NATURAL GAS.

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Many difficult but important questions have arisen in connection with this investigation, and in some cases they have been unusual, if not unique. For the solution of some of these there was no help to be obtained from previous censuses, as the production of natural gas was not an industry prior to the period embraced in the Eleventh Census. Some of the questions referred to have arisen in connection with the collection of the statistics of natural gas for the volume Mineral Resources of the United States, issued by the United States geological survey, and have been decided, but others are entirely new.

Since there is such an intimate connection between the geological horizons in which gas and oil are found, and the localities in which they occur are so nearly identical, the reader is referred to the report on petroleum, page 425 of this volume, to avoid verbatim reproduction of the discussions of these subjects.

In Pennsylvania and New York, and to some extent in other states, much of the gas produced is not used at the place of production, but is transported in pipes to other towns, and even to other counties and states, where it is consumed. The gas used in Pittsburg, which is in Allegheny county, Pennsylvania, comes chiefly from Westmoreland and Washington counties; that used at Johnstown, Cambria county, from Westmoreland county. The United Natural Gas Company, with its home office in Oil City, Venango county, Pennsylvania, has wells in McKean, Potter, and Butler counties, Pennsylvania, and in Allegany county, New York, from which gas is drawn not only to supply towns in these counties, but to pipe to other counties in Pennsylvania, and even to places in New York as far away as Buffalo, and to Youngstown, Ohio. Wheeling, West Virginia, gets its supply of gas from Washington county, Pennsylvania.

The question at once arose, to what county shall the statistics of this gas be credited? If only the question of production had been involved the answer would have been simple: to the place of production, of course. But, unlike other investigations, this included not only production but consumption as well. Indeed, its statistics of production are really those of consumption. Its measure of production is the amount consumed. No value can be placed upon the gas except as it is consumed. The gas wasted at the wells has no value. It is not stored, in the proper sense of the term, as it is produced, and it is not until it is burned in the grates or in the furnaces that it has commercial value. Hence its value at the point of consumption, and not of production, is the one that must be considered. In arriving at this value by the method of fuel displacement, which is one, and the most important, of the methods adopted, it was the value of the coal or wood displaced at the point of consumption, not of production, that was taken. Now, the question was, should this value be regarded as a value of an industry where the gas was produced or where it was used? The difficulty of arriving at a satisfactory conclusion was increased by other difficulties and questions which will be noted below, but the conclusion reached was that, in view of all circumstances, the production, value, etc., should be credited to the place of production, even though to ascertain this production and value we must go to the point of consumption.

This did not remove the difficulty, however. In many cases it is impossible to state the particular county from which comes the gas burned at a given place. In the neighborhood of Pittsburg this problem is not a difficult one. Practically all the gas produced by the Philadelphia Company, which supplies most of the gas used in Pittsburg, is from Westmoreland county, and the place of production of the gas furnished consumers by the other companies is easily ascertained; but in the case of the United Natural Gas Company of Northwestern Pennsylvania, that drew its supplies from 4 counties and sent gas to Buffalo from the wells of at least 3 counties through the same pipe line, the difficulty of determining how much gas came from each county added a new problem. This company was able, however, to give an approximately correct statement as to the amount of gas produced in each county. The company's total production was estimated at 7,312,000,000 cubic feet, produced as follows:

DISTRIBUTION, BY COUNTIES, OF THE GAS PRODUCT OF THE UNITED NATURAL GAS COMPANY.

COUNTIES.	Number of wells.	Total production in 1889. (Cubic feet.)
Total	97	7,312,000,000
Allegany county, New York	28	1,330,000,000
McKean county, Pennsylvania	45	5,030,000,000
Potter county, Pennsylvania	8	310,000,000
Butler county, Pennsylvania	16	642,000,000

In other cases of a similar character the owners of the wells have been able to give the percentage of the total product that should be placed to the credit of each county. Another complication has grown out of the fact that several companies distributing gas to consumers owned no wells and produced no gas, but bought gas from producers, who might themselves also sell to individual consumers. This required great care to avoid duplication. Another difficulty was to reach a unit of production. The proper unit of measurement is the cubic foot, but the conditions surrounding the production and consumption of natural gas are such as to make it absolutely impossible to reach accurate statements. The present report, therefore, only claims to be approximately correct, as it is impossible to ascertain the total production of natural gas in the United States in cubic feet, the only practical measurement for this product. A few wells have been accurately measured, but this measurement only gives the rate of production for the moment when the observations were taken, and this rate changes not only from day to day, but from hour to hour, and even from moment to moment. It is usually greater at certain times in the day, as in the morning, than at others. It also varies with the weather and state of the barometer. Consequently, even for the measured wells, only an approximate estimate of their production can be made, while for the unmeasured ones a fair statement is clearly impossible, though attempts have been made to procure data. These will be discussed elsewhere. Since the tendency is to exaggerate the production of natural gas, any figures as to production given may be safely considered as an overestimate, so far as the individual returns are concerned, though the totals for the United States are if anything an underestimate.

It is equally impossible to state, except approximately, the amount of gas consumed. Few meters to measure the gas were used in 1889, and only guesses as to the amount consumed can be given. Some discussion on this point will be given elsewhere.

It has been found exceedingly difficult not only to get accurate figures of production and consumption, but also accurate statements regarding the other details included in this report. This difficulty does not grow out of disinclination on the part of producers to give any information in their power, but comes from the peculiar character of the industry. A great many wells were bored in various sections of the United States in the hope of producing natural gas. Where these have been producers approximately correct records of cost, etc., are available. Where they have been small producers, or have been abandoned, or have been nonproducers, the facts regarding the cost, number of employés, etc., have been very difficult to procure. The wells in many cases have been drilled by nonresidents under contract or upon land that has been leased. When the venture has proved unsuccessful no record is preserved of cost, capital invested, wages paid, materials used, or any of the other details asked for in this report. For example, in looking at the table giving well records it will be seen that though wells were drilled in 1889 in Illinois, Texas, South Dakota, and Tennessee, there are blanks in the column of total cost, showing that no report as to cost could be secured from the parties drilling these wells. It will also be noted in West Virginia that 6 wells are reported as having been drilled, the total cost of which was but $2,000, which probably only includes the cost of a single small well. Concerning the other wells no figures could be secured; indeed, it is doubtful if any records were ever made.

Wherever it has been possible to do so estimates are made covering the missing figures, but it must be understood, unless it is expressly stated to the contrary, that the figures given in this report are only approximations, the best that could be made under the circumstances.

LOCALITIES IN THE UNITED STATES WHERE NATURAL GAS IS FOUND.

In a general way it may be said that natural gas has been found in varying quantities all through the territory from the Hudson river on the east to California on the west. In Alabama, California, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Missouri, New York, Ohio, Pennsylvania, South Dakota, Tennessee, Utah, West Virginia, Wisconsin, and Wyoming its existence is reported. In some of these states, however, it has not been found in commercial quantities. A shallow well, frequently a well put down for water, has shown the existence of gas, usually in the drift. In many cases also so-called gas springs have been found, from which a small supply of natural gas, usually marsh gas, is reported. In 1889 gas in commercial quantities was reported as having been produced in Arkansas, California, Illinois, Indiana, Kansas, Kentucky, Michigan, Missouri, New York, Ohio, Pennsylvania, South Dakota, Texas, and Utah. At the present time the important gas fields are those of western Pennsylvania, western New York, northwestern Ohio, and eastern central Indiana. It is the development of these districts that has caused the excitement in connection with natural gas which was so manifest in 1888 and to a less degree in 1889. The most important gas fields in these territories are those in the gas district in Pennsylvania in the neighborhood of Pittsburg, including the Murrysville and Grapeville fields, of Westmoreland county, and the several Washington county fields. In McKean and Venango counties there was also a large production of gas and considerable from Elk county. In Ohio the most important field is what has been called the Findlay, situated in Hancock county, while in Indiana the chief fields are in the neighborhood of Anderson, Kokomo, Marion, and Muncie. Each of these districts, as well as the other localities in which gas is found, will be discussed in connection with the report on the several states.

HISTORY OF THE USE OF NATURAL GAS IN THE UNITED STATES.

The earliest economic use of natural gas in this country was probably in lighting the village of Fredonia, Chautauqua county, New York, in 1821. For many years prior to this, even as early as the date of the survey of the Holland Land Company, gas had been observed issuing from the crevices of the slate rocks along the banks of the Canadaway creek, on which Fredonia is built. In 1821 a well 1½ inches in diameter and 27 feet deep was put down near the Main street bridge, which crosses this creek. This was probably the first well sunk for the purpose of obtaining natural gas. This well produced gas sufficient for some 30 burners, the burner being made by drilling a hole the size of a small knitting needle in a pipe. The light from one of these burners was regarded as equal to that of "2 good candles". Gas of 2-candle power would hardly answer the demand of to-day. The gas was conveyed from the well to the buildings in which it was used in wooden pipes. In 1824, on the occasion of Lafayette's visit, the village was lighted with natural gas.

In 1825 a small gasometer was put in and the wooden pipes replaced with lead ones, which so improved the conditions that the Fredonia Censor of December, 1825, says: "We witnessed last evening the burning of 66 beautiful, clear gas lights, and 150 lights could be supplied from this gasometer. There is now sufficient gas to supply another one as large."

The existence and utilization of this gas at Fredonia became widely known, both in this country and abroad, and excited the liveliest interest among scientific men; but so little suspected was the presence of the enormous volume of gas since developed that it was pronounced "unparalleled on the face of the globe", and Humboldt is quoted as declaring it the eighth wonder of the world.

This well of 1821, which was afterward drilled to the depth of 70 feet into the black shales of the Marcellus beds, was the only one producing gas in the village until 1858, though another well was sunk in 1850. It yielded water as well as gas and required constant pumping, the gas not having pressure enough to force itself through the water. This well was in uninterrupted use until 1885, when some repairs to Tifft's mill, adjoining, made it necessary to tear away the pumping machinery. The product of gas was but a trifle less than when it was first completed.

In 1859 a well of a peculiar character was sunk, or, rather, the second well, that of 1850, was enlarged. A shaft 30 feet deep, 6 feet in diameter at the top and 14 feet at the bottom, was dug. From the bottom lateral and 2 vertical borings, one 100 feet deep, the other 150 feet, were put down. A production of 4,500 feet of gas a day was secured, supplying 200 burners. In 1871 a still larger well was bored to the depth of 1,200 feet. In 1885 the total yield of these wells was 6,000,000 cubic feet; in 1889 but 1,642,500 feet.

Shortly after gas was found at Fredonia, Judge Campbell, of Westfield, New York, used natural gas from a spring near by for the lighthouse at Barcelona, a small harbor on Lake Erie. The contract to supply the lighthouse was abandoned in 1856, though the gas is still used, supplying all the churches, public halls, schools, and about 20 families. In 1827 a contract was made by Walter Smith, of Dunkirk, New York, with the government to supply the lighthouse at that place for a term of years, and a ½-inch pipe was laid 2½ miles from the Matteson gas spring at Fredonia; but owing to the size of the pipe no flow was obtained, and after many trials of other means of transportation the enterprise was abandoned.

The existence of marsh gas, the modern natural gas, was well known to the earliest explorers of the Kanawha valley. In 1775 Washington, while on a visit to the Kanawha to locate lands granted him for his military services, set apart and deeded to the public forever a square acre of land on which was located a "burning spring". Through some informality his intention in this gift was frustrated. The "burning spring" mentioned by Mr. Jefferson in his "Notes on Virginia" was probably this same spring.

The boring for salt water in the Kanawha valley, which was begun in the winter of 1807–1808, not only resulted in finding brine, but nearly every salt well became a gas well, the gas in many cases jetting the water into the air and taking fire. From wells only 15 to 20 feet deep the gas escaped in quantities, burning a long time. As early as 1815 a gas well was struck within the present city limits of Charleston. This well was bored for salt, and upon striking the gas reservoir it gave out a great volume of gas, which caught fire from a grate near at hand. Those boring the well conceived that it would be reckless to drill deeper, and abandoned it.

It is worthy of notice that many of the methods and appliances that have made deep well boring possible were developed and perfected at these salt gas wells. The chisel bit, the "jar", sectional tubing, made then of tin and soldered, instead, as now, of iron with screw joints, and the "seed bag" were used at the Kanawha valley salt wells before oil was found in western Pennsylvania.

So far as has been ascertained, the first use of gas in manufacturing was in "boiling salt", in the Kanawha valley of West Virginia, by William Tompkins in 1841, some 20 years after its use for lighting at Fredonia, New York. While boring a well for salt a short distance up the Kanawha river from the "burning spring" above alluded to, he struck a large and steady flow of gas, which was strong enough to force the salt water into a reservoir, from which it could be distributed to his furnace pans. He determined to use this gas as a fuel to "boil his furnace", and for this purpose extemporized a gasometer from a hogshead placed over the reservoir. Into this

primitive receptacle he conveyed the escaping water and gas, the water falling into the reservoir. The gas, conveyed through a pipe to the mouth of his furnace, a "salt block" 100 feet long by 6 feet deep and 4 wide, produced an intense heat under the whole row of kettles. In 1843 gas was struck in a well bored near Mr. Tompkins' well at the depth of 1,000 feet. The force of the gas was so great as to throw a column of salt water 150 feet above the mouth of the well. This is the first "gasser" and "roarer" on record.

From the beginning of the drilling of oil wells in Pennsylvania in 1859 natural gas has been obtained in greater or less quantities, either accompanying the oil or in wells that were true gas wells; that is, yielding little or no oil. In most of the flowing oil wells the pressure which forces up the oil is this gas. The attention of oil producers was first directed to the danger connected with this gas by the explosion at the Rouse well, on Oil creek, one of the first flowing wells struck. 18 persons lost their lives by the explosion of gas at this well. At first this gas was considered not only of no value, but a dangerous nuisance, and was carefully led away from the wells in pipes and burned to get rid of it. After a little, however, it began to be used for fuel under the boilers in drilling and pumping and for light and fuel in the towns and villages in the immediate vicinity of the wells. The proportion of the gas so used, however, until some 2 years since was very small. The apparatus for collecting this gas for use in raising steam in drilling was at first quite simple. The oil and gas as they came from the well were led into a barrel or hogshead, the oil being drawn off by a pipe at the bottom and the gas by a pipe at the top.

The so-called Leechburg gas well, the gas from which was the first used in iron making, was bored for oil in 1870 and 1871, the gas vein being struck in the latter year at a depth of 1,200 feet. This well is situated on the south side of the Kiskiminitas river, in Armstrong county, Pennsylvania, opposite Leechburg. For some months the gas was allowed to escape, without any attempt to utilize it, until in April, 1873, Messrs. Rogers & Burchfield bought the well and piped the gas across the river to their works on the north bank. The gas was accompanied by a large flow of salt water. To separate the gas from the water it was conveyed from the well by a 5⅝-inch pipe into a common cylindrical boiler, furnished with an ordinary safety valve. The water was drawn off at the bottom of the boiler through a quarter-inch pipe, it being forced out in a spray. From the top of this boiler receiver the gas was led across the river and distributed by a network of pipes through the mill. As noted above, this was the first use of gas in iron works.

The first gas piped any considerable distance was from what is known as the Harvey well, near Lardens mills, in Butler county, Pennsylvania. This at the time it was bored, in the fall of 1874, was the most powerful gas well in the section. In 1875 it was purchased by the Natural Gas Company, limited, the first natural gas company formed, and piped 17 miles, through a 6-inch pipe made of iron one-fourth of an inch thick, to the mill of Messrs. Spang, Chalfant & Co., at Etna, near Pittsburg. The gas was turned into the pipe in October, 1875, and traversed the 17 miles in 20 minutes, the observed pressure at the wells being 119 pounds.

The first use of gas in glass making appears to have been at the Rochester tumbler works, at Rochester, Pennsylvania. It has not been possible to learn the date of this use.

In 1883 Mr. J. B. Ford, at the Pittsburg plate glass works, at Creighton, Pennsylvania, succeeded in securing a supply of gas for his glass works, since which time these works have been run entirely by natural gas.

The most important fields in western Pennsylvania are the Murrysville and Grapeville, both in Westmoreland county. The first of the wells in the Murrysville district, Haymaker No. 1, was put down in 1878, and for 5 years its product was allowed to go to waste. In 1883 other wells were drilled, and pipe lines were laid to East Liberty and Pittsburg, which mark the beginning of the present extensive use of natural gas in that city.

