast quarter of 15. In the north half of section 16 three light wells are located, while the south half is undrilled.

The north halves of sections 17 and 18 contain good wells; the south half of 17 being undrilled, and that of 18 having three bores each with a showing of oil, but not enough to pay for pumping.

In addition to those mentioned, bores have been put down in the township as follows: Two gas wells in section 19; two wells with a showing of oil, and one dry hole, in the northwest quarter of 31; one dry hole in the southeast quarter of 24. While the results of the developments so far made in Bear Creek Township have not been flattering, there is little doubt but that some good wells will yet be found in the undrilled territory of the two northern tiers of sections.

JACKSON TOWNSHIP (24 NORTH, 13 EAST.)

While the north half of this township has proven above the average for the Indiana field, the south half has as yet yielded little oil, and that in isolated pools.

Many more wells would have been put down in the north half had it not been for the deep drives necessary in what is known as the Loblolly. This name is given to a low, marshy tract of territory occupying the larger portion of the two northern tiers of sections in the township. A number of small lakes, very narrow and deep, were formerly scattered throughout its area, while the greater portion, not occupied by the lakes, was covered with water during a part of the year. Much of this territory has in recent years been reclaimed by drainage, and the soil proves to be among the richest in the county.

Since the discovery of oil in Indiana numerous bores have brought to light the remarkable fact that the Niagara limestone, which underlies the drift in all other portions of the field, is entirely lacking in the greater part of the area known as the Loblolly; and that the drift, instead of ranging from 50 to 175 feet in depth, as elsewhere, is here from 250 to 420 feet, and in a few instances, even 520 feet deep.

This phenomenon is without doubt due to the presence of a preglacial channel, which was eroded through the Niagara limestone, then the surface rock, by a large river which flowed in a southwesterly direction through the townships of Wabash, Adams County; Jackson and Penn, Jay County, and Harrison and Washington, Blackford County, its course, but not always its limits, having been traced by the bores put down in recent years.

This stream was probably the outlet of the melting waters of a great glacier which occupied a region far to the northeast. These waters flowing for centuries over the Niagara limestone gradually wore a channel through its entire thickness in the region now known as the Loblolly. Afterward the glacier itself moved slowly over the region, grooving and planing the surface of the solid rocks, strewing for hundreds of miles in its track beds of clay and sand and gravel, thereby filling up the channels of its ancient outlets and so hiding all knowledge of their course and depth, until man, seeking with steel drill for a hidden resource, discovers the absence of the eroded rock and reasons out the cause thereof.

The Loblolly district simply embraces a portion of the old bed that was deeper than the rest. The drift deposited in it being so much thicker than over the surrounding area of Niagara rock, and having no solid support near the surface, as did the latter, settled to such an extent that its surface was a few feet lower, and over this lower portion the surface waters collected. Wherever the Niagara has been thus eroded the cost of putting down a well through the deep drift is much greater, being seventy-five cents to one dollar a foot, as against forty-five to fifty cents in other places.

The northernmost tier of sections in Jackson Township, Nos. 1 to 6, inclusive, have all proved highly productive of oil. In the northeast quarter of the southeast quarter of section 2, the drift was 372 feet thick and the Trenton was struck at an average depth of 984 feet. As no Niagara rock was found no casing was necessary. One well put down in January, 1896, started at 120 barrels, and in June was yielding twenty barrels daily. A pumping station of the Buckeye Pipe Line is located on the southwest quarter of this section.

On the A. Letts farm, in the southeast quarter of section 5, eighteen wells have been drilled, the Trenton being found at an average depth of 970 feet, and the average initial production of the wells being sixty barrels.

The south half of section 6, all of section 7 and the north half of section 8 are practically undrilled on account of the deep drift. On the south half of section 8 several fair wells have been drilled, the drift on the northwest quarter of the southeast quarter being 437 feet thick and the Trenton 968 feet down.

Sections 9 to 12, inclusive, contain some excellent wells, one on the Bechtel farm in section 10 having yielded 101 tanks in 100 days, and in October, 1896, when two years old, was producing thirty barrels daily. However, the most productive well in the township at that date was located on the southwest quarter of the northeast quarter of section 11. It was completed in July, 1896, and had an initial production of 200 barrels. In October it was still yielding 180 barrels of oil and sixty barrels of water daily. In it the Trenton was struck at 981 feet, and the first oil at 1,000 feet.

In the next tier of sections the north halves of 13 and 14 comprise some good territory; while the south halves have only a few very light wells, and lie just within the border of the producing field, no wells being found between West Liberty and Portland.

Section 15 contains but two light wells, while on the south halves of 16 and 17 no drilling has been done. The north halves of these sections contain some fairly productive wells. Section 18, the north half of 19, and all of 20 and 21 have had a number of bores put down which have yielded only gas.

The south half of section 19, the northwest quarter of section 30, and the adjacent territory to the west in sections 24 and 25, Penn Township, have embraced one of the richest areas in the Indiana field, five or six wells thereon having started off at 400 barrels each, and a number of others at 100 to 250 barrels.

On the northwest quarter of section 22 two light wells are located, and in the northwest of section 24, and the northeast of section 25, a showing of oil resulted in the only two bores put down in those sections. No drilling has been done in sections 26, 35 and 36. A few light wells are located in the north half of section 28 and one in the northwest quarter of section 27; the south halves of these sections being as yet undrilled.

Sections 29, 32 and the south half of 30 have as yet developed only gas, though one or two wells in 29 showed a large quantity of oil when first drilled in, but the supply was soon choked off by the gas, and the wells therefore abandoned.

All of section 31 and the northwest quarter of 33 can be classed as good territory; while one very light well in the northwest quarter of 34 has stopped drilling to the eastward.

There is little doubt but that many good wells will yet be located in Jackson Township. Much territory has been unnecessarily condemned on account of a gas well or dry hole having been put down between it and the known limits of producing territory.

All the central parts of the township which now yield gas, will eventually yield oil in greater or less amounts, though there is little chance of that area proving as rich as the two northern tiers of sections or the pool in sections 19 and 30.

PENN TOWNSHIP,

Jay County, comprises but 30 square miles, the western tier of sections of township 24 north, range 12 east, being attached to Harrison Township, Blackford County.

Of this area little more than one-half is at present producing oil, though almost the entire township lies within the productive area of the Indiana field.

The north half of section 1 contains a number of good wells; while the south half is within the limits of the deep drift and has but two bores, southeast quarter, each with but a showing of oil.

The south half of section 2 is undrilled, while the north half is fair territory, but not equal to that on either side. No drilling has been done in the southwest quarter of 3 and the southeast quarter of 4, but the remaining parts of these sections as well as all of 5, 8, and the west half of 9 is good productive territory. In the south half of 5 the Trenton ranges between 1,026 and 1,032 feet below the surface. A pumping station of the Buckeye Pipe Line is located on the northwest quarter of section 8 and another near the center of section 23 of this township.

Owing to the presence of the deep drift in the old preglacial channel, the east half of 9 and sections 10, 11 and 12 are untested; except the southeast quarter of 12, where a light producing well has been sunk, the drift at this point being 410 feet thick. One dry hole has been put down in the southeast quarter of 13, and the section thereby condemned. Sections 14 and 15 produce gas rather than oil, the region about Balbec furnishing much gas for the city of Bluffton. Section 16 and the south half of 17 are undrilled, while the north half of 17 contains a number of good wells. The west half of 20 is also a good territory; the east half, together with sections 21 and 22 belonging to a gas-producing area which is prominent in the center of this township. In this area the Trenton is usually found at a depth of 960 feet, showing that the crest of an anticline runs through the sections noted. Section 23 and the south half of 24 contain good wells; the north half of 24 having been condemned by four dry holes.