It was not until 1883, with the piping of the gas of the Murrysville district to Pittsburg and the striking of gas in the Westinghouse well at Homewood, Pittsburg, that natural gas began to be used extensively as a fuel. Prior to this time its use had been exceptional and at isolated works, but with the piping of this gas and the striking of the Westinghouse well the extension of its use became instant and well-nigh universal for manufacturing purposes in the neighborhood of Pittsburg. Its introduction into the rolling mills of Wilson, Walker & Co. and Shoenberger & Co. and the flint glass furnace of the Fort Pitt glass works was rapidly followed by its adoption in other establishments until (in 1889) few of the important manufactories of Pittsburg that are so situated as to obtain a supply of gas cheaply use any other fuel.

The Grapeville district was first developed in 1885. The first well in the Hickory district, Washington county, known as the McGuigan, was struck in March, 1882. The gas was allowed to waste for more than a year, when a 6-inch main was laid to Birmingham, a part of Pittsburg, situated on the south side of the Monongahela. The line was 22 miles long. In 1884 2 other wells were struck, and later 2 more. The supply from these 4 wells was enormous. A second portion of the Washington county field is the Cannonsburg. Some 5 wells had been drilled at the close of 1885. In that year 5 gas wells were drilled in the town of Washington. These supplied the town with fuel. The gas from the wells of the Hickory, McGuigan, and Cannonsburg districts, all lying a little northwest of Washington, have been piped to Pittsburg.

Gas first began to be utilized in manufacturing in Erie, Pennsylvania, about 1868, by the Jarecki Manufacturing Company. The first well was put down some 600 feet, and yielded largely at first, but the amount steadily decreased. This has been the history of all the wells in this region, the pressure at some being at first as much as 50 pounds to the square inch, but rapidly falling off and becoming extremely irregular. At the Erie furnace of Messrs. Rawle,

Noble & Co. an attempt was made in 1874 to use natural gas in a blast furnace. This gas was from a well 800 feet deep, with a pressure of 25 pounds. It was driven into the furnace by its own pressure through a three-eighths inch pipe inserted in the tuyères. Its use was not a success.

In Ohio the first use of natural gas appears to have been at Findlay, for domestic purposes. Natural gas had been known to exist in this place from its first settlement, and was met with in digging cellars, wells, and sewers, and in springs and rock crevices. Explosions in excavations were by no means infrequent. The gas collected from a well dug for water was introduced into a house in Main street in 1838, and has been burned ever since.

The first important developments in the Findlay field were in 1884, when the Findlay Natural Gas Company struck gas at a depth of 1,100 feet. The drilling in of the first important well took place in 1886.

The first of the Neff wells, referred to elsewhere, the gas from which was the first used to make lampblack, was drilled in 1865.

The first wells drilled in the Ohio shale were put down in 1860, at the time of the Pennsylvania oil excitement.

The first discovery of natural gas in the neighborhood of East Liverpool, Ohio, a locality noted for its manufacture of pottery, was in 1860 while drilling for oil. Gas was found at several places in the vicinity at the same time. At Jethro, a locality within the town limits of East Liverpool, 2 gas wells were struck; also 1 on Balls island, in the Ohio river, opposite the east end of the town; 1 on the McKinnon farm, east of the Cleveland railroad depot; 1 on the Virginia shore, directly across the river from this depot, and several others of but little note. The gas was struck at 400 to 600 feet from the surface. The Jethro well produced strong salt water in abundance, which was thrown out in strong volume by the pressure of the gas. A short time after the well was struck evaporating pans were put up and the gas utilized in evaporating salt water, which was also thrown out of the well by its pressure. Shortly after this utilization of the gas at the Jethro well the gas from another well at Little Beaver bridge, 4 miles east of East Liverpool and near the Pennsylvania state line, was utilized in the same way. It appears from this, therefore, that as early as 1860 natural gas was used in evaporating salt in the East Liverpool district. In October, 1873, Mr. Homer Laughlin sunk a well at his pottery within the town limits, this being the first well bored especially for natural gas. Its product was also the first gas utilized in the East Liverpool region for fuel and light, with the exception of the gas from the two wells above mentioned, which was utilized in salt manufacture. Two years later, or in 1875, other parties in East Liverpool bored wells, the gas from which was also used for fuel and light. These wells, however, have never been large producers, and have only furnished gas for light and fuel for small fires. Some years ago, at a time when a number of wells had been freshly bored, the gas from them was used in firing a very few kilns of pottery, a large number of the best wells, owned by different persons, being coupled or connected together. The supplies from these wells have been gradually falling off.

The first well bored in the Macksburg field, in 1877, yielded dry gas.

Gas was first discovered in Champaign county, Illinois, in 1853. At Litchfield, in Montgomery county, where the most important developments in this state have been made, it was first discovered in 1882, but the field assumed no importance until 1885.

The history of natural gas in other localities is of but little commercial importance.

ORIGIN OF NATURAL GAS.

Petroleum and natural gas have a common origin. They are both members of that most wonderful series of chemical compounds known as the paraffins, of which paraffin wax may be regarded as a representative of the solid portion of the series, petroleum of the liquid portion, and natural gas as the best known gaseous member. The origin of petroleum and natural gas is discussed somewhat at length in the report on petroleum.

GEOLOGICAL DISTRIBUTION OF NATURAL GAS.

While it is true that natural gas has been found in the strata of every geological age, from the drift down to the potsdam, it has been chiefly in the Trenton limestone of Ohio and the paleozoic strata of the upper coal measures of Pennsylvania that the great deposits of natural gas have been struck. The highest stratum in which any considerable quantity of gas has been found in Pennsylvania is the Homewood sandstone, the highest of the 3 recognized members of the Pottsville conglomerate. The lowest are the Kane sand and the sand of the Roy and Archer gas pool of Elk county. According to Mr. Carll, the geological position of the latter sand is 1,800 feet below the horizon of the Murrysville sand. As the question of the geological distribution of natural gas will be discussed in connection with the report on the several gas fields, it is not necessary to enter into a further discussion of the subject here.

COMPOSITION OF NATURAL GAS.

Natural gas is composed chiefly of several of the hydrocarbons of the paraffin series, together with nitrogen, a small portion of carbonic acid, and traces of oxygen. Free hydrogen in minute quantities is found in certain gases. Methane, or marsh gas, constitutes from 50 to 90 per cent or more of Pennsylvania natural gas. In addition to the hydrocarbons of the paraffin series, olefiant gas or other members of the olefine series are sometimes found.

The best and most thorough analyses of natural gas yet made are by Professor Francis Phillips, of the Western University, Pennsylvania. In the following table are found the analyses of 9 of these gases. The Fredonia gas is from the mains of the Fredonia Natural Gas Light Company, at Fredonia, New York. The Sheffield wells are in Warren county, Pennsylvania, and supply Sheffield, Iona, Brookston, Clarendon, Warren, Corry, and Erie, Pennsylvania, and Jamestown, New York. The Kane well is in Kane, McKean county; the Wilcox well is in Wilcox, in the same county; the Speechley well is near Oil City, in Venango county; the Lyons run well is at Murrysville; Raccoon creek is near Rochester, Pennsylvania; Baden is in Beaver county, near Rochester, while the Houston well is 2 miles south of Cannonsburg, in Washington county.

ANALYSES OF PENNSYLVANIA NATURAL GAS.

CONSTITUENTS.	Fredonia.	Sheffield.	Kane.	Wilcox.	Speechley.	Lyons run, near Murrysville.	Raccoon creek.	Baden.	Houston.
Total	100.00	100.00	100.00	100.00	100.00	99.92	100.00	100.00	100.00
Nitrogen	9.54	9.06	9.79	9.41	4.51	2.02	9.91	12.32	15.30
Carbon dioxide	0.41	0.30	0.20	0.21	0.05	0.20	Trace.	0.41	0.44
Hydrogen					0.02				
Ammonia									Trace.
Oxygen	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Sulphureted hydrogen							Trace.		
Paraffins	90.05	90.64	90.01	90.38	95.42	97.70	90.09	87.27	84.26

The paraffins contained in the above gas samples have the following composition by weight:

CONSTITUENTS.	Fredonia.	Sheffield.	Kane.	Wilcox.	Speechley.	Lyons run, near Murrysville.	Raccoon creek.	Baden.	Houston.
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Carbon	78.14	76.69	76.77	76.52	77.11	74.96	76.42	76.48	76.68
Hydrogen	21.86	23.31	23.23	23.48	22.89	25.04	23.58	23.52	23.32

The analysis of Trenton limestone gas, given by Professor Edward Orton in his report on Ohio gas, is as follows:

COMPOSITION OF NATURAL GAS FROM THE TRENTON LIMESTONE, OHIO.

CONSTITUENTS.	Findlay.	Fostoria.	Saint Marys.
Total	100.00	100.00	100.00
Hydrogen	1.64	1.89	1.74
Marsh gas	93.35	92.84	93.85
Olefiant gas	0.35	0.20	0.20
Carbonic oxide	0.41	0.55	0.44
Carbonic acid	0.25	0.20	0.23
Oxygen	0.39	0.35	0.35
Nitrogen	3.41	3.82	2.98
Sulphureted hydrogen	0.20	0.15	0.21

ACCUMULATION OF NATURAL GAS.

Whatever theory may be accepted as to the origin of natural gas, there are certain conditions necessary to its accumulation and storage, and if either of these is absent no large supply of gas can be expected. Small amounts of gas can be discovered without the presence of these conditions, but the wells will yield only a small supply, and that supply will be very soon exhausted. These vital conditions are three: (1) reservoir; (2) cover; (3) structure.

Gas is not stored, as often supposed, in large cavities or caves in the interior of the earth's surface, but chiefly in porous sandstones and limestones, gas as well as oil being found in the small interstices between the grains or in the pores.

The reservoir rock in western Pennsylvania is almost always a sand rock. The storage reservoir in Ohio is the Berea grit and the Clinton and Trenton limestones. Some little oil is found in shale, but the two great reservoirs in which the natural gas supply of the United States is stored are the sand rocks of western Pennsylvania and the Trenton limestone of northwestern Ohio and eastern central Indiana.

It is evident at once that were the whole structure above these reservoir rocks permeable, either through its entire structure or at points, by reason of the breaks and fissures in the strata, the gas would constantly escape

from the reservoir and it would soon be drained out. This is a phenomenon that is constantly noticed in connection with gas springs. The gas is leaking from the reservoir; hence it is evident that there must be a cover or cap to this reservoir to hold the supply in place, and that this cap must be impervious to the gas, or practically so, either from the absence of porosity or the absence of breaks and fissures. This cover is usually a shale, and in every important gas territory the reservoir rock is capped by a shale cover, which has retained the gas in place until the cover has been tapped by the drill. In Ohio, for example, the Cuyahoga and Berea shales cover the Berea grit, the Niagara shale the Clinton group, and the Utica shale the Trenton limestone. As a rule, with of course limitations, the deeper the storage rock and the closer to it the shale or cover the larger the deposits of gas and the greater the chance for their permanence.

A third factor comes in here, which is termed structure, or the arrangement of the rock that contains the gas. The existence of arches and troughs, or, in geological language, of anticlines and synclines, has long been noticed in connection with drilling for petroleum, and recently in drilling for natural gas, as well as their influence upon the storage of these hydrocarbons. The most effective statement of this influence of structure, or, as it may be called, the "anticlinal theory", was made by Professor I. C. White, of Morgantown, West Virginia. Though his statements were called in question, his theory commended itself to practical men, and its adoption led to the location of a considerable number of natural gas wells far in advance of the developments of the drill. This theory simply asserts that oil, and more especially gas, is to be found stored most largely in the apex of these anticlines. The great reservoir of the Trenton limestone gas in the Ohio field is found in an enormous anticline, as is noted in discussing the Trenton limestone in connection with the report on Ohio.

A fourth necessity in connection with the production of gas is pressure. Without stopping to discuss the subject at this place, as it will be discussed elsewhere, it may be said briefly that salt water is found on the outer boundary of gas and oil fields, and it is to the presence of this water that the pressure of the oil and gas is ascribed by most of the geologists of Ohio and Indiana, though most of the Pennsylvania geologists question its sufficiency. Dr. Phinney, of Indiana, claims that the initial pressure of a great many gas wells is about that of the weight of a column of water equal in height to the depth of the well.

PRESSURE OF NATURAL GAS.

The statements as to the pressure of the early gas wells were usually estimates based upon no accurate observations; indeed, there was no method of accurately arriving at this pressure available to the drillers of the first wells. Very soon, however, proper gauges were prepared and observations and measurements made; but even under these circumstances no uniform system was adopted, so that though a statement as to the pressure or production of a given well might be a fairly correct approximation as to that well under the conditions of the test, yet a comparison of the results at this well with those from another well made under different conditions would be without the least value.

In a general way it may be said that the highest actually observed and measured pressure has been in the neighborhood of 800 pounds to the square inch, closed pressure, the pressure being allowed to accumulate for a minute. In the first wells in the Findlay field the registered pressure was about 450 pounds; in the Murrysville field it reached 500 pounds; in the Indiana field the pressure was 400 to 500 pounds. It has been observed that with some few exceptions there is a pressure that is normal to each district, and that all wells in the same district ultimately show the same closed pressure; that is, the pressure measured when the well is closed and gas not escaping. Wells are sometimes measured by their flowing pressure; that is, the pressure shown on the gauge attached to the pipe through which the well is discharging gas into the air or into mains. Often when a well is first struck, owing to local causes, the pressure and production will be greater than the normal pressure of the district, but it is ultimately reduced to the normal figure. It is not to be inferred from this, however, that all wells of the same diameter and with the same ultimate pressure and located in the same district have the same production. Quite the contrary. In some wells the normal pressure, say 500 pounds, will be reached within a minute after the wells are closed; in others the normal pressure of the district will not be reached for days. It is evident that the well which reaches the normal pressure in a minute will be a greater producer than the one requiring hours to reach this pressure. All the wells in the neighborhood of Pittsburg had originally about the same normal closed pressure, that is, 500 pounds, but the wells in the several subdistricts in that vicinity show a great difference in the time required to reach this pressure, and consequently show great difference as producers. The same is true in the Findlay district. For example, the actually observed daily production of 4 wells in this district, as given by Professor Orton, is as follows:

OBSERVED DAILY PRODUCTION OF GAS WELLS IN FINDLAY, OHIO.

	CUBIC FEET.
Karg well	12,080,000
Cory well	3,318,000
Briggs well	2,565,000
Jones well	1,159,200

The original pressure in the Pittsburg district, as stated above, was about 500 pounds. In the Washington district, in the original wells, the pressure was about the same, but it has been found that gas from the different horizons, there being 4 in the Washington district, gives different pressures. In the Murrysville district the pressure is about the same as in the Pittsburg district. In the Wilcox district, in McKean county, Pennsylvania, the first pressure was about 575 pounds; in Butler county, 450 pounds; in Allegany county, New York, 450 pounds, and in Illinois 400 to 450 pounds, which was rapidly reduced to 125 pounds. This original pressure is rapidly declining. Professor Orton has paid more attention to this subject than any other of our geologists. He found the rock pressure in the original pioneer well in the Findlay, Ohio, district to be 450 pounds. In 1886 the pressure reached little, if any, above 400 pounds; during 1887 the fall was very gradual, the gauges marking 370 and 380 pounds; in May, 1889, the pressure had fallen to 250 pounds in independent wells, and in August of the same year it did not exceed 200 pounds. The wells in the city fell as low as 170 pounds at one time. Professor Orton's tabulated statement of the pressure of the wells in Findlay is as follows:

RATE OF DECLINE IN PRESSURE OF FINDLAY (OHIO) GAS WELLS.

	POUNDS.
1885 (original)	450
1886	400
1887, August	360 to 380
1889, May 1	250
1890, May 1	170 to 200

In the Stuartsville district the decline was as follows:

	POUNDS.
1888	450
1889, June	385
1889, August	365
1889, October	325
1890, May	275

In Bloomdale the rock pressure in 1887 was 400 to 465 pounds; in July, 1889, it had dropped to 375 and 390 pounds. A copy of a paper read at the meeting of the American Philosophical Society by Professor J. P. Lesley, state geologist of Pennsylvania, gives the following data concerning the gas pressures of the Grapeville field, from which it will appear that wells struck in February, 1886, had a pressure of 460 pounds. The same wells had February 2, 1891, a pressure of 65 to 70 pounds, while the initial pressure of wells struck in January, 1889, was 75 pounds.

MINUTE PRESSURE AT VARIOUS DATES AT GRAPEVILLE (PENNSYLVANIA) GAS WELLS.

[Pounds.]

Number.	Name.	Depth. (Feet.)	Struck gas.	At first.	April 27, 1889.	December 16, 1889.	May 26, 1890.	November 3, 1890.	December 1, 1890.	January 5, 1891.	February 2, 1891.
1	Klingensmith	1,100	February 13, 1886	460	390	250	180	100	95	75	65
2	Henry	1,133	June, 1886	460	380	260	170	105	100	75	70
3	Moore	1,149	June, 1886	460	390	260	175	100	95	75	65
4	Welker	1,144	October, 1886	460	380	260	170	105	100	.....	.....
5	Brown	1,224	May, 1887	460	390	260	180	100	95	75	65
6	Ferree	1,312	August, 1887	460	380	240	170	100	100	75	70
7	Minsinger	1,466	November 21, 1887	410	390	240	170	95	85	55	40
8	Shutts	1,468	February 13, 1889	380	390	250	165	100	85	70	60
9	Kipple	1,360	November 30, 1889	260	.....	260	165	100	95	75	65
10	Sylvis	1,357	January 13, 1890	235	.....	.....	170	105	.....	75	75
11	Truxel	1,267	February 20, 1890	225	.....	.....	180	100	.....	75	75
12	Byers	1,350	October, 1890	125	.....	.....	.....	.....	.....	65	60
13	Agnew	1,420	January, 1891	75	.....	.....	.....	.....	.....	.....	65

Calculating the average rate per day of the observed decrease, it is found to be as follows:

From April 27, 1889, 646 days, 321 pounds, 2.012 pounds per day.
From December 16, 1889, 413 days, 188 pounds, 2.197 pounds per day.
From May 26, 1890, 252 days, 107 pounds, 2.355 pounds per day.
From November 3, 1890, 91 days, 36 pounds, 2.528 pounds per day.
From December 1, 1890, 63 days, 30 pounds, 2.1 pounds per day.
From January 5, 1891, 28 days, 7 pounds, 4 pounds per day.

STORAGE OF GAS.

The waste of gas, especially in western Pennsylvania and in the Ohio fields, in which high-pressure gas is found, was at first simply enormous, the amount reaching a total so marvelous that it is impossible to form any accurate conception of it. It is estimated, for example, that the waste of gas at the Haymaker well No. 1, the first struck in the Murrysville district, during the five years when it was not used was the equivalent of 1,000 tons of coal a day. The Harvey well, the gas from which was piped to Spang, Chalfant & Co.'s in 1875, blew millions of feet of this valuable fuel into the air before it was utilized, and the gas from the McGuigan well, in the Washington county district of western Pennsylvania, was not used for over a year after it was struck. The waste of gas in Ohio and Indiana in the early history of these fields was simply incalculable. Very soon, however, measures were taken to stop this form of waste. At first it was sought to confine the high-pressure gas by placing caps with gates on the top of the well casing, but it was found in many instances that the pressure rapidly accumulated to a point where there was danger of blowing the casing out of the well, and this system was temporarily abandoned.

Two methods have been adopted for storing gas, one adapted to territory where the prospect of obtaining gas by drilling is reasonably certain, and the other applicable to all wells of ordinary pressure. The first consists simply in drilling as near as possible to the depth at which the gas reservoir is supposed to be and then "holding the well", as it is termed, and bringing it in by drilling a little deeper whenever the demand for gas or the decrease in other wells requires it. Recently, however, a method of storage by packing the wells has been adopted. This confines or stores the gas in its own reservoirs. The packer most largely in use is the same that is used in oil wells, only in putting the packer together for gas wells it is necessary to use extra precautions to prevent the gas from blowing off the rubber. This is done by fitting the rubber tightly to the inner pipe and wiring the end securely in place. One packer used is a rubber annulus from 8 to 20 inches in length, with an outside diameter half an inch less than the bore of the well. The inside diameter is large enough to permit it to go over the tubing used in the well. The pipe going through the rubber is screwed into a flange at the upper end, the flange being large enough to cover the end of the rubber. Then another flange is slipped over the lower end of the pipe the same size as the rubber, thus making a slip joint. The outside of the lower flange is threaded, so as to screw on to a sleeve which is large enough for a coupling to slide in. The coupling is screwed on to the lower end of the pipe going through the rubber. The coupling makes a pipe to engage with the shoulder on the flange which supports the anchor or lower part of the tubing while being lowered into the well or removed from the well, thus making a telescopic joint. Enough tubing is screwed together before the packer is screwed on to bring the packer as high from the bottom of the well as is desired. Then the packer is screwed on the tubing, then the balance on the top of the packer, until the bottom of the well is reached. One joint of the anchor or lower tubing is perforated to admit the oil or gas into it when the packer is expanded to the wall of the well. When the anchor strikes the bottom of the well the weight of the tubing above the packer comes on the rubber and forces the pipe into the sleeve or telescopic joint and presses the rubber between the two flanges and out to the wall of the well, thus making the oil or gas below the packer go into the tubing at the perforation, and thence to the top through the pipe. Of course the casing of the well is anchored down to prevent blowing out. While it may be fairly assumed from the statements and evidence that gas can be retained in a well without wasting, no means as yet seems to have been devised for saving the gas that escapes from the pipe after it has left the well.

Another method is to securely anchor the casing by attaching it to a framework securely bolted to the rock adjacent. In such cases the gas is held in place by a valve screwed on the top of the casing, and as the demand increases or diminishes the valve is opened or closed.

TRANSPORTATION OF NATURAL GAS.

When natural gas was first struck in quantity the location of manufactories that were to use it was such as to require the conduction of the gas some distance, and it still holds that most of the gas consumed in manufacturing and for domestic purposes is conveyed to considerable distances from the wells to the points of consumption. The conduits used are iron pipes. For the smaller conduits wrought-iron welded pipes are used; for the larger, in some cases, riveted wrought-iron pipes, and in others cast-iron pipes. The great pressure at first complicated the matter of conveyance, making it much more difficult to prevent leakage, though at the same time this great pressure made it possible to conduct gas to a greater distance than if the pressure had been less.

In view of the danger from leakage great precautions have been taken in laying pipes to provide, first, against leakage as far as possible, and, second, to provide means of removing that gas which may escape before it shall accumulate in sufficient quantity to be dangerous. In the system of laying pipes adopted by the Philadelphia Company in Pittsburg each joint of the pipe, which it is assumed will sooner or later leak more or less, is surrounded by a conical pile of broken stone inclosed in a covering of thick tarred paper, through which rises a vertical trumpet-mouthed pipe, intended to gather the gas which may leak from the joints into the interstices of the broken stones and to convey it away by a small pipe, which extends horizontally over the main pipe which conveys the main volume of the gas. This leakage or escape pipe is led at intervals of about 300 feet into a

lamp-post, where the gas may escape without harm into the open air, or, as is frequently the case, may be lighted for the purpose of illumination. Other methods have been adopted, but in all cases great care has been taken to provide against the danger resulting from leakage; and in view of the enormous amount of gas transported and the ignorance as to the necessary conditions to secure safety when many of the pipes were first laid, also in view of the explosive character of the gas when mixed with the proper proportion of air, the small number of accidents that have happened is truly remarkable.

NATURAL GAS AS AN ILLUMINANT.

As is elsewhere stated, the first use of natural gas in the United States was as an illuminant at Fredonia, New York, and yet, as indicated by analyses and practical tests, it is a heating rather than an illuminating gas. The illuminating hydrocarbons are either in small quantities or entirely wanting. There is occasionally a little olefiant gas present, rarely exceeding 1 per cent, however. This gas is chiefly marsh gas. Marsh gas is high in heating power, but burns with a yellowish flame, not giving much light. As a rule, the lighting power of natural gas is by no means low, though lower than coal gas usually furnished to consumers. The candle power of the natural gas of the Pittsburg district is usually given as 8, and of the Findlay (Ohio) from 12 to 14.

From the above statement it will be noted that natural gas, though in some instances it is as high in candle power as 12, is not as good an illuminant as coal gas, and is not usually employed as an illuminant where ordinary gas from coal can be procured at reasonable figures. The most careful and interesting experiments made with the use of natural gas as an illuminant were at Findlay, Ohio, under the direction of Mr. E. B. Philipp. With a 36-hole lava tip argand burner 12.57 candle power was obtained. A flat flame Bray burner gave a candle power of 10.85, while a special bat's wing burner gave a candle power of 11.57. These tests were made with the crude gas, but by partially purifying it by passing it through lime boxes, removing the carbonic acid and sulphureted hydrogen, the candle power was increased to 13.77. Probably the best results that have been obtained in the use of natural gas as an illuminant have been in connection with the various styles of burners using a hood or mantle, in which the light is derived from the incandescence resulting from the heating of the hood or mantle. The Welsbach is an example of this class of burners and the Campbell another. Some good results have also been obtained by using various forms of regenerative burners, such as the Siemens and the Haupt. The Todd burner, which is constructed on the principle that there is not enough carbon in the gas to give sufficient illumination under ordinary methods of burning, has also been used. The air before it comes in contact with the gas is heated to a very high degree, and, striking the gas, burns the hydrogen at once, rendering the carbon incandescent.

EXHAUSTION OF GAS.

That the supply of natural gas is limited and will ultimately be exhausted has never been questioned. When the great reservoirs of western Pennsylvania, northwestern Ohio, and eastern Indiana were first struck the supply was so bountiful that many were led to believe that it was practically inexhaustible; at least there is no other sensible explanation of the wastefulness with which it was used at first or the readiness with which manufacturing plants were located in the natural gas regions, away from cheap supplies of other fuel. But even while these parties by their action expressed their confidence in the continuance of the supply of gas at least for the near future, they were ready to concede that ultimately it would be exhausted. The question at issue was, how long could the supply be depended upon?

In the early history of natural gas, say in 1884 and 1885, there were various theories advanced as to the origin of it. The belief as to the continuance of the supply of gas depended somewhat upon which of these theories was accepted. They were known generally as the storage theory and the continuous production theory. The advocates of the storage theory asserted that the supply would be exhausted when the gas in the storage reservoirs had been consumed. The advocates of the continuous production theory, while they claimed that the supply was being added to by production going on continuously at a point below the storage reservoirs, yet conceded that it was not probable that the supply could be maintained in the face of the enormous consumption by any probable rate of production that is at present going on in the earth's interior. The advocates of the latter theory of course held that as production was continuous the day of exhaustion was further in the future than was admitted by the advocates of the storage theory, and that even when the vast storehouses that existed in the earth's crust prior to their being tapped were exhausted production would still continue and gas be supplied, though in smaller quantities.

The statistics of production of the census year 1889 show that the period of exhaustion of supply had been entered upon and that the day had passed when this wonderful fuel could be used so wastefully as it had been in many operations, and in the very near future it would be possible to use it only for those purposes which could afford to pay comparatively high rates for the convenience of having such a fuel, or at points where the demand does not bear such a relation to the supply as it does in western Pennsylvania and the other great gas-producing districts. It is probable that at many points it will continue to be used for years for domestic purposes, but its

use in large establishments demanding great quantities of fuel is in many sections of the country a thing of the past. These works can make artificial fuel gas by some one of the many known processes, at less figures in many instances than natural gas can be furnished. This is especially true at Pittsburg, where there is such a demand for gas for domestic uses and by other small consumers that the natural gas companies are refusing to continue to supply large industrial establishments except at a price that is prohibitory. Hence the use of natural gas in large industrial establishments in the Pittsburg district and others is falling off, and these works are returning to solid fuel or using artificially prepared gas.

Some interesting facts regarding the exhaustion of gas in certain fields have been observed. It is found as a rule, for example, that shallow wells, 200 to even 1,000 feet deep, whatever may be the pressure or supply when first struck, give out much sooner than what are known as deep wells. In certain fields the supply at individual wells is soon exhausted, and the amount furnished by new wells when first bored is a constantly decreasing quantity as compared with that supplied by the earlier wells. In other districts the life of wells is longer, but the earlier wells are now quite weak or entirely exhausted, and new wells sunk do not produce any such amount of gas as those at first drilled. In other districts, as the gas is exhausted, the salt water is finding its way into the wells drilled nearest to the borders of the pool in which the gas is found. Many wells in this way have been drowned out, while other wells in the district are still producing. In no district of any importance do the "great gassers" supply gas either at the same pressure or with the same volume as when first struck.

The gas areas of the country are evidently small, scattered irregularly, and hemmed in by water areas and oil areas, and if the theory of Professor Lesley is to be adopted, they are not absolutely stationary, but shift their positions slightly as the result in part of the pressure of these water and oil areas and in part of other seismic causes. This shifting of gas areas, Professor Lesley suggests, will become comparatively rapid in the direction of the working wells as the stock of gas is drawn off, and what was at first a gas flow will become changed to an oil or water field.

CONSUMPTION OF NATURAL GAS IN THE UNITED STATES.

It is impossible to give the consumption of natural gas in the United States for 1889; but few meters were used in that year, and those chiefly for measuring gas in small quantities. For large works, consuming hundreds of thousands of cubic feet an hour, no practicable meter was available. The amount consumed at a fire, or under a single boiler, or at a given furnace might be measured with some degree of accuracy, and the amount consumed at the time of the test regarded as the average consumption; but as consumption would vary greatly, it is evident that these figures could at best be only an approximation. In the tables therefore there has been no attempt to give the number of cubic feet of natural gas consumed. The number of fires, meaning fires for cooking and warming, the number of rolling mills, steel works, glass works, and other establishments are given. Quite a number of schedules give the estimated number of cubic feet consumed. From these a very rough approximation of the total number of cubic feet of natural gas consumed in the United States can be given.

The largest producer of natural gas in the United States is the Philadelphia Company, of Pittsburg. Its statement of the number of fires, mills, and works supplied in 1889, and the estimated number of cubic feet consumed for each purpose, is as follows:

FIRES, ETC., SUPPLIED WITH NATURAL GAS IN 1889 BY THE PHILADELPHIA COMPANY.

USES.	Number of each.	Total consumption.
Total	.....	180,000,000,000
Fires for cooking and heating	150,000	15,000,000,000
Iron and steel mills	30	65,000,000,000
Glass works	32	2,000,000,000
Other industrial establishments	648	98,000,000,000

This would be at the following rate of consumption by each per year:

	CUBIC FEET.
Fires for cooking and heating	100,000
Iron and steel mills	2,166,666,667
Glass works	62,500,000
Other industrial establishments	153,605,016

Through the courtesy of the same company the writer has been furnished with a very careful estimate of the amount of gas actually consumed by 21 mills at Pittsburg, based on meter tests extending over a few hours, which is given in detail on the following page.

MEASURED DAILY CONSUMPTION OF NATURAL GAS BY 21 MILLS AT PITTSBURG.

	CUBIC FEET.
Mill No. 1	3,800,000
2	1,866,600
3	1,666,210
4	3,393,480
5	1,947,000
6	791,240
7	2,303,640
8	3,474,900
9	1,986,380
10	11,181,260
11 and 12	17,640,860
13	2,597,900
14	3,010,240
15	7,432,960
16	2,526,280
17	14,583,460
18	5,362,080
19	2,173,140
20	9,005,160
21	18,000,000
Total	114,742,790

This would be an average of 5,463,942 cubic feet a day, or, on a basis of 300 days in the year, of 1,639,182,600 cubic feet a year actually consumed in work. Now, as these furnaces are kept hot the entire 24 hours, including Sundays, and as these estimates were made in 1890, when gas was used more economically than in 1889, the figures, given by the Philadelphia Company in the first estimate, do not seem excessive.