On the northeast quarter of section 25 is located the farm of W. S. Gardner, where the first wells of the famous "Gardner pool" were put down, several of which started off at more than 400 barrels each. This "pool," as far as developed, occupies about one and one-half square miles in sections 24 and 25, Penn, and 19 and 30, Jackson Townships. The land lies mostly in a valley, surrounded by higher ground on all sides. These higher knolls and ridges, such as "Tusey's Knob," in section 24, and "The Twin Hills," in the southwest of the northeast of 25, are composed of great masses of glacial sand and gravel rising 70 to 80 feet above the level of the valley. They are the deposits of a mighty

stream which was formed by the receding and melting glacier and show that the water must have moved in a southwesterly direction with a strong and rapid current, eroding the sand and gravel already deposited over a broad area to the northeast, and reassorting and depositing it in the hills and ridges of this region.

A large amount of promising undrilled territory lies within the limits of the oil field to the south and southwest of the Gardner pool, as well as on its northern border, condemned because a few dry holes or gas wells have been put down upon it.

The west half of section 25 and the southeast quarter of 26 have as yet produced no oil, the bores put down yielding gas.

The remainder of section 26 and the east half of 27 contain a number of good oil wells. On the Heller farm, just north of Camden (southeast quarter section 27), the No. 2 Well disclosed the following section:

Drift	50 feet.
Niagara limestone	153 feet.
Hudson River limestone	451 feet.
Utica shale	300 feet.
Trenton struck at	954 feet.
First porous stratum ("pay streak") at	977 feet.
Second porous stratum ("pay streak") at	1,014 feet.
Finished at	1,042 feet.

Between the first and second "pay streaks" there was about ten and one-half feet of hard non-porous limestone. In the Phillips well, 1,000 feet south, the Trenton was struck at 961 feet, and the first porous stratum at twenty feet lower; while the second "pay streak" was not found at all. On the Heller farm two wells were put down on a single acre, one of which started at ninety barrels; the other being a dry hole.

Two other wells just outside the boundaries of the acre were also dry holes.

The west half of 27, and section 28, as far as drilled, have yielded gas, instead of oil. Section 29 has two light wells on tbe east half, but the remaining wells put down have been gas producers.

In the southern tier of sections, 32 has produced gas from the three bores put down; 33 is undrilled, while 34 has one good well just west of Camden in the northeast quarter. This was put down in May, 1896, by the Manhattan Oil Company. It started at 200 barrels daily, and in October was producing twenty-five. Several additional wells were immediately drilled in the same section, but proved either dry holes or light gas wells.

The south half of 35 and the east half of 36 each contain a number of good wells; while the north half of 35 has been mostly condemned by two or three dry holes, and the west half of 30 has proven gas territory. On A. Graves' farm in the southwest quarter of 35, nine wells have been

drilled, the average depth of the Trenton rock being 965 feet. Three of these yielded gas, and the remainder oil, several having started with an initial production of 200 barrels.

Much of Penn Township is, as yet, gas territory; and when the supply of this valuable fuel is exhausted, oil in paying quantities will, doubtless, be found in much of the central and southern sections; but the yield will probably be much lighter than in those localities where the Trenton lies lower, and the bore results immediately in a productive well. As in other portions of the field, a number of tracts lying within the confines of good territory, have been condemned by a dry hole or two. These tracts should, and doubtless would, yield oil, should additional bores be put down. Before oil was found in Jay County, thirty or more gas wells were located in the vicinity of Camden. The numerous bores put down for oil have reduced both the pressure and the volume of the gas, and a number of the wells have had to be abandoned.

KNOX TOWNSHIP.

The northern half of this township has had a number of bores drilled on it, but the only portion now producing oil is the northwest quarter of section 1, where a few light wells are located.

One light well, not now pumping, is located on the northwest quarter of section 4, and several others have been put down in section 11.

The most promising of the latter, known as the "Wingate Well," when first completed, showed 100 barrels of oil and 3,000,000 feet of gas. The oil finally subsided and the well is now producing gas alone.

GREENE TOWNSHIP

lies wholly without the present productive area, but a number of bores within its bounds have developed oil in small quantities. One of these was in the northwest quarter of section 3, and another on the banks of the Salamonie River in the west half of section 8.

The first well to show oil in Jay County was drilled in 1887 on the Penn farm, two and one-half miles west of Portland (northeast quarter of northwest quarter of section 24), Greene Township, by Benjamin Fulton, since noted as an oil operator. The well was drilled for gas, but without shooting yielded thirty-five barrels of oil a day for several days. There being no pipe line or storage facilities, the well was capped in and abandoned.

The next year the "Gilbert Well" was put down on the same quarter section. It yielded much gas and flowed, without pumping, enough oil to fill a large tank. It has been recently overhauled and, according to

Mr. Fulton, was yielding ten barrels of oil daily in June, 1896. The Trenton was found in these two wells at a depth of about 970 feet, the following being a record of the section of the Gilbert well:

Drift	42 feet.
Niagara limestone	193 feet.
Hudson River limestone	435 feet.
Utica shale	300 feet.
Trenton struck at	970 feet.
Finished at	995 feet.

In the southwest quarter of section 10, Wayne Township, a bore was put down, the Trenton occurring at 1,035 feet, and a small quantity of oil was found, but not enough to warrant further drilling in that region.

In Richland township, in the southwestern corner of Jay county, a number of the wells put down for gas have in the past shown the presence of oil in small quantities. This fact led E. Priddy, a successful operator from Findlay, Ohio, to put down a test well for oil on the farm of Evan Evans, one mile southwest of Redkey. This well was drilled in October, 1896, and furnished the following record:

Drive pipe	59 feet.
Casing	278 feet.
Trenton struck at	980 feet.
Oil, showing only, at	1,000 feet.
Salt water at	1,030 feet.
Abandoned at	1,070 feet.

* * *

At New Corydon, in the northeastern part of Jay County, two wells were put down in 1895, one of which showed quite a quantity of oil, and the other a dry hole.

* * *

That the Trenton rock underlying the surface of Knox, Greene, Wayne, Bear Creek and Wabash Townships contains oil in greater or less quantities has been shown by the numerous bores in which it has been already found. There are doubtless large areas of those townships where the rock occurs in the porous condition necessary to the accumulation of oil in quantity, but those areas can only be determined by future drilling. The bores put down in those townships up to the present have been so located that they, for the most part, happened to miss the accumulations. Where one good well is found others will most likely be found near it; oftentimes, however, the second well happens to be located in the wrong spot, proves a failure, and so disheartens the operator.

The Ohio and Indiana fields are, without doubt, connected, and the line of connection will, in the future, be found in northern Jay or southern Adams Counties, perhaps in both.

Again, when the present gas area of Jackson, Knox and Greene Townships shall have yielded up its more subtle fluid the oil will rise to take its

place, and a light producing oil field will result. Where the Trenton lies ten to thirty feet lower than in the area at present yielding gas, oil will be found in larger quantities; but drilling is the only method by which the location of such areas can be determined.

BLACKFORD COUNTY.

This county comprises but 165 square miles, embraced in four civil townships. It lies west of Jay, south of Wells and east of Grant Counties. The surface is for the most part level or slightly rolling, the only hills being due to the eroding action of water. The soil, like that of the surrounding counties, is fertile, being of glacial origin and containing, therefore, all the constituents needed by the cereals and grasses. The principal products are the standard cereals, wool and live stock.