Altogether, reports have been received of the estimated consumption at 33 iron mills, 32 in Pennsylvania and 1 in Ohio. These statements are as follows:

STATES.	Number of mills.	Total consumption. (Cubic feet.)	Average consumption per mill per year. (Cubic feet.)
Total	33	67,456,579,000	2,044,138,758
Pennsylvania	32	66,425,000,000	2,075,781,250
Ohio	1	1,031,579,000	1,031,579,000

The total number of iron and steel works reported as using gas in the United States in 1889 was 95, of which 73 were in Pennsylvania, 10 in Ohio, 6 in Indiana, and 6 in West Virginia. The directory of the American Iron and Steel Association, published early in 1890, gives the number of iron and steel mills in the United States using natural gas as 104. The discrepancy between the number of mills reported to the census and in the directory doubtless comes from the fact that in some cases what is reported as a mill in the census returns may be reported as two or more in the iron and steel directory, and it is also possible that the special agent has failed to receive returns from one or two small mills. The Pennsylvania works are as a rule very much larger consumers of gas than the Ohio and Indiana works. Of the 10 Ohio works, 5 are quite small steel works, using on an average not over 500,000,000 cubic feet a year. If we assume that the Pennsylvania and West Virginia iron and steel works consumed 2,000,000,000 cubic feet a year as an average, the 5 Ohio and 6 Indiana iron mills 1,000,000,000, and the 5 Ohio steel mills 500,000,000, the estimate will at least be large enough to cover the actual consumption and some wastage. This will give the following estimate of the total consumption of gas in iron and steel works in the United States in 1889:

TOTAL CONSUMPTION OF NATURAL GAS IN THE IRON AND STEEL WORKS OF THE UNITED STATES IN 1889, IN CUBIC FEET.

STATES.	Mills.	Number of works.	Average consumption per year per works.	Total consumption for 1889.
Total		95	1,805,263,158	171,500,000,000
Pennsylvania	Iron and steel	73	2,000,000,000	146,000,000,000
West Virginia	Iron	6	2,000,000,000	12,000,000,000
Ohio	Iron	5	1,000,000,000	5,000,000,000
Do	Steel	5	500,000,000	2,500,000,000
Indiana	Iron	6	1,000,000,000	6,000,000,000

It is not so easy to arrive at an average consumption of gas in glass making as in some other industries. The estimate, as previously given, of the Philadelphia Company of the average consumption at each glass works (a glass works being understood to be a furnace) is 62,500,000 cubic feet per year. The consumption of 3 other Pennsylvania glass works show a total use of 158,250,000 cubic feet, or 52,750,000 cubic feet each, or about 10,000,000 cubic feet a year less, but these were at smaller works, and are evidently underestimates.

Some very important tests have been made both in Pittsburg and in Ohio as to the amount of gas consumed in glass works. Below are given the results of a series of meter tests made by the Philadelphia Company at Pittsburg glass houses. The tests continued over 160 hours in each case. Tests were made at 4 10-pot window-glass furnaces and at 7 10-pot flint-glass furnaces.

DAILY CONSUMPTION OF NATURAL GAS AT A 10-POT WINDOW-GLASS FURNACE AT PITTSBURG.

	CUBIC FEET.
Melting furnace	270,000
2 blow furnaces	60,000
1 flattening oven	27,000
Stoves, pot arch, sand furnace, etc	2,000
Total	359,000

DAILY CONSUMPTION OF NATURAL GAS AT A 10-POT FLINT-GLASS FURNACE AT PITTSBURG.

	CUBIC FEET.
Melting furnace	164,000
5 glory holes	36,000
2 leers	32,000
1 boiler	24,000
Stoves, pot arches, mold ovens, etc	2,000
Total	258,000

These are averages for every day in the month, and would make the monthly consumption of gas at a 10-pot window factory, on the basis of 30 days to a month, 10,770,000 cubic feet, and of a 10-pot flint house 7,740,000 cubic feet. This is probably under the actual figures.

In Ohio some very thorough tests of consumption of natural gas in glass houses have been made. Tests were made at 5 window-glass and bottle houses, with the following results (the figures include all the gas used per pot for 24 hours):

CONSUMPTION OF NATURAL GAS AT 5 WINDOW-GLASS AND BOTTLE FACTORIES IN OHIO.

	CUBIC FEET.
1	58,800
2	60,000
3	61,200
4	61,360
5	60,270

These tests were made with the Robinson pipe-line guage. Test No. 4 in the above table shows the average run of a 10-pot window factory. The number of pots measured at the 5 factories ranged from 8 to 18. The supply pipes varied in size, being 4, 5, and 6 inches in diameter, and the pressure from 16 to 60 ounces. In view of these facts the close agreement of these measurements is remarkable; but at the same time they differ materially from the consumption at the Pittsburg factories. The consumption at the Pittsburg window factory is but 36,000 cubic feet per pot for 24 hours, as against 60,000 in Ohio. The probability is that this difference does not come from an error, but from the greater wastefulness with which gas is used in Ohio. Professor Orton, from whose report the figures concerning Ohio are taken, says: "It might be expected * * * that 40,000 cubic feet of gas would suffice for a day's run per pot; but, whether from lavish use or other causes, about 50 per cent additional is actually used. There can be but little doubt that if the glass manufacturers were required to pay 5 or 6 cents per 1,000 cubic feet by meter or gauge a large economy would at once be effected." The Ohio tests of flint-glass furnaces were made at 8 works. The results were as follows per pot for 24 hours:

CONSUMPTION OF NATURAL GAS AT FLINT-GLASS WORKS IN OHIO.

	CUBIC FEET.
1	31,230 39,270
2	37,430
3	38,470
4	40,530
5	41,230
6	41,370
7	44,450 49,875
8	50,100

In explanation of the disparity of results at these tests, it is stated that some of the works were run to their full capacity, while others were not. At the two factories for which two measurements are given the tests were made at different times. The figures show a consumption of from 35,000 to 45,000 cubic feet per pot per day. It will be safe to place the average at 40,000 cubic feet. And here again the great disparity between Pittsburg and Ohio measurements is seen. Pittsburg shows an average per pot for 24 hours of, say, 26,000 cubic feet, as against 40,000 cubic feet in Ohio. According to the Ohio figures a window-glass pot consumes 1,800,000 cubic feet a month and 18,000,000 cubic feet a year of 10 months. According to the Pittsburg figures the consumption is 1,080,000 cubic feet a month or 10,800,000 cubic feet a year. An Ohio flint house consumes per pot 1,200,000 cubic feet per month, or 12,000,000 cubic feet a year, while a pot at a Pittsburg house requires but 780,000 cubic feet a month, or 7,800,000 cubic feet a year.

The number of glass works reported as using gas in 1889 is 111. In some cases a works as reported has 2 furnaces, and in one case 5. The number of furnaces in these 111 works is estimated at 150. Assuming that the consumption of each furnace is 125,000,000 cubic feet, the total consumption of gas in glass making in 1889 was 18,750,000,000 cubic feet.

The number of industrial establishments in the United States other than iron, steel, and glass works reported as using gas was 2,369. These include some very large establishments, as pipe works, machine shops, foundries, brick works, electric-light plants, breweries, nail mills, wire mills, kilns for burning pottery, tiles, bricks, etc., as well as planing mills, small wood-working establishments, etc. Of these 2,369 establishments returns of the estimated amount of gas consumed have been received from 1,075, which are reported in 1889 as consuming 113,557,478,750 cubic feet, or an average of 105,634,864 cubic feet each. Of these 1,075 works, 895 were in Pennsylvania, with a reported consumption of 118,767,357 cubic feet each, 77 in Ohio, with an average consumption of 61,481,224 cubic feet each, and 103 in Indiana, with an average amount consumed of 24,527,762 cubic feet each. Assuming the average amount consumed at each industrial establishment other than iron, steel, or glass works at 100,000,000 cubic feet, the total consumption in the United States in the 2,369 works would be 236,900,000,000 cubic feet.

The number of domestic fires, or fires for cooking and heating, using natural gas in the United States is reported as 466,034. It is evident from the schedules that in some cases a domestic consumer who may have from 5 to 10 fires is counted as 1 fire, while in other cases each fire in a house is called a fire. It is estimated that the total number of fires supplied with natural gas is at least 500,000. These fires include ranges, cook stoves, furnaces, and heaters, which are large consumers, as well as grates and small heating stoves.

Returns of the estimated consumption of gas in 236,939 of these fires have been received, showing a total consumption of 40,545,338,550 cubic feet, an average of 171,121 cubic feet each per year. This is perhaps an overestimate. Returns for 190,939 fires in Pennsylvania were received, which show an average amount consumed of 121,730 cubic feet; of 30,872 fires in Ohio, with an average amount consumed of 249,792 cubic feet; while from Indiana returns for 15,128 fires were received, showing a consumption of 633,907 cubic feet. The Pennsylvania report is probably most nearly right. Assuming 125,000 cubic feet as the average amount consumed by a fire and 7 months as the average time each fire is burned, this would make the average daily consumption for the 210 days nearly 600 cubic feet per fire. This would be 50 feet per hour for 12 hours. On the basis of 500,000 fires and an average yearly consumption of 125,000 cubic feet per fire, the total amount of gas consumed in 1889 in cooking and heating would be 62,500,000,000 cubic feet.

Returns of the use of 5,482,125,000 cubic feet in pumping oil by pipe lines have been received. It is estimated that this use consumed 7,500,000,000 cubic feet.

It is also estimated that 30,000,000,000 cubic feet of gas were consumed in the oil and gas regions in drilling and operating oil and gas wells of which no record has been obtained.

Further, it is estimated that at least 25,000,000,000 cubic feet of gas were used for purposes for which no record has been kept, or of which no details have been supplied the Census Office.

From the figures given above, we have the following as the estimated consumption of natural gas in the United States in cubic feet:

TOTAL CONSUMPTION OF NATURAL GAS IN THE UNITED STATES IN 1889.

	CUBIC FEET.
Iron and steel mills	171,500,000,000
Glass works	18,750,000,000
Other industrial establishments	236,900,000,000
Heating and cooking	62,500,000,000
Pumping oil	7,500,000,000
Drilling and operating oil and gas wells	30,000,000,000
Other uses	25,000,000,000
Total	552,150,000,000

These figures are to be taken only as the best approximation possible, and are to be accepted under the conditions expressed in the discussion preceding.

This total is enormous, and shows how wastefully natural gas has been used. It is assumed roughly that

30,000 cubic feet of gas equal in heating power 1 ton of Pittsburg coal. This is not correct, but it is near enough for comparison. On this basis the natural gas consumed in the United States, as given above, would equal in heat value 18,405,000 tons of coal. The actual fuel displacement, given elsewhere, is in round numbers 10,000,000 tons. As natural gas is burned most wastefully, perhaps more than double the amount actually needed to do a given work being used, it is probable that our estimate is not too large.

PRODUCTION AND VALUE OF NATURAL GAS IN THE UNITED STATES.

The proper unit of production of natural gas should, of course, be cubic feet, as the measurements of gas are usually in this unit. The conditions of its production, however, are such that it is utterly impossible to arrive at a correct statement of the number of cubic feet of natural gas produced. This same remark will apply to statements regarding its distribution, sale, and use. Gas in 1889 was in but few instances sold by meter. Usually so much per fire, or per furnace, or per boiler, or per pot in glass works, or per ton of iron was charged for its use, no account being taken of the amounts used.

In Ohio some attention has been paid to the measurement of the production of certain wells. Two methods have been adopted: the anemometer for small wells, yielding 1,000,000 cubic feet or less a day, and a modification of Pitot's tubes for larger wells. The use of the anemometer for this purpose was first suggested, so far as is known, by Mr. Emerson McMillin, of Columbus, Ohio, and was first used in measuring the Adams well, at Findlay, in June, 1885. The measurements obtained have been compared with those obtained by other methods and their reliability established.

The use of the modified form of Pitot's tubes was devised and worked out by Professor S. W. Robinson, of the Ohio state university.

The most carefully observed pressures and productions have been made in Ohio in the Findlay field. The actual production of wells varied in 1885 from 80,000 cubic feet at the Adams wells to 12,080,000 cubic feet at the Karg well. It was estimated from measurements that in 1886 the great wells of the Murrysville district, Pennsylvania, yielded 15,000,000 cubic feet a day on an average; the Tarentum wells about 1,500,000. In the Findlay field in 1889 the new wells produced about the same as in 1885, while in Indiana the high-pressure wells produced from 1,000,000 cubic feet upward.

In 1889 some of the wells drilled in the Trenton limestone early in the year in Upper Sandusky yielded from 1,000,000 to 1,500,000 cubic feet of gas a day, while later in the summer a large well, yielding 15,000,000 cubic feet a day, was struck. The Mellott well, near Stuartsville, had a daily production of 28,000,000 cubic feet, while one near Bairdstown is reported to have shown the amazing open pressure of 45 pounds, which would be equivalent to a daily production of 33,000,000 cubic feet; but while individual wells of greater volume than any that had ever before been drilled were found in Ohio in 1889, the Findlay field as a whole was steadily losing its pressure, and consequently its production.

While it is impossible to give the production of natural gas in the United States in cubic feet, it is possible to reach approximately the consumption of this gas, basing figures therefor upon meter tests and estimates at certain works and assuming the average of these tests and estimates as representing approximately the average consumption at each of the works of the same kind in the United States using natural gas in 1889. The number of mills, furnaces, glass works, boilers, houses, fires, etc., using natural gas has been obtained with a reasonable degree of accuracy, and in some cases the amount consumed has been measured, so that on the basis of these figures a fair approximation of the amount of gas consumed may be obtained. As the investigation into the production of natural gas really becomes an inquiry into the consumption, the measure of production being actually the amount consumed and not that wasted into the air, these figures of consumption will approximately represent the production of natural gas with the exception of that which went to waste. This consumption, as is given in the preceding table, under the heading "Total consumption of natural gas in the United States", was 552,150,000,000 cubic feet, which is equivalent to 18,405,000 tons of coal, on the basis of 30,000 cubic feet equaling in heating power 1 ton of coal.

In arriving at the value of this gas several difficulties were encountered. The most natural course to pursue would be to give as the value of this gas the amount of money actually received for it, but this would be very much under its actual value. While it is possible for companies furnishing gas to state the exact amount received during the year from consumers, there are many instances in which industrial establishments, such as iron works, glass works, etc., located in gas districts, bore their own wells and secure an ample supply of fuel at an outlay amounting only to the cost of boring the well and laying the pipe from the well to the plant, no further care or attention being required. The cost of drilling the well and laying the pipe is charged to expense, and after this no amount is charged for the gas. Further, in many localities, especially in Indiana and Ohio, a neighborhood combines to put down a well for supplying its residences, stores, etc., and the original cost, which is the total expense in connection with drilling the well and piping the gas, is distributed among the several parties, and no further charge is made for fuel. In other instances certain towns, in order to secure the location of industrial and other establishments, have furnished gas in large quantities for nothing or at a nominal rate, so that in these cases the amount received for the gas would in no way represent its value.

The best basis of calculation of the value of natural gas consumed in the United States is believed to be that by fuel displacement adopted in the yearly reports of the Mineral Resources of the United States, of the United States geological survey. The amount of coal necessary to perform a given work, that is, to raise steam in boilers, to produce a ton of iron or steel, to operate an 8 or 10 pot glass furnace, or a glasshouse containing one or more furnaces with a given number of pots, is quite accurately known, and the value of the coal or wood required to do this work is assumed to be the value of the natural gas used to perform the same work, whatever may be the amount of money paid for this gas. For instance, in Pittsburg it is quite generally conceded that it requires about 35 bushels of coal, of 76 pounds per bushel, to puddle a ton of iron, about 14 bushels to heat a ton of iron, and 12 bushels of slack to raise the steam required in a mill to produce a ton of iron.

At a rolling mill near Pittsburg the cost of fuel for making bar iron, including the cost of puddling, heating, and making steam and removing ashes, was $2.22 a ton. At a mill in Ohio producing 50 tons of iron a day the cost of coal was $200 a day. Adding to this the wages of the men who handled the coal, hauled away the cinders, etc., and the cost of grate bars and fire brick, would make the total cost of coal fuel $5.25 a ton of iron produced, while the gas was supplied to this mill for $1.90 a ton.