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

The Ft. Wayne, Cincinnati & Louisville Railway crosses the county from north to south, and the Pittsburgh, Cincinnati & St. Louis from northwest to southeast, the two crossing at Hartford City, the county seat.

About one-fourth of the area of the county is at present producing oil. This area occupies the northern two-thirds of Harrison Township and the northeastern fourth of Washington Township.

Montpelier, in the northern part of the former township, being the closest railroad town to the rich fields of the southern part of Wells County, has, within recent years, become the principal oil center 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.

HARRISON TOWNSHIP.

This township comprises forty-two square miles, the western tier of sections of the Congressional township 24 north, range 12 east, being added to township 24 north, range 11 east, in its make-up. Of this area, twenty-five square miles are at present producing oil in greater or less quantities.

The territory embraced in the sections of the upper tier may be classed as good, with the exception of the northern halves of sections 1 and 2, which yield much gas in connection with the oil, and section 6 (24 north, 11 east), where the wells have proven light producers.

In the southern outskirts of Montpelier, southwest quarter of section 3, is the oldest oil well in the county. It was put down in 1890 and started

with a good flow of gas and about twenty-five barrels of oil per day. A record of the formation passed through by the bore of this well is as follows:

Drift	17 feet.
Niagara limestone	233 feet.
Hudson River limestone	432 feet.
Utica shale	280 feet.
Trenton struck at	962 feet.
Total depth	981 feet.

The well in June, 1896, was still yielding oil at the rate of about six barrels a day.

In the western part of section 5 and in section 6, the Trenton is found rather high, 960 to 970 feet, and much gas is given off with the oil.

The largest pumping station of the Buckeye Pipe Line Company is located on the bank of the Salamonie River, northwest quarter of section 3, a short distance northeast of Montpelier. The oil from the receiving tanks of the producers in the Indiana field is pumped by the smaller pumping stations of this company to this large one at Montpelier. Two 25,000 barrel tanks are here located, and all Indiana oil, except the small amount pumped by the station at Ruth, Wells County, passes through these tanks and is pumped through two mains to Preble, Ohio. In September, 1896, an average of 14,000 barrels a day was being pumped from the Montpelier station.

Of the second tier of sections, the wells put down in No. 7 have proved light producers, while those in No. 8 have been uniformly good. In No. 9 the northern half is light territory. The southern half is somewhat better, being, seemingly, a northern extension of the good productive area of section 16. The northwest quarter of No. 10 is a good producing area, but the south half of that section has developed nothing but dry holes. The northeast quarter and sections 11 and 12 are considered very light territory, the wells starting out at twenty to forty barrels and soon dropping down to a low output. In section 7 (24 north, 12 east) the yield rises again and a number of good wells are located thereon.

Starting back on the next tier, No. 18 (24 north, 12 east) and Nos. 13, 14 and the east half of 15 contain only light producing wells. The west half of 15, all of 16 and 17, except the northwest quarter, where gas territory sets in, are highly productive. This area, together with the north half of 21, seems to form a pool, surrounded by much poorer territory. On the Evers farm, in the northwest quarter of 15, the average depth of the Trenton in eight wells was 1,000 feet, and the average initial production 125 barrels. In section 18 some light producing wells are found in the northern half, while the southern half has so far yielded gas. Many of the gas wells in this township and Washington were put down before oil was discovered. As a consequence, they were stopped in

the upper porous stratum, or "pay streak." If drilled deeper they would have struck the second porous stratum and have yielded both gas and oil. In section 19 and the north half of 30, a number of good wells were located in the season of 1896, the known limits of the productive field being extended for about two miles to the southwest. On the McMahan farm, northwest quarter of section 30, the Trenton was found at 976 feet. Section 20 is undrilled, except the northeast quarter of the southwest quarter, where a bore producing gas was put down. The north half of 21 contains a number of good wells, while the south half, as well as section 22, is untested. Section 23 contains two dry holes in its northwest quarter, and 24 several gas wells on its west half, the remainder of the two sections being undrilled.

The preglacial channel through the Niagara, mentioned on page 65, extends in a southwesterly direction through several sections in this part of the township, and has prevented drilling on account of the much greater expense necessary in getting through the deep drift. Its limits have not as yet been defined, but several bores in section 13 (range 11) and section 19 (range 12) required over 400 feet of drive pipe. A gas well in the southwest quarter of section 29 passed through 405 feet of drift, so that the channel probably passes out of the township through sections 30 and 31.

Section 19 (24 north, 12 east) has proven light up to the present, while on the north half of 30 (in the Godfrey Reserve) a number of good wells were put down in 1896 by Dr. White, of Indianapolis.

An average record, as furnished by these, was as follows:

Drive pipe	128 feet.
Casing set at	254 feet.
Trenton struck at	968 feet.
Finished at	1,035 feet.

Farther south the Trenton rises, being found at 934 feet in section 31 (24 north, 12 east). As a result, nothing but gas has been found in the bores put down to the westward in the southern third of Harrison Township, though a showing of oil was found in the one in the southwest quarter of section 29, and in another located on the south margin of the deep drive region in the northeast quarter of section 34.

WASHINGTON TOWNSHIP (24 NORTH, 10 EAST).

The line marking the southern limit of the present known productive oil area of the State enters this township on the east in section 24, and passes diagonally to the northwestern corner. About eleven square miles of the township are, therefore, included within the Indiana field.

Of the northern tier of sections Nos. 1 to 5, inclusive, are all good producers, while 6 is yet untested. The Buckeye Pipe Line has a

pumping station on the northwest quarter of section 3. Sections 7, 8 and 9 are practically untested, the northeast quarter of 8 having two light wells, and the corresponding quarter of 9, one dry hole. In section 10 the production has been a good one, but in 11 salt water rather than oil has been the result of drilling, especially in the south half. Section 12 is good territory, while the bores put down in 13 and the northern halves of 14, 15, 16 and 24 have all been light producing. The remaining sections of the township have yielded only gas where drilling has been done; though in some instances, as in the wells put down by the Fort Wayne Gas Company in sections 21, 22 and 23, a good showing of oil has also resulted.

As the yield of gas diminishes much, if not all, of the territory in the southern half of both Washington and Harrison Townships will in the future produce oil. As noted above, where the two are found in conjunction the gas occupies the upper "pay streak" and the oil the lower. The yield of oil will not, therefore, be so great as in the areas already partly drilled in the northern halves of these townships.

GRANT COUNTY,

in which the most westward extension of the Indiana oil field is located, lies west of the counties of Wells and Blackford, and south of Huntington and Wabash Counties. It comprises an area of 418 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. & K. C., the C., W. & M., and the P., C. & St. L. railways passing entirely through it and having a common junction point at Marion, the county seat.

The oil bearing territory of Grant county is at present limited to the northeastern corner, and comprises the greater portion of Van Buren township and a small part of Washington township. This area will now be treated in detail.

VAN BUREN TOWNSHIP (25 NORTH, 9 EAST.)

The northern half of this township has proven one of the best portions of the Indiana oil field. It owes its development largely to the acumen and energy of Mr. E. J. Little, a progressive and well informed operator, who, after selling his interest in Nottingham Township, and about Geneva, Adams County, entered the Van Buren field after it had been practically condemned, and, undaunted by several failures, stuck to it until he proved it what he believed it to be, a rich oil territory.

The first well which produced oil in Grant County was put down for gas in 1890 by J. H. McBride, of Butler, Ohio. It was located in the outskirts of the town of Van Buren, in the northwest quarter of section 15, and its record as obtained and preserved by Mr. Little is as follows:

Drive pipe	155 feet.
Casing	380 feet.
Trenton struck at	996 feet.
Total depth	1,033 feet.

It yielded a small amount of gas and some oil, but the latter was not thought to be in paying quantities, and as there was no pipe line to carry it away, the well was not pumped and was soon abandoned.

In August, 1893, E. J. Little drilled the second well in the Van Buren field, on the northwest quarter of section 24. Here the Trenton was found at 1,000 feet, and a natural flow of oil, estimated at fifty barrels a day, resulted. It soon changed into a water well and was abandoned.

The third well was put down by Mr. Little on the southeast quarter of section 9, just north of Van Buren. It yielded but ten barrels a day and was soon abandoned.

In the spring of 1894 a fourth well was put down on the J. B. Cory farm (southwest quarter of section 16). It flowed oil for some time, but not enough to warrant the putting in of a pipe line.

In the fall of 1894 Bettman, Watson & Co. entered the field and put down two wells on the southeast quarter of section 15. The yield from these wells was sufficient to justify the Standard Oil Company in laying a pipe line to Van Buren, and the field began to open up immediately after the line was completed.

The first four sections of Van Buren Township have not, up to the present, proved very promising territory. The north halves of 1, 2 and 3 are untested, while the wells on the south halves have proven light.

Section 4 has several large salt water wells on its east half; its southwest quarter contains, however, some fair wells. Sections 5, 6, 7, and the north half of 8, contain good wells; the south half of 8 being untested.

Section 9 is what oil men call "spotted." In the northwest quarter is located one of the best wells in the county. It was completed in March, 1896, and by August 1 had produced twenty tanks of oil. On the northeast quarter a large salt water well is located; while the southwest quarter contains a big gas well, which pumps some oil, and the southeast quarter contains a dry hole. On the north half of section 10 are two dry holes, while the south half contains a number of light producing wells. The average of four well records in this section is as follows:

Drive pipe	106 feet.
Casing set at	409 feet.
Trenton struck at	982 feet.
Total depth	1,020 feet.

Until 1896 it was thought that sections 11 and 12 would prove like those of the north, rather light in production. However, Mr. Jas. H. McCormick, an experienced operator from Bluffton, decided to test them, and, as a result, has eleven good wells, ten of which, in the month of October, yielded 5,000 barrels of oil. In section 11 the drift is about 114 feet thick and the Trenton is found at an average depth of 970 feet. The Buckeye Pipe Line has its most western pumping station in the southeast quarter of this section.

In the next tier of sections, numbers 13, 14 and 15 have proven excellent territory. On the Creviston farm, in the northwest of 14, the Trenton lies at 968 feet, and ten wells started out with an average initial production of 60 barrels. On the John Swisher farm, in the northeast of 15, the record of a well finished on April 7, 1896, was as follows:

Drive pipe	108 feet.
Casing set at	410 feet.
Trenton struck at	968 feet.
Total depth	1,018 feet.

Initial production, 160 barrels.
Production June 12, 25 barrels.

On the Boxel farm (southwest quarter of 15) the Trenton was found at 965 feet, 118 feet of drive pipe and 385 feet of casing being necessary. In June, 1896, the first well on the Doyle farm, in the same quarter section, was finished with an initial yield of 100 barrels. The second, 600 feet south, finished in August, started at twenty-five barrels. By the first of October they were yielding thirty and ten barrels, respectively. In general, it may be said, that in the immediate vicinity of Van Buren the drift is 105 feet thick and the Niagara limestone about 305, making 410 feet the amount of casing used.

Section 16 has yielded much salt water and but little oil, except on the southeast quarter, where a number of good wells are located, the Trenton being found here at 968 feet, while in the salt water wells in the other portion of the section it ranged between 983 and 990 feet.

To the west the yield is much less, the east half of section 17 being very light territory. The west half is better, and, with the south half of 18 and the north halves of 19 and 20, may be termed fair. A number of wells were put down in these sections in 1896 by the Bettman, Watson, Bernheimer Company, of Marion. On November 1 the average yield of eighteen of these wells in the immediate vicinity of Landessville was said to be ten barrels a day. The north half of 18 and the south halves of 19, 20 and 21 are untested, while the north half of 21 has three light wells and two dry holes to its credit.

Both 22 and 23 are good productive sections. On the Kirkpatrick farm, in the northeast quarter of 22, is located the well which had the greatest initial production in the Indiana field. It was finished in June, 1896, and after being shot flowed at the rate of 150 barrels an hour for two or three days. The flow then stopped, and after a few days' pumping the well began yielding nothing but salt water. This was kept up for several weeks, when the oil came in once more, and in October it was producing fifteen barrels daily. But few spouting oil wells have been drilled in Indiana, and where found their spouting continues for but a few days. The average depth of the Trenton in section 22 is 967 feet.

The west half of section 24 contains some fair wells, the east half being untested. A few light wells have been finished in the northwest quarter of 25 and the north halves of 26 and 27, the remainder of these sections, as well as all others in the two southern tiers of the township, being untested up to December 1, 1896.

WASHINGTON TOWNSHIP (25 NORTH, 8 EAST).

In this township oil has been found in paying quantities only in sections 1, 12, 13, 24, 25 and 26. On the White farm, northwest quarter of section 12, a well was finished in May, 1896, which started at ten barrels an hour, but the yield soon dwindled, and in November it was producing much salt water and little oil. Several bores which produced gas have been drilled in the southwest quarter of 1 and south half of section 2, as well as in the north half of 11.

The south half of section 12 and the north half of 13 are untested. The south half of 13 and section 24 contain a number of fair wells. One or two light producing bores are located in the north half of 25, while on the J. C. Tinkle farm, in the south half of 26, is a well which was finished October 15, 1896, and started at seventy-five barrels a day. This well is farther southwest than any in the Indiana field, and is probably

the forerunner of a number which will be put down in this extension during the winter of 1896–7. In sections 25 and 26 the Trenton rock dips to the south, and an average record, as shown by the bores, is as follows:

Drift	132 feet.
Niagara limestone	368 feet.
Hudson River limestone	250 feet.
Utica shale	235 feet.
Trenton at	985 feet.
First "pay streak"	1,009 feet.
Salt water	1,023 feet.

Outside of the productive area as shown on the map, few wells have been put down in Grant County which showed the presence of oil. One in the northeast quarter of section 36, Washington Township, has yielded a small amount. Another on the land of Joshua Strange, near Arcana, Monroe Township (24 north, 9 east), started in as a heavy gas producer, and finally began to show oil in the fall of 1896. Two tanks were filled, but, there being no pipe connection, the well was capped in and pumping stopped.

* * *

The Van Buren oil field is noted for the small number of "dry holes" found therein, the relative proportion being less than in any other part of the Indiana field, unless it be in the southern half of Hartford Township, Adams County. The oil-bearing stratum of the Trenton is softer and more easily drilled than in Wells County. As a result, the initial product is greater and drops down faster. For example, a 100 barrel well in Wells County will be yielding fifty barrels at the end of two or three months. The same well, if in the Van Buren field, would probably start at 150 to 200 barrels, and be down to twenty or thirty in three months. There seems to be about so much oil to a certain area of territory, and the more rapidly it is taken out the sooner the end comes. As yet, however, few of the wells in the Van Buren territory have been abandoned for lack of production. The output reaches a certain limit—as five to eight barrels a day—and holds it steadily for months, or even years.