The cost of fuel for running a 10-pot flint glass works at Pittsburg for 45 weeks was as follows:

Slack coal	$2,809.78
Coke	1,288.29
Benzine for glory holes	1,584.48
Total	5,682.55

It is also estimated that 40 bushels of coal per pot are enough to run a window glass plant 24 hours, which would make 400 bushels of coal for a 10-pot furnace per day, or on a basis of 30 days in a month and 10 months in the year, 120,000 bushels a year. This would be equivalent to 4,560 tons of coal. Assuming this is the average consumption of a furnace, though it is probably a little in excess of the average, and that there were 150 glass furnaces using natural gas in the United States in 1889, it would make a consumption at these 150 glass furnaces of 684,000 tons of coal. The consumption of natural gas in the glass works in the United States is given elsewhere as 18,750,000,000 cubic feet.

While in the following table of production the value of natural gas in the United States in 1889 is given by both methods, that is, the value of the gas consumed as actually returned and the value of fuel displacement, the value of the fuel displacement is regarded as the actual value.

VALUE OF NATURAL GAS CONSUMED IN THE UNITED STATES IN 1889, BY STATES, AND THE AMOUNT AND VALUE OF COAL AND WOOD DISPLACED BY THE SAME.

STATES AND TERRITORIES.	Value of natural gas supplied and used.	COAL DISPLACED.		WOOD DISPLACED.	
		Tons.	Value.	Cords.	Value.
Grand total	$11,044,858	10,198,930	$20,932,059	69,018	$165,040
Pennsylvania	8,287,383	6,863,062	11,593,989	.....	.....
Indiana	1,362,472	716,461	2,002,762	44,888	72,940
Ohio	1,120,997	1,660,456	5,123,569	24,130	92,100
New York	204,325	130,159	530,026	.....	.....
Missouri	27,825	11,859	35,687	.....	.....
Kansas	13,660	4,538	15,873	.....	.....
California	12,680	3,517	12,680	.....	.....
Illinois	8,658	7,245	10,615	.....	.....
Kentucky	2,580	615	2,580	.....	.....
West Virginia	2,000	600	2,000	.....	.....
Texas	1,728	288	1,728	.....	.....
Arkansas	375	107	375	.....	.....
Utah	150	18	150	.....	.....
South Dakota	25	5	25	.....	.....
Total	11,044,858	9,398,930	19,332,059	69,018	165,040
Used at pipe lines	.....	100,000	200,000	.....	.....
Used for drilling and pumping wells	.....	400,000	800,000	.....	.....
Other uses	.....	300,000	600,000	.....	.....

In the above table the column headed "Value of natural gas supplied and used" indicates only the amount received by the producers for gas supplied, while the values given under "Coal displaced" and "Wood displaced" are the values of the coal or wood that would be required to do the same work as was done by natural gas.

The great discrepancy between the actual amount received and the value of the coal or wood that would be required to do the same work is noticeable. The amount received by the producers from the consumers for the amount of natural gas consumed in the United States in 1889, so far as the same could be ascertained, was $11,044,858, while the value of the coal displaced by natural gas was $19,332,059 and of wood $165,040, making a total of $19,497,099.

While the preceding table down to the "total" represents, and is intended to represent, only the totals of the figures received from the different producers of natural gas, there are certain producers from whom no returns have been received and certain uses of natural gas which have not been included in the table, which would very materially increase these figures. These uses are chiefly in raising steam for pumping oil in the different pipe lines and for the drilling and operating of oil and gas wells. Almost all of the power required for drilling gas wells has come from steam produced by natural gas. A great many oil wells have been bored with natural gas and power for pumping a great many wells furnished by the same fuel. In some cases this gas has come from the wells of large producers of natural gas. In other cases wells that are rated as oil wells supplied natural gas in small quantities, which was used for drilling and pumping. It is estimated that the fuel displaced in the United States at the oil pipe line stations by natural gas was about 100,000 tons of coal, and the coal displaced by natural gas in pumping and drilling wells was fully 400,000, and for other uses 300,000. These are very conservative estimates, but assuming that they are correct, and that the average value of this coal was $2 a ton, this would add 800,000 tons more to the amount of coal displaced and $1,600,000 to the value of the same, making the total coal displacement 10,198,930 tons and total value of the same $20,932,059. Adding to this the value of wood displaced, $165,040, there would appear as the value of natural gas consumed in the United States in 1889, measured by fuel displacement, $21,097,099.

In the following table, from Mineral Resources of the United States for 1888, is given the amount and value of coal displaced by natural gas from 1885 to 1888, inclusive:

AMOUNT AND VALUE OF COAL DISPLACED BY NATURAL GAS FROM 1885 TO 1888, INCLUSIVE.

[Short tons.]

LOCALITIES.	1885.		1886.		1887.		1888.	
	Coal displaced.	Value.	Coal displaced.	Value.	Coal displaced.	Value.	Coal displaced.	Value.
Total	3,131,600	$4,857,200	6,453,000	$10,012,000	9,859,000	$15,817,500	14,063,830	$22,629,875
Pennsylvania	3,000,000	4,500,000	6,000,000	9,000,000	8,883,000	13,749,500	12,443,830	19,282,375
Allegheny county	2,000,000	2,500,000	4,000,000	5,000,000	5,477,000	6,846,250	7,302,700	10,223,780
Remainder of Pittsburg district	500,000	750,000	1,000,000	1,500,000	1,610,500	2,415,750	2,447,330	3,670,995
Western Pennsylvania, outside of Pittsburg district	500,000	1,250,000	1,000,000	2,500,000	1,795,500	4,487,500	2,693,800	5,387,600
New York	56,000	196,000	60,000	210,000	111,000	333,000	125,000	332,500
Ohio	50,000	100,000	200,000	400,000	500,000	1,000,000	750,000	1,500,000
West Virginia	20,000	40,000	30,000	60,000	60,000	120,000	60,000	120,000
Indiana			150,000	300,000	300,000	600,000	660,000	1,320,000
Illinois	600	1,200	2,000	4,000	5,000	15,000	25,000	75,000
Kansas			2,000	6,000				
Michigan			4,000	12,000				
Elsewhere	5,000	20,000	5,000	20,000				

From the above table, in comparison with the table previously given, showing the value of natural gas produced in the United States in 1889, etc., it will be seen that the total value of natural gas consumed in the United States from 1885 to 1889, inclusive, measured by fuel displacement, is as follows:

TOTAL VALUE OF NATURAL GAS CONSUMED IN THE UNITED STATES FROM 1885 TO 1889, INCLUSIVE, DETERMINED BY VALUE OF COAL OR WOOD DISPLACED.

1885	$4,857,200
1886	10,012,000
1887	15,817,500
1888	22,629,875
1889 (*a*)	21,097,099

a The figures for 1889 are corrected value instead of value given in the table.

These figures show that the highest limit of production was reached in 1888, when the total value of gas consumed was $22,629,875. This had fallen to $21,097,099 in 1889, a reduction of about $1,532,776 in the total value of gas consumed. This indicates that the decline in the production of natural gas has begun, and while the total value of gas consumed may be kept up nearly, if not quite, to the figures of 1889 by increasing the charges to consumers, it is evident that the total production will never again reach what it was in 1888

USES OF NATURAL GAS.

The chief uses of natural gas are as fuel for heating purposes. A small amount is used as an illuminant, and a still smaller amount for the manufacture of lampblack, or carbon black, as it is sometimes called, for use in painting, as a lubricant, and especially for the manufacture of carbons for electric lighting. The complete freedom from grit of the carbons so prepared especially adapts it to use for the purpose mentioned.

In endeavoring to arrive at the uses to which natural gas was put in 1889, for the purpose of forming a basis for reaching a conclusion as to its consumption, 6 chief divisions or uses were made, as follows: first, domestic fires,

including all fires for cooking and heating in houses, stores, and offices; second, iron rolling mills; third, steel works; fourth, glass works; fifth, other gas companies; sixth, other industrial establishments, including machine shops, foundries, brick works, brass works, electric-light plants, breweries, nail mills, wire mills, potteries, planing mills, etc. In the following table is given a statement of the number of fires or works as previously classified:

USES TO WHICH NATURAL GAS PRODUCED IN 1889 WAS PUT.

STATES AND TERRITORIES.	Fires for cooking and heating.	Iron rolling mills.	Steel works.	Glass works.	Gas companies.	Other industrial establishments.
Total	466,034	75	20	111	9	2,368
Pennsylvania	280,484	58	15	69	8	1,604
Indiana	109,015	6	.....	11	1	439
Ohio	70,050	5	5	31	.....	278
New York	4,362	.....	.....	.....	.....	11
Missouri	339	.....	.....	.....	.....	2
Kansas	798	.....	.....	.....	.....	2
California	23	.....	.....	.....	.....	5
Illinois	940	.....	.....	.....	.....	20
Kentucky	6	.....	.....	.....	.....	4
West Virginia	5	*a*6	.....	.....	.....	1
Texas	2	.....	.....	.....	.....	1
Arkansas	3	.....	.....	.....	.....	1
Utah	6	.....	.....	.....	.....	.....
South Dakota	1	.....	.....	.....	.....	.....

a These mills procured their gas from Pennsylvania.

From this it appears that the total number of domestic fires, or those used for cooking and heating, was 466,034, of iron rolling mills 75, of steel works 20, of glass works 111, of gas companies 9, and of other industrial establishments 2,368. More than one-half of the fires were in Pennsylvania, 58 of the 75 rolling mills, 15 of the 20 steel works, 69 of the 111 glass works, 8 of the 9 gas companies, and 1,604 of the 2,368 other industrial establishments.

As stated in discussing the consumption of natural gas in the United States, it is certain that this table does not show all of the fires using natural gas, nor all of the industrial establishments burning it. It is very probable that in several cases, instead of reporting the number of fires for heating and cooking in which natural gas is used in a given town, the number of domestic consumers is reported, each consumer having two or more fires, as the report would evidently show. The number of fires for heating and cooking has been estimated at 500,000.

It is also evident from an inspection of the returns that in several cases it is known that an establishment reported as 1 establishment contained 2 furnaces, and in one case as high as 5. It is therefore believed that regarding a glass works as a single furnace the number of glass furnaces in the United States using natural gas in 1889 was at least 150. At the close of 1889, for example, there were at least 500 pots in glass works in Ohio using natural gas. On the basis of 10 pots to a furnace, this would make 50 glass furnaces instead of 31, as reported in the table.

WELL RECORD.

The total number of wells producing natural gas December 31, 1888, was reported as 1,502, and at the close of December, 1889, 2,247. The total number of producing wells completed in 1889 was 799, and the number reported as abandoned in 1889 was 134. Adding to the number of wells completed at the close of 1888 the number of producing wells drilled and completed in 1889, and deducting from this the number reported as abandoned, we should have 2,167 as the number of producing wells at the close of 1889, whereas the number as given was 2,247. It is evident from this that there is an error in the report somewhere, but the probabilities are that the number of wells reported as producing at the close of 1889 is correct. As it would be much easier to state at the close of 1889 how many wells were producing at the close of that year than it would to state the number that had been drilled during the year, it is assumed that the number of producing wells at the close of 1889 is correct approximately.

Assuming that the statement of the number of wells producing at the close of 1888 and 1889 is correct, namely, that 1,502 were producing at the close of 1888 and 2,247 at the close of 1889, it will be seen by reference to statistics of production that, notwithstanding the increase in wells, there has been a decrease in total production of gas, indicating that, though some of the largest wells that were ever struck were completed in 1889, the production per well was very much less in 1889 than in 1888.

There were 892 gas wells completed in the United States in 1889; of these 799 were productive and 93 were dry holes. It is probable that the number of wells drilled in 1889 was in excess of the number given in the table. It was found impossible to get information from quite a number of localities where wells were drilled without finding gas. The probabilities are, however, that all of the producing wells are reported in the table. The wells from which no report was received were either nonproducers or their product was so small that they were abandoned.

At the close of 1888 there were 48 wells drilling for gas, and at the close of 1889 93 wells.

The total cost of drilling wells, including drive pipe, casing, etc., in the United States in 1889 was reported as $1,605,393. This is below the actual figure. It was impossible to secure any information concerning the cost of a number of wells which were drilled in 1889 and which were nonproducers. The cost of drilling a gas well is the same as that of drilling an oil well, with the exception of the tank at well. The expenditure for drilling has been so thoroughly discussed in the report on petroleum that it need not be reported in detail here. It varies with the depth, size of hole, strata through which it is drilled, location of well, difficulty of preparing the ground, etc. The following may be taken as a fair average cost of a 2,000-foot well drilled in the neighborhood of Pittsburg:

AVERAGE COST OF A 2,000-FOOT WELL DRILLED NEAR PITTSBURG.

Rig	$550
Boiler and engine	750
Drilling, at $1 per foot	2,000
Casing (2,000 feet at $0.47½)	950
Tubing (2,000 feet at $0.12½)	250
Incidentals	300
Total	4,800

In West Virginia the cost would be higher than this. In other parts of Pennsylvania the cost would be less, while it is not probable that the cost of drilling wells of the same depth in Ohio and Indiana would equal these figures.

WELL RECORD, BY STATES.

STATES AND TERRITORIES.	DRILLING WELLS.		WELLS COMPLETED IN 1889.			NUMBER OF WELLS PRODUCING.		Number abandoned in 1889.	Total cost of drilling wells, including drive pipe, casing, etc.	DETAIL OF COST.	
	December 31, 1888.	December 31, 1889.	Total.	Producing.	Dry holes.	December 31, 1888.	December 31, 1889.			Labor.	Material.
Total	48	98	892	799	93	1,502	2,247	134	$1,605,393	$346,572	$378,590
Pennsylvania	18	31	239	207	32	810	999	47	683,709	208 454	231,824
Indiana	20	39	307	293	14	287	576	17	431,535	34,028	39,582
Ohio	4	10	196	180	16	287	448	38	331,212	66,836	81,778
New York	5	12	65	55	10	69	119	3	74,752	23,604	14,256
Missouri			19	14	5	5	13	8	30,000		
Kansas			16	14	2	5	25	2	9,800	6,450	3,350
California		1	1	1		5	6		5,135		
Illinois			4	2	2	9	10	1			
Kentucky			29	21	8	20	37	13	26,750	1,500	1,000
West Virginia			6	5	1		4	1	2,000	1,600	400
Texas		5	1	1		1	1				
Arkansas			2	1	1	1	2	1	8,000	2,500	5,500
Utah						2	2				
South Dakota	1		2	2			1	1			
New Mexico						1	1				
Tennessee			2	1	1		1	1			
Wisconsin			3	2	1		2	1	2,500	1,600	900

Taking into consideration the localities in which natural gas wells in the United States were drilled, it is believed that $4,000 a well will cover the average cost of wells drilled for natural gas in 1889, or a total of $3,568,000, which is a little more than double the amount given in the above table.

Under the heading "Detail of cost" in the above table is included only the cost of labor and material where wells were drilled by the owners and not under contract. While the totals of this labor and material are included under "Total cost of drilling wells, including drive pipe, etc.", there is also included in "Total cost" the cost of wells drilled by contract for which no figures of labor and material have been received.

CAPITAL.

The total capital reported as invested in the production and transportation of natural gas in the United States at the close of 1889 was $59,682,154. Of this amount $12,795,715 is given as the value of lands and $46,886,439 as the value of rigs, wells, pipe lines, and other property.

The total acreage of land, both owned and leased, held by natural gas producers is reported as 564,700. Of this amount 46,802 acres are reported as owned and 517,898 acres leased. The average value per acre of this amount is $22.66. This is evidently too low a valuation, and probably comes from the fact that it is based on the land paid for leases. This question has been so thoroughly discussed in the report on the production of petroleum that it need only be referred to here. It is customary in leasing oil or gas land to pay so much bonus down for the lease, the amount varying from $5 to $50 an acre and a royalty of the gas produced. It is fair to assume (certainly it is fair in consideration of the fact that $20,000,000 worth of gas was produced from these 564,700 acres of land) that the average value of this land is at least $100 an acre.

Of the 564,700 acres of land held in the United States 467,175 acres were held in Pennsylvania, Indiana, and Ohio. This amount is certainly worth an average of more than $100 an acre, some of it considerably more. Assuming this price, $100, for the average value of all land held, the value of land would be $56,470,000, instead of $12,795,715. It is but fair to say that some of this land reported as gas land is also oil land, certain wells on the same leases producing oil and others gas.

Of the $46,886,439 reported as the value of property other than lands, $7,472,157 is given as the value of rigs, wells, etc., $31,637,284 as the value of pipe lines used in transporting the gas from wells to consumers, and $7,776,998 as the value of other property.