As in the eastern part of the field, there are usually two "pay streaks" found in Grant County, the one seventeen to twenty feet below the top of the Trenton, the other twenty-eight to thirty-eight feet below. In many gas wells put down in the early history of the field the upper streak alone has been pierced; if when the well has ceased to yield gas it be bored deeper the oil in the lower stratum will be reached. Much less paraffine is found in the oil of the western part of the Indiana field than in that of the eastern, and especially the Trenton limestone field of

Ohio. In the latter the hole has to be cleaned up once a month; in the Van Buren field once a year often suffices.

The limits of the known oil bearing area of Grant County will, in all probability, be extended westward over the greater portion of Washington Township; and as the yield of gas continually diminishes, a lighter producing territory will probably be found in the northern halves of Centre and Monroe Townships. South of this developments have not been sufficient, as yet, to foretell what the future will bring forth.

HUNTINGTON COUNTY

comprises an area of 384 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 740 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 underlaid 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 composing 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 northwest to southeast and the latter from northeast to southwest, while the "Clover Leaf" cuts across the southeastern corner.

The area of Huntington County, at present producing oil; is small, being limited to the southern third of Jefferson Township and the southeastern corner of Salamonie Township, though one or two bores in Wayne Township have given a fair yield, but not enough, as yet, to warrant the laying of a pipe line to them.

JEFFERSON TOWNSHIP (26 NORTH, 9 EAST).

The most northern well in this township is a test well located on the Weaver farm, southwest quarter of northwest quarter of section 21. It started October 1, 1896, at about 100 barrels a day. The nearest producing territory to it is in the south half of section 28, where several good wells were drilled in June of the same year. On the W. F. Trammel farm the following record was furnished by a bore finished June 10:

Drive pipe ..... 165 feet.
Casing ..... 415 feet.
Trenton struck at .....1,001 feet.
Initial production, 100 barrels.
Production October 1, 15 barrels.

The territory between the Weaver well and the south half of 28 is as yet untested; but, lying between two productive points, it is counted as good until it is proven otherwise.

The southeast quarter of section 29 contains two light wells, and the southwest quarter of 27 several good ones; while in the northwest quarter of 26 a dry hole is located, and in the southwest quarter of the same section, where the Trenton was found at 977 feet, a fair well came in, in December, 1896. This comprises the results of the boring done in this tier of sections to date.

In the south tier, the northeast quarter of 31 has several good wells located on it. The remainder of the section and the north half of 32 are untested; while the yield of the south half of 32 is light. Section 33 and the northwest quarter of 34 contain as good wells as are found in the township; the portion of 34 being especially rich. The south half of that section has, up to the present, yielded only light wells. The production in sections 35 and 36 has also been generally light, though some good wells have been recently put down on the John Karringer farm, east half of northwest quarter, section 35, where the Trenton was found at 980 feet.

Outside the present field, I was able to hear of but one bore that had been put down for oil in Jefferson Township. It was located on the Satterthwaite farm (east half of the southeast quarter, section 7). The Trenton was found rather high, 964 feet, but the bore yielded salt water only.

SALAMONIE TOWNSHIP.

The oil operations in this township have, up to the present, been confined to sections 25, 26, 34, 35 and 36, in the southeastern corner. Outside these sections but two bores have been put down; one at Warren, in section 29, which resulted in a dry hole, and the other in the southwest quarter of section 22, where the Trenton was found low, 1,005 feet, and a salt water well, with but a showing of oil, resulted.

The wells in section 25 are located in the southeast quarter, the southwest quarter, and one in the northwest quarter. All are fair producers. Five or six wells are producing near the center of 26 and three in its southeast quarter, the remainder being undrilled.

Only the south half of section 34 has been tested and salt water resulted in the two bores put down. Two salt water wells and one fair producer have been drilled on the west half of 35, while the east half has a number of good wells, the best one, close to the south line of the section, making sixty barrels a day when it was two and a half years old. The Trenton in the east half of 35 and the west half of 36 is found at 985 to 990 feet. The southwest quarter of 36 is pretty well drilled over, sixteen bores having been put down upon it, twelve of which resulted in fair wells. The southeast quarter of this section has been condemned by two bores which developed salt water only, while the north half has a few fair wells within its bounds.

The trend of the drilling in this township seems to be to the northwest. There is no reason, however, why oil should not be found in the territory south of Warren, the one dry hole in that section having been put down at an early date and only to a shallow depth in the Trenton.

WAYNE TOWNSHIP.

The Sterling Oil Company has put down several test wells in this township. A bore on the John Sparks farm (northeast quarter of southwest quarter section 15) developed salt water. Much difficulty was experienced in sinking this well, five different holes having been started. The drift was found to be 153 feet thick and 515 feet of casing was necessary.

On the A. T. Searles farm (southwest quarter section 24) a bore finished in July, 1896, showed the following record:

Drive pipe	301 feet.
Casing set at	515 feet.
Trenton struck at	986 feet.
Total depth	1,024 feet.

Initial product, 100 barrels.
Output October 1, 10 barrels.

Two tanks were filled, and no pipe line being in the vicinity, the well stopped pumping. This is the most northwestern well in the Indiana field.

On the George Babcock farm in section 35, a well drilled in September, 1896, yielded gas only.

The three townships of Wayne, Jefferson and Salamonie lie on the northern limit of the Indiana gas field. The oil area may, in time, be found to cover the greater portion of the territory embraced within their

bounds, but the chances of its extending farther north in the other townships of Huntington County are very remote. At the present writing, the best prospective territory in the county lies in the southwestern fourths of Salamonie and Jefferson Townships.

CHAPTER III.

THE PRODUCTION OF PETROLEUM IN INDIANA.

The raising of petroleum from the porous stratum or reservoir in the depths of the Trenton, where it has laid for thousands of years, to storage tanks upon the surface of the earth, where it can be utilized by man, is termed the "Production of Petroleum."

The evolution of the processes involved in the present advanced methods of production from the primitive ones used by the first "oil operators" 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 life-time in mastering the details of producing oil at a minimum cost, often finds himself handicapped before he has completed his first well.

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 the 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 "wild-cat" bore. Any one who makes a special study of the Indiana field will soon note that the Standard Oil Company and other large operators do little "wild-catting," but profit by the experience of the small operators who indulge in it. "Wild-catting" 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.

Choosing a Locality for Operating.

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

Usual Terms of a Lease.

acre shall be paid until the first well is drilled. The landowner 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. Of a farm of eighty acres not more than three need 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 $300 to $1,000, 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 sometimes 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 the Indiana field:

In Consideration of the sum of.....dollars, the receipt of which is hereby acknowledged, ..., of .....County, in the State of Indiana, first party, hereby grant unto....., second party, their heirs and assigns, all the oil and gas in and under the following described real estate, together with the right to enter thereon at all times for the purpose of drilling for oil and gas, and to erect and maintain all buildings and structures and lay all pipes necessary for the production and transportation of oil or gas taken from said premises. Excepting and reserving, however, to first party the.....part of all oil produced and saved from said premises, to be delivered in tanks at wells, or in the pipe lines with which second party may connect their well, or wells; said real estate being described as follows:

All that certain tract of real estate situated in the Township of....., County of ....., in the State of ....., bounded and described as follows, to wit:

.....

.....

containing.....acres, more or less.

To have and to hold the said interest in and to the above premises on the following conditions:

If gas only is found, second party agrees to pay.....dollars each year for the product of each well while the same is being marketed off the premises, and first party may use gas free of cost to heat.....stoves in dwelling house during said time.

Whenever first party shall request it, second party shall bury all oil and gas lines being laid through tillable land, below plow depth, and pay all damages done to growing crops by reason of burying and removing said pipe lines.