CAPITAL INVESTED IN THE NATURAL GAS INDUSTRY IN THE UNITED STATES IN 1889.

STATES AND TERRITORIES.	Total capital.	NUMBER OF ACRES OF NATURAL GAS LAND.				VALUE OF PLANT.		
		Total acreage.	Owned.	Leased.	Value.	Rigs, wells, etc.	Pipe lines.	Other property.
Total	$59,682,154	564,700	46,802	517,898	$12,795,715	$7,472,157	$31,637,284	$7,776,998
Pennsylvania	34,398,832	277,430	25,411	252,019	7,589,968	3,757,961	18,955,018	4,695,885
Indiana	8,205,813	77,493	12,294	65,199	1,090,218	1,396,949	4,792,548	926,098
Ohio	12,953,750	112,252	3,712	108,540	3,241,679	1,702,051	6,418,342	1,591,678
New York	1,162,429	49,870	533	49,337	298,120	169,753	580,519	114,037
Missouri	313,300	15	5	10	176,800	90,800	44,200	1,500
Kansas	160,000	2,002	2	2,000	10,200	22,500	27,200	100,100
California	51,750	6	6	.....	1,900	49,635	215	.....
Illinois	45,220	19,044	44	19,000	3,200	23,620	18,400	.....
Kentucky	2,146,400	23,215	3,800	19,415	275,550	128,950	800,700	941,200
West Virginia	114,700	218	.....	218	11,280	103,395	25	.....
Texas	80,000	725	725	.....	72,500	1,500	.....	6,000
Arkansas	24,000	2,000	.....	2,000	20,000	3,500	.....	500
Utah	3,000	.....	.....	.....	.....	2,970	30	.....
South Dakota	1,360	.....	.....	.....	.....	1,273	87	.....
New Mexico	3,000	.....	.....	.....	.....	3,000	.....	.....
Tennessee	14,500	270	270	.....	2,700	11,800	.....	.....
Wisconsin	4,100	160	.....	160	1,600	2,500	.....	.....

LABOR AND WAGES IN THE PRODUCTION OF NATURAL GAS IN THE UNITED STATES IN 1889.

The total number of persons employed in the production of natural gas in the United States in 1889 is given as 6,684, to whom $1,736,389 were paid in wages. Of the total number of employés, 374 were foremen or overseers, 889 mechanics, 5,004 laborers, 6 boys under 16 years, 395 males engaged in office work, and 16 females engaged in office work. It must be understood that these workmen were employed not only in the production of gas, but in its distribution. This report is by no means satisfactory, and is to a large extent meaningless, or at least the terms used are such as to lead to confusion in the classification. A better classification is given in the second table below, which shows more in detail the number of persons employed and by more definite occupations.

LABOR AND WAGES.

STATES AND TERRITORIES.	TOTAL.		FOREMEN OR OVERSEERS.		MECHANICS.		LABORERS.		BOYS UNDER 16 YEARS.		OFFICE.			
											Males.		Females.	
	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.
Total	6,684	$1,736,389	374	$235,553	889	$357,840	5,004	$851,945	6	$648	395	$285,439	16	$4,964
Pennsylvania	3,282	1,092,709	145	126,424	399	207,210	2,529	571,445	1	50	202	185,567	6	2,013
Indiana	2,007	341,851	153	58,865	324	97,091	1,408	134,388	2	160	115	49,287	5	2,060
Ohio	983	241,218	59	40,702	97	32,997	757	125,938	3	438	63	40,337	4	806
New York	357	34,235	11	4,152	37	4,443	296	17,687	.....	.....	12	7,868	1	85
Missouri	2	85	.....	.....	1	50	1	35	.....	.....	.....	.....	.....	.....
Kansas	3	2,100	.....	.....	1	900	1	200	.....	.....	1	1,000	.....	.....
Illinois	5	1,222	1	750	.....	.....	3	172	.....	.....	1	300	.....	.....
Kentucky	21	13,016	3	3,360	14	8,056	3	520	.....	.....	1	1,089	.....	.....
West Virginia	6	1,800	.....	.....	6	1,800	.....	.....	.....	.....	.....	.....	.....	.....
Texas	3	1,980	1	900	1	720	1	360	.....	.....	.....	.....	.....	.....
Arkansas	4	2,500	.....	.....	4	2,500	.....	.....	.....	.....	.....	.....	.....	.....
South Dakota	1	73	.....	.....	1	73	.....	.....	.....	.....	.....	.....	.....	.....
New Mexico	4	2,000	.....	.....	4	2,000	.....	.....	.....	.....	.....	.....	.....	.....
Wisconsin	6	1,600	1	400	.....	.....	5	1,200	.....	.....	.....	.....	.....	.....

Of the $1,736,389 paid for wages in 1889, $235,553 was paid to foremen or overseers, $357,840 to mechanics, $851,945 to laborers, $648 to boys under 16 years, $285,439 to office force, males, and $4,964 to office force, females. In addition to these wages a large amount of money was paid to contractors for drilling wells, laying pipe lines, etc., into which labor entered largely. Of wages so paid no account is given.

In the following table will be found totals showing the occupation and number of employés of each kind in the United States:

CLASS OF LABOR.	Total.	Pennsylvania.	Indiana.	Ohio.	New York.	Missouri.	Kansas.	Illinois.	Kentucky.	West Virginia.	Texas.	Arkansas.	South Dakota.	New Mexico.	Wisconsin.
Total	6,684	3,282	2,007	983	357	2	3	5	21	6	3	4	1	4	6
Presidents	1	1													
Treasurers	2	1	1												
Bookkeepers	132	36	80	9	7										
Clerks, males	248	160	41	40	4		1	1	1						
Clerks, females	22	4		17	1										
Telegraph operators	10	6		1	3										
Superintendents	54	13	29	7	5										
Foremen or overseers	311	130	121	44	10			1	3		1				1
Electricians	9	1		8											
Inspectors	39	34	5												
Station agents	35	25	10												
Agents	1				1										
Engineers	10	2	6		2										
Fitters or plumbers	318	146	160	12											
Drillers	146	61	38	32	10		1			4					
Tool dressers	34	22		12											
Carpenters	28	21	5							2					
Fieldmen or wellmen	61	52		6	3										
Teamsters	42	19	10		13										
Linemen	59	23	33		3										
Warehousemen	2	2													
Blacksmiths	2	2													
Tongsmen	69	69													
Watchmen	12	7			5										
Mechanics	340	153	92	37	33	1			14		1	4	1	4	
Laborers	4,691	2,291	1,374	755	257	1	1	3	3		1				5
Boys under 16 years	6	1	2	3											

TOTAL EXPENDITURE FOR MATERIALS DURING 1889.

The total expenditure during 1889 for all materials used in drilling wells, operating and caring for the same, building pipe lines, and for all other materials, was $13,184,497. Of this amount $165,677 was paid for materials used in building rigs, $467,540 for materials used in drilling wells, $282,882 for materials used in operating, shutting in, and caring for wells, $7,044,438 for pipe lines, $285,180 for materials used in fitting, $28,794 for torpedoes, and $4,915,086 for all other materials. Considerable work was done by contract, including labor and materials. It was impossible to make a division of the amounts between labor, materials, etc.

TOTAL EXPENDITURES FOR MATERIALS DURING 1889.

STATES.	Total.	Building rigs.	Drilling wells.	Operating, shutting in, and caring for wells.	Pipe, couplings, etc., in building and repairing pipe lines.	Used in fitting.	TORPEDOES.		All other materials.
							Number.	Value.	
Total	$13,184,497	$165,677	$467,540	$282,882	$7,044,438	$285,180	281	$28,794	$4,915,086
Pennsylvania	4,963,780	113,022	326,674	188,550	855,192	227,926	55	6,167	3,246,249
Indiana	1,921,072	3,800	42,710	38,712	1,761,203	40,190	82	10,275	24,182
Ohio	5,722,865	26,019	66,751	44,710	4,261,054	970	86	8,228	1,315,133
New York	511,141	17,336	22,405	5,810	131,144	16,094	41	2,330	316,022
Missouri	14,200	500			12,200				1,500
Kansas	14,705	4,500	6,500	1,800	1,555		2	350	
California	90				90				
Illinois	17,600			1,600	16,000				
Kentucky	15,644	500		1,700	6,000		15	1,444	6,000
Wisconsin	3,400		a2,500						900

a Includes cost of rigs, drive pipes, casing, and tubing.

PIPE LINES.

The total number of feet of pipe line used in the distribution of natural gas in the United States at the close of 1888 was 25,564,594, and at the close of 1889 was 37,746,093, divided into sizes as follows:

TOTAL NUMBER OF FEET OF PIPE LINE USED IN THE DISTRIBUTION OF NATURAL GAS IN THE UNITED STATES AT THE CLOSE OF 1888 AND 1889.

SIZES (inches).	1888.	1889.
Total	25,564,594	37,746,093
⅝	2,201	3,341
½	907	7,135
¾	423,764	886,925
1	1,157,774	3,039,912
1¼	324,938	730,454
1½	632,774	840,226
2	4,987,328	7,222,308
2½	52,360	53,780
3	3,052,615	4,213,230
3¼ / 3½	8,422	8,422
4	3,165,590	4,913,883
5	294,127	308,434
5⅝	184,800	233,106
6	3,308,077	3,866,192
8	5,167,462	6,979,459
9 / 10	1,405,120	2,141,368
12	642,900	1,369,613
14	643	643
16	569,252	480,693
20	193,780	205,942
24	106,669	148,056
30 / 36	83,091	92,971

The tendency is toward the use of larger pipes, as these will transport more gas with less loss by friction than smaller pipes.

NATURAL GAS IN PENNSYLVANIA.

The following statement regarding natural gas and petroleum in Pennsylvania has been prepared for this report by Mr. John F. Carll, to whom special acknowledgment is due.

All the petroliferous rocks thus far profitably developed in western Pennsylvania and the contiguous portions of New York and West Virginia are found in sediments of devonian and carboniferous age; hence in discussing the various prolific horizons it is only necessary to consider that part of the geologic column which overlies the silurian system. The chart of these upper paleozoic rocks now generally accepted is as follows:

TABLE OF THE PALEOZOIC ROCKS.

NUMBER.

XVII. Greene county series: From surface to top Washington upper limestone.
XVI. Washington county series: From top Washington upper limestone to top Waynesburg sandstone.
XV. Monongahela series: From top Waynesburg sandstone to base Pittsburg coal.
XIV. Pittsburg series: From base Pittsburg coal to base Mahoning sandstone.
XIII. Allegheny series: From base Mahoning sandstone to top Homewood sandstone.
XII. Pottsville series: From top Homewood sandstone to base Olean conglomerate.
XI. Mauch Chunk: From base Olean conglomerate to top subolean conglomerate.
X. Pocono series: From top subolean to top of Venango-Butler oil group.
IX. Catskill series: Venango-Butler oil group.
VIII. Chemung, Portage, Genesee, Tully limestone, Hamilton, Marcellus, Upper Helderberg. — From base of Venango-Butler oil group to top of Oriskany sandstone.
VII. Oriskany sandstone.

Formations Nos. XVII, XVI, and XV, all lying above the Pittsburg coal bed, are found only in the southwestern part of the state. Their aggregate thickness near the West Virginia line is about 1,600 feet; north of the Ohio and

Allegheny at Pittsburg they are reduced to nothing by erosion, as only a few patches of Pittsburg coal remain in high, isolated knobs. None of these rocks have ever produced oil or gas in paying quantities in Pennsylvania.

No. XIV, 550 to 600 feet in thickness, has a more extended range than the above. The crinoidal limestone and its accompanying red shale lie near the center of the group and come to the surface in northern Allegheny and southern Armstrong. Its bottom member, the Mahoning sandstone, holds its place among the country rocks as far north as Red Bank creek. This sandstone has produced some oil in the Dunkard creek region of Greene county and near Pleasant Unity in Westmoreland county, but it can not be rated as a very profitable oil-bearing rock.

No. XIII, thickness about 300 feet, carries the valuable Freeport, Kittanning, Clarion, and Brookville coals and the ferriferous limestone, but produces neither oil nor gas.

No. XII, the Pottsville series, is in western Pennsylvania, a composite formation from 250 to 350 feet in thickness, consisting of 3 sandstones, separated by beds of shale carrying the Mercer and Sharon coal seams and limestones. Various geographical names are used in designating these sandstones: for the uppermost, Homewood sandstone, Johnson Run sandstone; for the middle, Connoquenessing sandstone, Kinzua creek sandstone; for the basal, Sharon-Olean-Ohio conglomerate. This group, well defined and persistent all across the western end of the state, lies at the base of the productive coal measures, and probably represents the millstone grit of England. The Pottsville series is not under sufficient cover nor deep enough below river drainage in the northern counties to fit it for oil production; but on Slippery Rock, in Lawrence county, and at Smiths Ferry, in Beaver county, some heavy oil has been obtained apparently from its bottom member. In Washington county it sometimes produces both oil and gas. One of the most remarkably prolific wells of that section, the Manifold well, yielded a light-gravity oil from the Homewood sandstone. It is also productive in many localities in West Virginia and Ohio. As an oil-bearing group, however, even under ample cover, it is pockety, unreliable, and deceptive, permanently rewarding few of the operators who engage in its development.

The Olean conglomerate, a massive pebbly stratum measuring from 40 to 70 feet in thickness, lies completely uncovered along its northerly outcrop upon the highlands near the Pennsylvania-New York state line at an elevation of 2,340 feet above ocean level. North of this range every vestige of it has been removed by erosion, but towards the south it plunges under cover, dipping at an average rate of about 19 feet to the mile. In central McKean it has taken on its back the upper members of No. XII; near Bradys Bend it disappears beneath the waters of the Allegheny, bearing all the rocks of No. XIII above it; at Pittsburg it is found 850 feet below the river level—150 feet below tide and 2,490 feet below its northerly outcrop. Here, beneath the highlands, it carries above it Nos. XIII and XIV and part of No. XV. Continuing onward to the southwestern portion of Greene county, its dip is more variable, being affected by the anticlinal waves which trend across that part of the state, but it gradually sinks and increases its cover until all the rocks of Nos. XV, XVI, and XVII have been added to its load, burying it in some places more than 2,400 feet beneath the surface.

Since the sediments along the range of the oil belt were deposited layer upon layer in conformable sequence, and subsequently elevated bodily to their present inclined position by the Appalachian uplift without any serious stratigraphical disturbance, it follows that the dip of this Olean-Sharon conglomerate represents approximately the dip of all its associated rocks, both above and below it. Hence, if an oil well at Bradford commencing at the base of the Olean conglomerate requires to be sunk 1,850 feet to reach the Bradford oil sand, one to reach the same horizon anywhere at the southwest must go 1,850 feet plus whatever thickness of cover may be above the conglomerate. This is a broad theoretical calculation, however, which can not always be depended upon except within certain bounds and along lines running in the proper direction; but it serves to show why the oil wells in the southwestern field require to be so much deeper than those in the northeastern.

No. XI (Mauch Chunk red shale, or mountain limestone) seldom exceeds 50 feet in thickness along its northerly outcrop in McKean, Warren, and Crawford counties, where it is generally a bed of sandy shale; but in the latitude of central Butler the mountain limestone makes its appearance, and farther south the characteristic red bands of this division come in, gradually expanding its dimensions to about 180 feet in Greene county and 200 or more in West Virginia. In Pennsylvania the oil and gas indications in this group are of no commercial importance, but in West Virginia and Kentucky the indications appear more promising.

No. X, the Pocono series, is very variable both in composition and thickness. Along the Pennsylvania oil belt it measures from 400 to 500 feet in thickness, but in Huntingdon county swells to over 2,100 feet. As the series is traced southward the dividing line between Nos. X and XI becomes somewhat indistinct, the deposits occupying the horizon of juncture being of such a character that it is difficult to say where one group ends and the other commences. In Venango and Crawford counties it is principally a mass of shale, carrying the Shenango sandstone at its top and the Berea grit near its center. Bordering the Pennsylvania-Ohio line a similar structure prevails, but in southern Butler, Allegheny, and Westmoreland counties another well-defined sandstone, the Butler gas sand, makes its appearance near the bottom of the series, and when this sand is fully developed the Berea grit appears to be absent.