No well shall be drilled nearer than.....feet to the house or barn on said premises.

In case no well is completed within.....from this date, then this grant shall become null and void between all parties hereto, unless second party shall pay to said first party.....dollars, annually, for each year thereafter the completion of such well is delayed.

The second party shall have the right to use sufficient gas, oil and water to run all necessary machinery for operating for any purpose on said real estate, and shall also have the right to remove all its property from said premises at any time.

....

.....

It is understood between the parties to this grant that all conditions between the parties hereto shall extend to their heirs, executors and assigns.

IN WITNESS WHEREOF, the parties to this grant have hereunto set their hands and seals this..... day of ....., 189..

.....[SEAL]

WITNESSES. .....[SEAL]

.....

.....

AGREEMENT.

FROM .....

TO .....

Date.....189..

LOCATION.

Sec. No..... *Township*.....

County.....

State of.....

Rec'd for Record.....189..

Time Recorded.....189..

In Book.....*Page*.....

Recorder.....*County*.

.....Acres.

STATE OF.....
COUNTY OF..... } ss.

On this....day of.....189.., before me, a....., in and for said county, personally appeared....., to me well known, and acknowledged the signing and execution of the within instrument and grant to be....free and voluntary act for the uses and purposes therein set forth.

Witness my hand and.....seal.

.....

.....

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 300 feet from the property line in order to first obtain the oil which might otherwise be raised by the 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 often considered in determining the site of the well. If other 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 fifteen barrels a day for a year or two, 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 about 600 feet apart; that distance, in the language of the oil field, being termed "a location."

Locating the Wells.

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 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 not less than ten and often twenty acres are given to the well. On the smaller leases one to every eight acres is often drilled. The degree of the porosity of the rock should govern the acreage to a large extent. Where comparatively open, each well drains a larger territory, and fewer bores are necessary than where the pores are close.

Having selected a site for his well, the operator next contracts for a rig, the main feature of which is the derrick. This 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 a 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 seventy-two feet, and it forms the most conspicuous object which characterizes an oil field.

The Rig.

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 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 more 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 Indiana in 1896 the price paid for the rig complete was about $275.

After the well is completed the rig is, in most cases, left standing, though small operators often 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.

The rig having been completed, the contract for drilling the well is let. 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 $700 to $1,500, according to number and quality. His engine is of a pattern built especially for the purpose and costs about $450. Sometimes the contractor owns several, perhaps a dozen, strings of tools, and is drilling a number of wells at the same time.

In the Indiana field in 1896 the contract price for drilling was fifty cents a foot. 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.

Drilling the Well.

The wages paid the drillers in 1896 were $4.00, and the tool dressers $3.00 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 the Trenton varies much, but is usually from nine to twelve days. The shortest time which came to my notice was six days and six hours, made by J. G. Herriet, a contractor in Wells County.

As already noted, the surface of the territory in the Indiana field is covered with the so-called "drift," a heterogeneous mass of sand, gravel, bowlder-clay, etc., 30 to 250 feet, or, in the Loblolly district, as high as 450 feet thick. Through this a strong iron drive-pipe, furnished by the owner of the well, must be driven, as in pile driving, to the solid bed rock. This pipe is usually eight inches in diameter, sometimes ten, and is fitted with a steel shoe on the lower end. That it may be driven more easily it is usual to drill inside, clean out the earth and cut ahead, loosening the hard clays or breaking any bowlders that may be in the way.

After reaching the Niagara limestone an eight inch bit is used and iron casing, in lengths of 17 to 20 feet and 5⅝ inches in diameter, is set as fast as the drilling progresses, thus shutting off the water. From the bottom

of the Niagara to the oil-bearing stratum there is little or no water and a 5½ inch bore is made, the drilling being done through the drive-pipe and casing already down.

Shooting the Well.

As soon as the porous stratum is passed through, if there is a fair showing of oil, the well is torpedoed 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 50 to 60 feet, 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. Nitroglycerine 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 120 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 nitroglycerine 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 twenty quarts of the explosive. 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 nitroglycerine. After the lowering line of the last shell has been reeled up, an iron casting, called the "go-devil," is dropped into the bore, and the "shooter" and spectators retreat some distance from the derrick.

A person one hundred yards away will, after an interval of thirty to fifty seconds, experience a slight jarring of the earth, accompanied by a muffled report somewhat louder than a pistol shot. A minute or two 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 finally 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 canisters 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 twenty-five barrels. The cost in 1896 of such a tank was eighty dollars.

After tubing the well and connecting it with the tank, the necessary pumping apparatus must be bought, as few Indiana wells flow naturally for any length of time.

If a number of wells are to be drilled a power house is located near the center of the lease and a small engine placed therein. Each well is supplied with an oscillating walking beam, to which the necessary pumping or sucker rods which ply up and down inside the tubing are attached.

Pumping the Oil.

When several wells are pumped by one engine the power is transmittted to the walking beam of each by means of long rods or wire ropes provided with suitable angle-knees to change the direction of the pull. The engine runs an oscillating pull-wheel which gives horizontal movement to the rods radiating from it to the different wells. These rods are suspended above the ground by ropes attached to poles or posts which are set in a row between the power house and well. The pull-wheel draws the rods in one direction, and on the return the weight of the sucker rod, hanging from the walking beam, 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 engine and wells) can not look after more than that number and do it right. The fuel used for pumping is usually gas, the wells

*See frontispiece.

on the lease often furnishing enough; though in most instances it is piped in from a distance. Oil is used to some extent, and will probably be more used in the future.

Several of the leading operators about Van Buren and Montpelier have begun to use gas engines for pumping, and so far have been very favorably impressed with their work At Van Buren Mr. E. J. Little, in October, 1896, was pumping six wells at an expense of but $8.00 a month for gas. The engine is so constructed that natural gas and compressed air are blended and then exploded by electricity generated in a small battery at hand. The sudden expansion of the mixture moves a piston and so creates motion. The engines need no attention other than oiling once or twice a day. The pumper has more time to look after the wells and can attend to a greater number of them. The cost of the gas engine has up to the present kept it from more common use, the price of one suitable for pumping being $650 in 1896.

The average cost of the first well on a lease, if drilled to a depth of 1,000 feet, was about as follows in the Indiana field in 1896:

Cost of a Producing Well.

Rig	$275
Drilling	500
Drive Pipe	100
Casing	250
Shooting	110
Tubing and pumping outfit	200
Engine and boiler	500
Two tanks @ $80	160
Belting, etc	85
Total	$2,180

The second well will cost $500 less, as the one engine and boiler will do for both. The larger operators, where putting up their own rigs and drilling their own wells, expend less money. Thus seven wells on one lease close to Van Buren cost $1,100 each, connected to the power. Of seven on another lease in Chester Township, Wells County, where the rig and drilling were let by contract, the first cost $2,400 and the remaining six $1,200 each.

After a tank has been filled with oil the latter must be steamed to reduce the impurities and 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. The process of "production" is then complete, and the oil is ready for the market.

Cost of Operating a Lease.

The cost of operating an oil lease after the production has been established need not be more than $75 per month; the salary of the pumper being $45 to $50, and the cost of fuel, if gas, about $25. A dozen, or even twenty wells can, however, be operated almost as cheaply as one after they have been con-

nected with the power. An extra pumper may have to be employed, but otherwise no additional expense is entailed.

Where the plant has been established, it will pay to pump as low as two or three wells, even if the yield is only five barrels each per day, provided, the price of oil is fifty cents or more per barrel.

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

Expense per month:

Salary of pumper	$50
Cost of fuel	25
	$75

Income per month:

250 barrels oil @ 50 cents	$125
Net income per month	$50

With six five-barrel wells on the lease, the income would be $375 and the expense $75; a net gain of $300 per month.

Where a well is inside of producing territory, and promises a fair output, little difficulty is experienced in getting a branch of the Buckeye Pipe Line Company laid to it. This pipe line company is an adjunct of the great Standard monopoly, and up to the advent of the Cudahy Pipe Line, transported all the oil produced in the Indiana field with the exception of a small production in Adams County, which the Manhattan Oil Company controls.

Marketing the Oil.

When a tank is full, or nearly so, the pumper notifies a gauger of the Buckeye Company, who comes and measures its contents and turns it into their line. He at once notifies the Ohio Oil Company (the Indiana branch of the Standard Oil Company), at Montpelier, and, after deducting 2 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 Buckeye Company, together with the market price of the same. These certificates can be cashed at the various banks in the oil field, or are payable over the counters of the company at Montpelier. The Standard Oil Company, owning, as it does, the only pipe lines of any size entering the Indiana field, controls the price of Indiana oil. It can raise or lower it at will. It is said that in 1895, wishing to get possession of outstanding certificates harmful to its interests, it forced the price of Indiana and South Lima oil to $1.15 a barrel. Immediately it had accomplished its object, the price was gradually lowered until in the fall of 1896 it ranged between 57 and 61 cents. At all times within the past few years North Lima oil, though of the same quality as that from Indiana and South Lima, has sold at from five to ten cents a barrel more, for the reason that competition exists in the former district. The Pennsylvania and West Virginia oils,

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The cost of operating an oil lease after the production has been established need not be more than $75 per month; the salary of the pumper being $45 to $50, and the cost of fuel, if gas, about $25. A dozen, or even twenty wells can, however, be operated almost as cheaply as one after they have been con-

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

Expense per month:

Salary of pumper	$50
Cost of fuel	25
	$75

Income per month:

250 barrels oil @ 50 cents	$125
Net income per month	$50

With six five-barrel wells on the lease, the income would be $375 and the expense $75; a net gain of $300 per month.

Where a well is inside of producing territory, and promises a fair output, little difficulty is experienced in getting a branch of the Buckeye Pipe Line Company laid to it. This pipe line company is an adjunct of the great Standard monopoly, and up to the advent of the Cudahy Pipe Line, transported all the oil produced in the Indiana field with the exception of a small production in Adams County, which the Manhattan Oil Company controls.

Marketing the Oil.

When a tank is full, or nearly so, the pumper notifies a gauger of the Buckeye Company, who comes and measures its contents and turns it into their line. He at once notifies the Ohio Oil Company (the Indiana branch of the Standard Oil Company), at Montpelier, and, after deducting 2 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 Buckeye Company, together with the market price of the same. These certificates can be cashed at the various banks in the oil field, or are payable over the counters of the company at Montpelier. The Standard Oil Company, owning, as it does, the only pipe lines of any size entering the Indiana field, controls the price of Indiana oil. It can raise or lower it at will. It is said that in 1895, wishing to get possession of outstanding certificates harmful to its interests, it forced the price of Indiana and South Lima oil to $1.15 a barrel. Immediately it had accomplished its object, the price was gradually lowered until in the fall of 1896 it ranged between 57 and 61 cents. At all times within the past few years North Lima oil, though of the same quality as that from Indiana and South Lima, has sold at from five to ten cents a barrel more, for the reason that competition exists in the former district. The Pennsylvania and West Virginia oils,

being of a better quality, bring from 47 to 58 cents more per barrel than the Indiana product.

The Cudahy Pipe Line, being of small capacity, can do little towards increasing the price of Indiana oil. It is a private line, constructed to relieve its owners (who, next to the Standard, are the largest producers in the Indiana field) from the power of the Standard, rather than to serve as a competitor to the latter company.

The real value of a barrel of crude Indiana petroleum, when one takes into consideration the manifold products derived from it, is nearly double its present market price of 58 cents. But with the output wholly in the power of a monopoly, which is commonly reputed to "know no scruples in its treatment of competitors," there is little chance for the Indiana producer to receive just value for that which he produces. At present he is wholly deprived of the benefits ever accompanying free competition. He must take his choice of staying out of the field or selling the product for the arbitrary price fixed by the one purchaser.

A producing well often has to be overhauled and cleaned. Where the production has run down there have been in recent years several attempts to increase it by the use of hydrochloric (muriatic) acid, some of which have been quite successful. A well in the northwest quarter of section 4 (24 north, 13 east), Jackson Township, Wells County, operated by the Fry Oil Company, when three years and a half old, had a production of but five barrels daily. It was then treated with 148 carboys of acid, costing something over $400. In six days the acid was neutralized, and the well began pumping twenty barrels a day and kept it up for several months.

Use of Muriatic Acid in Old Wells.

On the Schooley farm, in the southeast quarter of northwest quarter of section 29 (25 north, 12 east), Nottingham Township, Wells County, a well which in April, 1895, started at 150 barrels was down to ten barrels in June, 1896. Studebaker, Bennett & Co., of Bluffton, Indiana, then treated it with a carload of muriatic acid at a cost of $400. They let it stand for nine days and then cleaned it out, and it began yielding fifty barrels a day, which it kept up for six weeks; for the second six weeks it averaged thirty barrels daily, and by October 15 it was down to fifteen barrels. In both of the above wells the acid treatment was a success financially, but in several other wells in Adams and Wells Counties it has proven a failure. Where the porous stratum is rather coarse, the acid acts more freely on the dolomite and probably increases the flow for a while. Where the stratum is close-pored, a carload of acid does not affect the rock far enough distant from the well to cause much increase in the production.

Statistics of the Indiana Oil Field.

The production of oil in Indiana has gradually increased from 33,375 barrels in 1889, when the wells at Terre Haute first began yielding, to 4,659,290 barrels in 1896. In no year has the production diminished below that of the preceding year, though in 1896 the gain was but 272,850 barrels, or 6.2 per cent., whereas in 1895 it was 697,466 barrels, or 18.9 per cent. The lower price of oil and the general stagnation of business preceding the national election prevented many wells from being drilled in 1896 which would otherwise have been put down.

In the following table is shown the total production of petroleum in Indiana by months from 1891 to 1896. The largest production in any one month is seen to have been in May, 1896, when 442,490 barrels were produced:

TOTAL PRODUCTION OF PETROLEUM IN INDIANA FROM 1891 TO 1896, BY MONTHS.

[Barrels.]

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.
January	6,171	15,841	111,824	259,000	300,568	371,430
February	5,981	18,946	96,025	232,107	230,559	335,053
March	5,159	24,794	134,549	282,376	310,303	381,680
April	4,973	26,184	146,493	287,330	352,077	390,297
May	5,757	31,033	186,939	321,502	397,001	442,490
June	8,136	40,888	209,616	333,479	403,569	437,628
July	10,809	49,203	221,666	327,349	434,376	428,413
August	11,603	56,109	248,353	345,031	420,132	407,990
September	16,500	66,034	245,615	319,588	409,169	405,106
October	19,029	95,699	252,568	339,424	393,153	345,662
November	20,801	129,270	245,607	304,030	373,789	327,826
December	21,715	144,067	236,038	337,450	361,436	314,715
Total	136,634	698,068	2,335,293	3,688,666	4,386,132	4,588,290

Adding to the 4,588,290 barrels, the amount transported by the Buckeye Pipe Line from the Indiana field, 71,000 barrels, the amount produced by the Northern Indiana Oil Company between September 17 and January 1, we have 4,659,290 barrels as the total product of the Indiana field for 1896.