Three oil and gas bearing horizons are to be credited to this series, to wit: (1) Shenango sandstone, (2) Berea grit, (3) Butler gas sand.

(1) The Shenango sandstone, in common with all the oil-producing strata, has had different names applied to it in

different localities. Along its northerly outcrops, where it is well exposed and seldom more than 40 feet in thickness, it is called the subolean conglomerate in the counties of McKean and Crawford, and Shenango sandstone in the counties of Crawford and Mercer. Thickening as it goes southwestward, it becomes the drillers' Big Injun in the Greene county and West Virginia oil field, the Logan sandstone of the Ohio reports, and the salt-water rock of the Macksburg oil region. North of Pittsburg, though pierced by thousands of wells, it has never given any promising indications. In Washington county sporadic but unimportant deposits of both oil and gas have been found, and in Fayette county a gas field of sufficient pressure and volume was developed in 1887 to warrant piping the gas to Uniontown, where it is still being utilized.

The first great and really prolific pool of oil and gas in this Big Injun sand was discovered by Mr. E. M. Hukill while vigorously prospecting in the Dunkard creek region for the Washington county oil sands. His Mount Morris well No. 1 was struck in October, 1886; but it was nearly a year later before active work commenced in the new field. A number of large oil wells and several powerful gas wells have since been obtained, and the belt or pool extends toward the southwest several miles across the state line into West Virginia. How far it may continue and what grade this rock is destined to take among the celebrated oil horizons of the country remains to be demonstrated by future developments; but with the untested wilds of West Virginia spreading out at the southwest it would not be surprising if the field should eventually be greatly extended and rank with the best at the north. A pipe line has already been laid for transporting the oil to market, and the average run for the month of December, 1888, was 729 barrels per day.

(2) The Berea grit is of little importance as an oil bearer in the state of Pennsylvania, having been productive only in a few limited areas in Mercer, Lawrence, and Beaver counties. In Ohio, however, it furnishes heavy oil at Mecca, Grafton, etc., and light oil at Macksburg and other localities near the Ohio river. It is there also, where found under sufficient cover, the repository of valuable deposits of natural gas.

(3) The Butler gas sand has its best development in southern Butler, Allegheny, and the eastern part of Westmoreland counties. It lies from 40 to 80 feet above the First sand of the Venango-Butler oil group, and varies in thicknesss from 30 to 60 feet. Whether it is an independent sand bed or only the easterly representative of the Berea grit is not yet positively known, as no line of closely-connected sections of oil-well borings between the Berea grit region of Ohio and the Butler oil belt have been published. As far as known the Berea grit is never positively identifiable in its theoretical horizon in any well where the Butler gas sand is normally developed. Hence, it is quite possible that the Butler gas sand and the Berea grit are identical, the sand bed having been deposited over the southern part of the Butler belt at a lower level than elsewhere in Pennsylvania and Ohio. This sand, as its name indicates, is almost exclusively a gas-bearing sand.

No. IX, Catskill. This series holds the world-renowned First, Second, Stray, and Third sands of Oil creek, now called the Venango-Butler oil group, whose combined production from the striking of the first well in August, 1859, to January 1, 1890, aggregates about 128,000,000 barrels. Speaking in general terms, the group in a productive form (but not persistently productive throughout its whole extent) reaches from Tidioute, in Warren county, to Waynesburg, in Greene county, being about 130 miles in length, and, say, from 10 to 20 miles in width. Between these points no oil has been produced along the trend of the belt from any of the underlying strata, although many wells have been drilled from 200 to 2,000 feet below the Third sand, and only an inconsiderable quantity has been obtained from the overlying rocks, as mentioned above. Neither has any commercial gas been discovered in the older rocks, except in the Speechley gas field of Venango county, where the southeasterly extension of one of the Chemung oil sands of Warren county is overlapped by the Venango group. Northeast of a line drawn from the northwest corner of Warren county to the northwest corner of Clearfield county the Catskill rocks are so altered in composition and stratigraphical arrangement that they are unproductive, and in addition to this the prevailing northerly slope carries them into the hilltops before reaching the state line. Southwest of Waynesburg the rocks have not been very thoroughly exploited, owing to the deep, hazardous, and expensive drilling; but the developments thus far made indicate unfavorable changes in the composition and structure, which seem to give notice that the southerly end of the productive belt is near. This group has a thickness of about 300 feet in Warren county, 360 in Butler county, 450 at the Ohio River, and 500 feet in Washington county, and going in a transverse direction it thickens toward the east, swelling to 700 feet in the Murrysville and Grapeville gas fields of Westmoreland county, and thence rapidly increasing to 2,500 in Blair county and 5,000 feet in Carbon county.

The sandstones of this group, like all other sandstones, are subject to variations in thickness, composition, and methods of stratification. In one place 3 well-defined sand beds may appear, in another 5 or 6; still the 6 sands are always found within exactly the same geological horizon as the 3; but drillers, not understanding this fact, have invented new names or misapplied old ones as they moved from field to field until the original simplicity of nomenclature adopted on Oil creek has been entirely lost sight of. It so happened that the first wells on Oil creek commenced to drill below the Berea grit, which is completely cut through by the stream and escarps plainly above water level all the way from Titusville to Oil City; consequently the first massive sandstone encountered was the top member of the oil group. This the pioneers very naturally called First sand. Finding another about 140 feet from the top of the First, and still another about 140 feet deeper containing abundant supplies of oil and gas, they counted these Second and Third. Before reaching the productive rock (say, 30 feet above it) an impure gray sand

was passed through, which was at first considered as an accidental or "stray" sand, out of place and unworthy of notice. It was not long, however, before this stratum was found in some of the wells improved in constitution and largely productive, and thenceforward it became one of the regular members of the group under the name of "stray sand". These 4 sandstones, with their included shale beds, are the sole constituents of the Venango-Butler oil group, in which have been found all the noted oil and gas pools of the country, from Warren county to Greene. There are no other members on Oil creek where it has its typical normal development, and it takes in no new ones in its extension southward. Of course the group varies locally in thickness, in the number of its sand beds, and in special details of structure, but its top and bottom planes are always well defined, and whatever confusing and misleading names may be applied to individual productive horizons they all fall, when properly correlated, within these lines.

The sand beds lying in the horizon of the regular First sand have been variously called in different districts as follows:

First sand horizon: Quinn sand, Amber oil sand, Franklin lubricating oil sand, Second, Fifty-foot, Hundred-foot, Salt-water rock, Gantz, Murrysville gas sand, Grapeville gas sand.

Second sand horizon: Lytle sand, Amber oil sand, Salt-water sand, Stray Third, Third, Fourth, Thirty-foot, Blue Monday, Bowlder, Hickory, Gordon, Pine Run.

Stray sand horizon: Gray Rock, Bowlder, Blue Monday, Hickory, Clover seed, Black oil sand, Second, Third, Fourth.

Third sand horizon: Gordon, Weister, Hickory, Green oil sand, Fourth, Fifth, Sixth.

Many other names have been used, but these are sufficient to show how utterly impossible it is for one to satisfactorily locate an oil or gas bearing horizon if he has nothing but the popular local names to guide him. The terms Fourth, Fifth, and Sixth are particularly misleading, since they carry the inference that these sands lie below the regular Third sand and add 3 productive members to the group, which is clearly not the case.

No. VIII. This series as numbered in Pennsylvania includes 7 divisions of the geological chart of New York, its cover being the Catskill group, its base the Oriskany sandstone. The corniferous limestone, one of its basal members—

Outcrops at Black Rock, New York, forming a slight barrier and a small island in the outlet of Lake Erie. From this point it can be traced eastward as far as Cayuga lake, and westward to the Enniskillen oil fields of Canada. Dipping at the rate of 25 feet to the mile, it plunges under the oil regions of western Pennsylvania to a depth of more than 5,000 feet, and then rises to daylight along the easterly slope of the Cincinnati uplift in eastern Ohio. Superimposed upon this limestone lies the Erie division of the New York reports, which, in ascending order, is composed of the Marcellus slates or shales, characteristically black and pyritous, the Hamilton group of gray shales and limestones, the Genesee slates, black and similar in appearance to the Marcellus, and the Portage and Chemung groups. These deposits bring us up to the base of the Venango-Butler group.

The total thickness of the series, as measured in the Wheatland well, near West Middlesex, Mercer county, is 2,635 feet, and in the Conway well, 9 miles south of Franklin, Venango county, 3,275 feet. The first is but a short distance from the Ohio line, the last is on the Venango oil belt. These wells, commencing, of course, above the Catskill rocks, were respectively 3,484 and 3,880 feet deep. The Westinghouse well at Pittsburg failed to reach the corniferous limestone, although it was sunk to a depth of 4,618 feet.

The several oil and gas sands of the counties of McKean, Warren, Forest, and Elk lie in the Chemung division of No. VIII, and no commercial oil or gas has been found in Pennsylvania in any of the deeper rocks. Only 3 or 4 wells are known to have reached the corniferous limestone, but these are sufficient to show that, on account of its great depth and variable composition, it is, to say the least, a very unpromising stratum to drill for.

In Warren and Forest the upper part of the Portage-Chemung incloses several well-defined and massive layers of white or gray oil-bearing sandstones, the first lying about 300 feet from its top, the last about 1,200 feet. These are known in descending order as the oil sands of Warren, Clarendon, Cherry Grove, and Cooper; and they lie embedded in typical Chemung slates which also extend below the Cooper sand as far as the drill has pierced. Some of the productive pools of this group lie not more than 10 miles east of productive pools in the Venango group, but the sands of the former thin out and disappear in this interval, so that hardly a trace of them can be found in the deep wells sunk through the latter.

To the southwest, however, one of these deep sands can be traced across Forest and Venango for about 30 miles, and in eastern Venango, under the name of "Speechley sand", is largely productive of gas, but so far barren of oil. This gas rock underlies the middle ground between the Venango and the Clarion belts, where the Venango group is imperfectly developed.

The McKean group: Stretching out toward the northeast, the Warren sands extend into the Bradford district, and no doubt some of them could be identified with the upper sands of the Bradford or McKean group if drillers would take the trouble to keep a few reliable records in this region; but they will not do this, and we must be content with the above qualified statement, as it is impossible under the present circumstances to systematically trace any particular stratum from one district to the other.

Elk group: Along the southeasterly edge of the Bradford field, and also of Warren and Forest, 2 or 3 other brown sands are found beneath the horizon of the Bradford sand, the lowest one lying about 1,700 feet below the top of the Chemung formation. These sands are found at Startwell, Smethport, Wilcox, Kane, and in Elk county. They appear to be meagerly developed beneath the Bradford and Warren-Forest groups to the northwest, and, per contra, the sands of the last-named group are poorly developed or entirely wanting along the range of the Elk group. It is to be remembered also that the Bradford oil sand is limited approximately in its western extension to a northeast-southwest line projected through the Cooper field of Warren county, where a brown sand somewhat similar to the Bradford oil rock, and which is sometimes productive, immediately overlies the white or gray Cooper sand.

Reviewing what is said above, it is seen that all along the Venango-Butler oil belt, from Tidioute southwestward, the Portage-Chemung is simply a homogeneous mass of slates or slaty shales with no sandy layers worthy of note; that under the Warren and Forest district it contains in its upper 1,200 feet several beds of coarse white or gray oil sands, the first one lying about 300 feet below the top of the mass, this 300 feet, the intervals between the sandstones and the measures below the Cooper sand, as far as the drill has gone, being occupied by grayish slates or shales, with some bands of red similar to those underlying the Venango belt; that under the Bradford district, to a depth of about 1,300 feet (and Allegany, New York, may be included here), similar conditions to those of Warren and Forest exist, except that the most productive sands of Bradford are brownish black instead of white or gray; that in Potter, southeastern McKean, and Elk other brown sands are found to the depth of about 400 feet below the horizon of the Bradford sand, and that in these fields, as in the pools along the Venango belt, the productive portion of one range never, as a general rule, overlaps the productive portion of another.

The oil and gas producing horizons of Pennsylvania come in geological sequence as follows:

No. XIV. Mahoning sandstone.
No. XIII. Barren.
No. XII. Homewood sandstone.
Olean conglomerate.
No. XI. Barren.
No. X. Big Injun.
Berea grit.
Butler gas sand.
No. IX. First sand and its divisions.
Second sand and its divisions.
Stray sand and its divisions.
Third sand and its divisions.
No. VIII. North Warren and Bradford "slush oil".
Warren sand.
Clarendon sand.
Cherry Grove—Balltown sand.
Cooper sand.
Bradford "Third sand".
Wilcox lower gas sands.
Kane sand.
Elk county sands, extending to a depth of about 1,700 feet beneath group No. IX.

As far as known at present the interval between the Elk county sands and No. VII is barren.

Of the Silurian rocks nothing is known from practical well drilling in western Pennsylvania except in one locality. In the city of Erie the Presque Isle well was successfully bored down to the Trenton limestone, the great oil and gas producing rock of Lima and Findlay, Ohio, but no encouraging indications of either oil or gas were developed. The Trenton rock contained nothing but salt water. It was struck at 4,310 feet from the surface, or 3,710 feet below ocean level. At 1,325 feet the corniferous limestone was found, hence from its top to the Trenton there is an accurately measured interval of 2,985 feet. From this it would seem probable that the Trenton limestone could not be reached at Pittsburg at a depth of less than 8,000 feet, and possibly the overlying shales may thicken in that direction and make the depth considerably greater.

PRODUCTION.

The total value of natural gas produced in Pennsylvania in 1889, as shown in the first table on the following page, measured by the amount received for it, was $8,287,383. The amount of coal displaced by this natural gas was 6,863,062 tons, the value of this coal being estimated at $11,593,989. In addition to this, much the larger proportion of the 500,000 tons of coal estimated as having been used in drilling oil and other gas wells and in the pumping of oil, both in pipe lines and at the wells, was consumed in Pennsylvania. This table shows some facts that require explanation. The largest amount of coal displaced credited to any one county is to Westmoreland, 4,039,222 tons being displaced by the gas from this county, while but 90,500 tons are reported as displaced by the gas produced in Allegheny county, though Allegheny county, in which is Pittsburg, consumed many times more natural gas than any other county in the United States. The explanation of this is that most of the gas consumed in Allegheny county comes from Westmoreland and Washington counties. It will be noticed that the amount and value of coal displaced by gas in Westmoreland county is very little more than the amount received for the gas. In other words, the producers of natural gas in these counties receive for the gas very nearly the value of the coal displaced by it.

PRODUCTION OF NATURAL GAS IN PENNSYLVANIA IN 1889, BY COUNTIES.

COUNTIES.	Value of natural gas supplied and used.	COAL DISPLACED.	
		Tons.	Value.
Total	$8,287,383	6,863,062	$11,593,989
Allegheny	178,127	90,500	213,200
Armstrong	6,500	4,853	7,280
Beaver	198,046	136,761	223,405
Butler	299,692	151,350	390,909
Cambria	3,240	3,350	5,000
Clarion	30,455	13,338	31,497
Elk	380,932	313,230	396,665
Erie	15,192	6,047	19,926
Fayette	62,500	60,869	70,000
Forest	32,769	21,420	57,900
Greene	797	350	800
Indiana	14,690	10,000	20,000
Jefferson	4,720	1,710	5,220
McKean	1,220,116	622,628	2,401,668
Mercer	13,000	6,000	13,000
Potter	20,468	15,601	63,387
Venango	866,485	996,410	2,506,450
Warren	18,000	13,350	20,000
Washington	471,520	356,073	688,992
Westmoreland	4,449,534	4,039,222	4,548,780

In the following table will be found a statement of the uses to which the natural gas produced in Pennsylvania in 1889 was put:

USES TO WHICH NATURAL GAS PRODUCED IN PENNSYLVANIA IN 1889 WAS PUT.