It will be noted that the production in each of the winter months is less than in those of spring or summer. This is usually the case, there being, during the cold season, fewer wells drilled in and a smaller yield from those already finished. The shipments are greater than the production in winter and the price usually rises a few cents per barrel.

In the following table will be found a statement of the production of petroleum in Indiana from 1889 to 1896, inclusive:

PRODUCTION OF PETROLEUM IN INDIANA FROM 1889 TO 1896.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Total production (barrels of 42 gallons)	33,375	63,496	136,634	698,068	2,335,293	3,688,666	4,386,132	4,659,290
Total value at wells of all oils produced, excluding pipage	$10,881	$32,462	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,842,166
Value per barrel	$0.32⅝	$0.51⅛	$0.40	$0.37	$0 45	$0.48	$0.64	$0.61

NUMBER OF WELLS COMPLETED IN THE INDIANA OIL FIELD FROM 1891 TO 1896, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891							6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896	76	90	86	136	148	151	113	121	70	57	66	66	1,180
Total													4,538

On January 1, 1897, there were 3,442 wells producing oil in the Indiana field, so that 1,096 of those completed had either proven dry holes or had ceased to yield oil in quantity sufficient to pay for pumping.

INITIAL DAILY PRODUCTION OF NEW WELLS IN INDIANA OIL FIELD FROM 1891 TO 1896, BY MONTHS.

[Barrels.]

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.
January		342	1,020	2,361	2,132	1,557
February		250	913	2,935	1,413	1,875
March		289	2,805	3,395	2,504	2,090
April		316	4,135	3,175	3,473	2,820
May		505	3,155	4,450	3,035	3,195
June		545	5,595	4,386	4,923	3,155
July	253	595	3,880	3,530	3,067	2,335
August	135	1,295	4,184	3,435	2,760	2,650
September	875	2,145	2,055	3,149	3,175	1,700
October	330	4,155	3,442	3,455	2,651	1,500
November	390	3,050	2,305	3,323	2,560	1,395
December	175	3,160	2,968	2,654	2,025	1,100
Total	2,158	16,647	36,457	40,748	33,718	25,372

One feature of the oil industry which has come into common use, and which should be abandoned, is that of giving the initial output of a well rather than its settled production after 30 or 60 days. Because a well starts out at 100 to 250 barrels a day is no sign that its total production will be a large one. From the well records given in the detailed account of the Indiana field, it will be noted that the production falls rapidly. In general it may be said that a 50-barrel well will be down to 10 barrels in two months and to five barrels in a year. A fifty-barrel well is a fair average well for the entire Indiana field, the average production of which is about four barrels per well per day. A well that starts off at 150 to 250 barrels gets down to the average in time, the only difference being that the oil bearing stratum which the bore has pierced is a little more porous than in the one yielding 50 barrels.

Average Production of Indiana Field.

While the waste in the oil field of the State has not been proportionally as great as that which characterized the early days of the natural gas area, it is even yet far above what it ought to be; the waste of both gas and oil being in the course of a year an enormous one. Many wells are drilled which yield both gas and oil; and the drillers, seeking only the latter, allow the former to escape or burn it freely in flambeaux and other lights. Again, where only gas is found the well is often abandoned without being properly capped, and much valuable fuel is thereby lost.

Waste in the Oil Field.

Moreover, one can not pass through the oil field without noting that every pool and stream of water is covered with oil, thousands of barrels being allowed to go to waste through leakage and overflow of tanks; overflow of wells when first shot; or through the oil passing off in quantity with the salt water flowing from the tanks. With these two fuels it is like everything else which is abundant for a time; satiety begets careless and excessive use. The time will come, and that before many years, when the stored reservoirs of these great resources will have been drained, and only the dregs be left as a reminder of the plenty that has been.

As has been already noted, it is the small operator who does most of the "wild-catting." A man with a few hundred dollars of surplus money gets the "oil fever," believes there is oil to be found in his vicinity, and proceeds to organize a company among his neighbors or fellow-townsmen. The bore is sunk, and if it proves dry it serves the purpose of marking a tract which is thereafter avoided. If it be a gas well its output may be used as fuel if that commodity is not already too abundant. If it be a fair producing oil well, and yet some distance from the main field, the company will have difficulty in getting a pipe line to carry away the product; and, not wishing to assess the members for another well, the chances are that the one bored

The Small Operator.

will be finally plugged, and the only benefits derived from its boring will be the marking more clearly the limits of the productive field. The average "wild-catter" is satisfied if he makes $5,000 in the oil business. If a good well is struck close to the limits of territory already producing, it and the lease on which it is located are usually sold to a company with larger means. This company puts down six or eight bores, and if they are fair or good producers it, in time, usually sells to a still larger company, like the Standard or the Northern Indiana, for a good profit. The usual selling price in the Indiana field for an oil property consisting of a lease of eighty to one hundred and sixty acres, with three to eight wells, having a settled production, is $300 a barrel for the average daily production. More money has been made by Indiana operators in thus partially developing and selling leases to the larger companies than in any other way.

The Indiana Field as a Whole.

From a careful study of the Indiana oil field, and conversations with the leading operators therein, it is the writer's opinion that nearly, if not quite, as much money is being spent in the field each year, as is gotten out of it. Some men who understand fully the details of oil production and are following the business of producing as a vocation, are making money in large amounts, but many who enter the field for purely speculative purposes are losing it. The principal reason for this is, that there is no certainty of striking oil at any one place, even on the best proven territory. But little reliance can be put in the size or shape of any so called "pool" in Indiana, as, on account of the deep drift covering the surface, the anticlines and the synclines of the Niagara and Trenton rock can be determined only by the drill. All wells are, therefore, risky investments. In the words of a leading operator, "Each new bore is practically a wild-catting experiment—a lottery, where you pay $1,500 to $2,500 a chance, and sometimes draw a big prize, sometimes a fair one, and often a blank." As the spirit of speculation is ever rife among the American people, individuals are plentiful who are willing to accept the chances at the prices given, and so each year sees many wild-cat bores go down, a large proportion of which are losing investments.

As the output of the older wells is constantly diminishing, it is necessary that a large number of new ones be put down each year to prevent the annual production from dropping. While in 1896 the annual production was increased, the new output did not increase proportionally the average production of the field, and the older operators believe that unless a large area of virgin territory is soon located the average will soon drop from four barrels to three, or even less, per well.

Up to the present the farmers who have owned the land on which producing wells were bored are the ones who have been most benefited by the discovery of oil in Indiana. They had everything to gain and

nothing to lose in leasing their property. Some of the first operators in the field after losing money finally regained it and much more by staying with the business and developing and selling leases in the manner already mentioned, while a large number of them still possess valuable producing property. The Standard Oil Company has also, doubtless, made much money in the Indiana field both as a producer and a purchaser.

Finally, it may be said that an investor who wishes to become a *bona fide* producer can yet make money in the Indiana field if his property is managed on strictly business principles. To such an investor we would say: Put your money in a partially developed or good prospective lease within the known productive limits. Remember that one large well will not make any man a fortune; twenty small ones may in time. The yield of the large one will in time become much less; that of the twenty small ones will hold out for a long time. Connect the twenty wells to one power and put a good man in charge of it Pump steadily so as to get all the oil possible. Keep your drilling tools, your lead pipes and your pumping machinery in good condition. Be saving of fuel and especially look out for overflow and waste of your production. Let other people do the wild-catting, and if you desire to make new investments follow where they lead.