COUNTIES.	Fires for cooking and heating.	Iron rolling mills.	Steel works.	Glass works.	Gas companies.	Other industrial establishments.
Total	280,484	58	15	69	8	1,604
Allegheny	6,704	4	.....	1	1	21
Armstrong	819	.....	.....	.....	.....	4
Beaver	6,746	3	.....	.....	.....	7
Butler	3,725	.....	.....	6	.....	14
Cambria	123	.....	.....	.....	.....	.....
Clarion	1,855	.....	.....	.....	1	48
Elk	2,150	.....	.....	.....	.....	12
Erie	584	.....	.....	.....	.....	1
Fayette	3,500	.....	.....	2	.....	.....
Forest	1,805	.....	.....	.....	.....	26
Greene	.....	.....	.....	.....	.....	3
Indiana	500	.....	.....	.....	.....	2
Jefferson	352	.....	.....	.....	.....	.....
McKean	28,999	.....	.....	.....	6	71
Mercer	500	.....	.....	.....	.....	1
Potter	88	.....	.....	.....	.....	25
Venango	17,317	1	1	3	.....	291
Warren	500	.....	.....	.....	.....	4
Washington	15,070	6	2	17	.....	264
Westmoreland	189,147	44	12	40	.....	810

This table shows that 280,484 fires used gas in Pennsylvania for heating and cooking in 1889; also 58 iron rolling mills, 15 steel works, 69 glass works, 8 gas companies, and 1,604 other industrial establishments. Of the fires for heating and cooking 189,147 were supplied with gas from wells in Westmoreland county, as well as 44 of the 58 rolling mills, 12 of the 15 steel works, 40 of the 69 glass works, and 810 of the 1,604 other industrial establishments.

WELLS.

The number of wells producing natural gas in Pennsylvania at the close of 1889 was 999, and 810 at the close of 1888, making an increase during the year 1889 of 189 wells. The number of wells reported as abandoned during the year 1889 was 47. Of 239 wells completed during the year 207 were producing and 32 dry holes.

The total cost of drilling these wells, including drive pipe, casing, etc., was $683,709, of which $208,454 was expended for labor and $231,824 for materials, making a total of $440,278, the remaining $243,431 having been paid for contract work.

WELL RECORD, BY COUNTIES.

COUNTIES.	DRILLING WELLS.		WELLS COMPLETED IN 1889.			NUMBER WELLS PRODUCING.		Number abandoned in 1889.	Total cost of drilling wells, including drive pipe, casing, etc.	DETAIL OF COST.	
	December 31, 1888.	December 31, 1889.	Total.	Producing.	Dry holes.	December 31, 1888.	December 31, 1889.			Labor.	Material.
Total	18	31	239	207	32	810	999	47	$683,709	$208,454	$231,824
Allegheny	1	.....	7	5	2	27	35	7	26,426	4,990	4,610
Armstrong	.....	.....	2	2	.....	3	5	.....	8,000	(a)	.....
Beaver	.....	.....	.....	.....	.....	82	70	12	22,704	16,104	6,600
Butler	.....	3	29	22	7	50	70	6	64,192	4,451	5,768
Cambria	.....	.....	1	1	.....	4	5	.....	5,000	(a)	.....
Clarion	.....	5	22	15	7	14	29	.....	31,211	1,240	971
Elk	.....	.....	10	10	.....	10	20	.....	26,198	18,662	7,536
Erie	.....	1	7	7	.....	69	76	.....	3,994	2,125	1,369
Fayette	.....	.....	.....	.....	.....	4	4	.....	.....	.....	.....
Forest	.....	.....	3	3	.....	11	14	.....	3,700	400	900
Greene	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Indiana	.....	.....	4	1	3	2	3	1	22,000	(a)	.....
Jefferson	.....	.....	3	3	.....	6	8	1	5,523	3,600	1,923
McKean	5	2	24	23	1	97	120	1	47,589	11,877	23,712
Mercer	.....	.....	.....	.....	.....	7	5	2	.....	.....	.....
Potter	.....	.....	4	4	.....	6	10	.....	6,078	2,400	2,678
Venango	5	.....	39	34	5	101	135	.....	67,470	32,400	35,070
Warren	.....	1	1	.....	1	6	6	.....	800	(a)	.....
Washington	1	2	24	23	1	51	70	7	101,596	24,250	39,446
Westmoreland	6	17	59	54	5	260	313	10	241,228	85,955	100,841

a Contract.

In the following table will be found a statement of the number of wells completed in Pennsylvania in each month of 1889, together with the number of dry holes and number of completed wells which were productive:

WELLS COMPLETED IN PENNSYLVANIA IN 1889, BY MONTHS.

MONTHS.	Total number of wells completed in each month.	Number of dry holes.	Number of wells producing.
Total	239	32	207
January	27	2	25
February	9	2	7
March	13	1	12
April	12	2	10
May	13	4	9
June	17	5	12
July	17	3	14
August	21	5	16
September	19	1	18
October	23	1	22
November	29	1	28
December	39	5	34

In the following table will be found a statement of the number of wells producing at the close of December, 1888, and of each month of 1889:

PRODUCING WELLS.

MONTHS.	Total number producing.	Total number abandoned.
1888.		
December 31	810	7
1889.		
January 31	826	9
February 28	831	2
March 31	838	6
April 30	857	2
May 31	862	4
June 30	874	
July 31	887	4
August 31	902	2
September 30	920	4
October 31	941	2
November 30	968	1
December 31	999	4

CAPITAL.

From the returns received the total amount of capital employed in the development, production, and transportation of natural gas in Pennsylvania in 1889 was $34,398,832. Of this amount $7,589,968 was reported as the value of the land and $26,808,864 as the value of other property.

The total number of acres of natural gas territory in Pennsylvania in 1889 was 277,430, of which 25,411 acres were owned and 252,019 leased. As stated above, the value of this land was $7,589,968, which would make the average price per acre $27.36, which is evidently the cost of the leases and not its value as gas-producing territory.

The value of rigs, wells, etc., is given as $3,757,961. As there were 999 producing wells at the close of 1889, the average value of each well was $3,762.

The total value of pipe lines, including right of way, in Pennsylvania is given as $18,955,018. The total number of feet of pipe line laid in this state at the close of 1889 was 18,813,574, which would make the average price per foot $1.01.

CAPITAL INVESTED IN THE NATURAL GAS INDUSTRY IN PENNSYLVANIA IN 1889.

COUNTIES.	Total capital.	NUMBER OF ACRES OF NATURAL GAS LAND.				VALUE OF PLANT.		
		Total acreage.	Owned.	Leased.	Value.	Rigs, wells, etc.	Pipe lines.	Other property.
Total	$34,398,832	277,430	25,411	252,019	$7,589,968	$3,757,961	$18,955,018	$4,095,885
Allegheny	992,325	6,602	66	6,536	108,206	140,000	488,000	256,119
Armstrong	60,000					20,000	30,000	10,000
Beaver	1,827,210	7,003	3	7,000	35,400	335,800	1,376,000	80,010
Butler	849,914	33,456	1	33,455	97,205	143,761	585,585	23,363
Cambria	30,000	40		40	7,000	15,000	8,000	
Clarion	183,431	2,856	521	2,335	52,850	72,477	52,644	5,460
Elk	421,852	7,409	6,516	893	295,600	31,388	93,564	1,300
Erie	170,638	1,030	944	86	78,360	56,484	31,104	4,690
Fayette	100,000					100,000		
Forest	145,900	1,801		1,801	65,100	25,700	47,100	8,000
Greene	3,200	6	1	5	500	2,000	500	200
Indiana	88,500	10,000		10,000	19,500	22,000	40,500	6,500
Jefferson	35,000	1,016		1,016	2,200	14,600	17,300	900
McKean	4,285,722	36,964	12,199	24,765	1,269,605	215,112	2,438,836	362,169
Mercer	30,000	1,010		1,010	2,000	2,500	25,000	500
Potter	334,119	6,158	2	6,156	137,737	50,294	119,268	26,820
Venango	3,049,797	64,541	2,799	61,742	510,288	127,941	1,739,255	672,313
Warren	40,800					10,300	30,000	500
Washington	2,387,394	27,548	32	27,516	577,775	261,883	1,348,639	199,097
Westmoreland	19,363,030	69,999	2,327	67,663	4,330,642	2,110,721	10,483,723	2,437,944

LABOR AND WAGES.

The total number of employés engaged in the natural gas industry in Pennsylvania, as will be seen from the table given on the following page, was 3,282, more than one-half of whom were employed in the production of gas from

Westmoreland county. The total amount of wages paid these 3,282 persons was $1,092,709. Of the total number of employés, 145 were foremen or overseers, to whom was paid $126,424; 399 were mechanics, to whom was paid $207,210; 2,529 were laborers, to whom was paid $571,445; 1 boy under 16 years, to whom was paid $50; 202 males in office, to whom was paid $185,567, and 6 females in office, to whom was paid $2,013.

LABOR AND WAGES, BY COUNTIES.

COUNTIES.	TOTAL.		FOREMEN OR OVERSEERS.		MECHANICS.		LABORERS.		BOYS UNDER 16 YEARS.		OFFICE.			
											Males.		Females.	
	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.
Total	3,282	$1,092,709	145	$126,424	399	$207,210	2,529	$571,445	1	$50	202	$185,567	6	$2,013
Allegheny	224	21,687	14	8,800	59	1,800	151	4,577			9	6,510		
Armstrong	1	900	1	900										
Beaver	77	47,552	5	4,418	28	17,567	32	14,932			12	10,635		
Butler	138	20,875	5	3,600	20	2,764	110	13,163			2	1,300	1	48
Cambria	2	750	1	600			1	150						
Clarion	75	4,640	5	952			66	2,248			4	1,440		
Elk	8	5,225	5	3,600			1	545			2	1,080		
Erie	5	564	2	245	1	3	1	16			1	300		
Fayette	4	2,520	1	720	2	1,080					1	720		
Forest	12	6,900	2	1,560	1	180	3	1,560			6	3,600		
Greene	1	50	1	50										
Indiana	2	1,440	1	720							1	720		
Jefferson	1	700	1	700										
McKean	490	92,350	13	12,917	45	24,272	394	22,308			37	32,808	1	45
Mercer	2	1,646	1	1,020	1	626								
Potter	76	6,821			12	1,013	64	5,808						
Venango	229	121,808	18	19,288	38	20,910	148	52,232			23	28,598	2	780
Warren	3	1,530			2	913	1	587						
Washington	113	36,155	9	7,851	4	1,300	86	17,284	1	50	13	9,670		
Westmoreland	1,819	718,626	60	58,483	195	134,782	1,471	436,035			91	88,186	2	1,140

In the following table is given a detailed statement of the number and class of employés, range of wages, etc., by counties:

CLASSIFIED WAGES IN PENNSYLVANIA, BY COUNTIES.

CLASS OF LABOR.	Total.	ALLEGHENY.		ARMSTRONG.		BEAVER.		BUTLER.	
		Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	3,282	224		1		77		138	
Presidents	1								
Treasurers	1								
Bookkeepers	36	9	$50 to $100 per month			3	$75 to $100 per month	2	$65 to $75 per month.
Clerks, male	160					7	$45 to $60 per month		
Clerks, female	4							1	$48 per month.
Telegraph operators	6								
Superintendents	13	4	$50 to $100 per month			2	$125 to $250 per month		
Foremen or overseers	130	9	$40 to $85 per month	1	$75 per month	5	$70 to $82 per month	5	$10 to $100 per month.
Electricians	1								
Inspectors	34								
Station agents	25								
Engineers	2								
Plumbers or fitters	146	50	$2.25 per day			12	$1.75 to $2.50 per day	1	$1.50 per day.
Drillers	61					8	$5 per day	16	$3.50 to $3.75 per day.
Tool dressers	22					8	$3.50 per day		
Carpenters	21								
Fieldmen	52								
Teamsters	19								
Linemen	23								
Warehousemen	2								
Blacksmiths	2								
Tongsmen	69								
Watchmen	7					1	$40 per month		
Mechanics	153	1	$60 per month					22	$2 to $3 per day.
Laborers	2,291	151	$1 to $1.50 per day			31	$1.75 per day	91	$1.50 to $2 per day.
Boys under 16 years	1								

CLASSIFIED WAGES IN PENNSYLVANIA, BY COUNTIES—Continued.

CLASS OF LABOR.	CAMBRIA.		CLARION.		ELK.		ERIE.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	2		75		8		5	
Presidents								
Treasurers								
Bookkeepers			2	$25 to $40 per month			1	$25 per month.
Clerks, male					2	$40 to $50 per month		
Clerks, female								
Telegraph operators								
Superintendents			1	$50 per month				
Foremen or overseers	1	$50 per month	5	$1.50 to $2 per day	4	$30 to $150 per month	2	$1.25 to $2 per day.
Electricians								
Inspectors								
Station agents								
Engineers								
Plumbers or fitters							1	$2.25 per day.
Drillers								
Tool dressers								
Carpenters								
Fieldmen								
Teamsters			5	$4 per day				
Linemen					1	$20 per month		
Warehousemen								
Blacksmiths								
Tongsmen								
Watchmen								
Mechanics								
Laborers	1	$1.50 per day	62	$1 to $2.25 per day	1		1	$2 per day.
Boys under 16 years								

CLASS OF LABOR.	FAYETTE.		FOREST.		GREENE.		INDIANA.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	4		12		1		2	
Presidents								
Treasurers								
Bookkeepers							1	$60 per month.
Clerks, male			6	$40 to $60 per month				
Clerks, female								
Telegraph operators								
Superintendents	1	$60 per month					1	$60 per month.
Foremen or overseers	1	$60 per month	2	$50 to $80 per month	1	$50 per month		
Electricians								
Inspectors								
Station agents								
Engineers								
Plumbers or fitters								
Drillers								
Tool dressers								
Carpenters								
Fieldmen								
Teamsters								
Linemen								
Warehousemen								
Blacksmiths								
Tongsmen								
Watchmen								
Mechanics	2	$2 per day	1	$2 per day				
Laborers			3	$2 per day				
Boys under 16 years								

CLASSIFIED WAGES IN PENNSYLVANIA, BY COUNTIES—Continued.

CLASS OF LABOR.	JEFFERSON.		M'KEAN.		MERCER.		POTTER.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	1		490		2		76	
Presidents								
Treasurers								
Bookkeepers			17	$50 to $75 per month				
Clerks, male			20	$50 to $88 per month				
Clerks, female			1	$45 per month				
Telegraph operators							5	$2 per day.
Superintendents								
Foremen or overseers	1	$58.33⅓ per month	13	$45 to $166.66⅔ per month	1	$85 per month		
Electricians								
Inspectors								
Station agents								
Engineers								
Plumbers or fitters			31	$1.25 to $2 per day				
Drillers			14	$3.75 to $4 per day			6	$4 per day.
Tool dressers			2	$3 per day			6	$3.50 per day.
Carpenters								
Fieldmen							4	$2 per day.
Teamsters								
Linemen							3	$2 per day.
Warehousemen								
Blacksmiths								
Tongsmen								
Watchmen							5	$2 per day.
Mechanics			20	$1.90 to $3 per day	1	$2 per day		
Laborers			372	$1.50 to $2 per day			49	$1.50 per day.
Boys under 16 years								

CLASS OF LABOR.	VENANGO.		WARREN.		WASHINGTON.		WESTMORELAND.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	229		3		113		1,819	
Presidents					1	$150 per month		
Treasurers					1			
Bookkeepers					1	$75 per month		
Clerks, male	23	$72 to $145 per month			9	$40 to $100 per month	93	$50 to $200 per month.
Clerks, female	2	$30 to $45 per month						
Telegraph operators							3	$75 per month.
Superintendents					1	$125 per month	3	$100 to $200 per month.
Foremen or overseers	18	$50 to $187.50 per month			9	$40 to $90 per month	52	$50 to $115 per month.
Electricians							1	$60 per month.
Inspectors	1	$2 per day					33	$65 per month.
Station agents							25	$65 per month.
Engineers							2	$75 to $150 per month.
Plumbers or fitters	1	$2 per day					50	$2.25 per day.
Drillers	6	$4 per day					11	$2 to $4.50 per day.
Tool dressers	6	$4 per day						
Carpenters	12	$3.50 per day					9	$2.75 per day.
Fieldmen	48	$50 per month						
Teamsters	8	$5 per day					6	$50 per month.
Linemen							19	$55 per month.
Warehousemen							2	$2 per day.
Blacksmiths							2	$60 per month.
Tongsmen	12	$2.25 per day					57	$2 per day.
Watchmen							1	$65 per month.
Mechanics	4	$50 to $70 per month	2	$2 per day	4	$62 per month	96	$2 to $3.80 per day.
Laborers	88	$1 to $2 per day	1	$2 per day	86	$1.25 to $2 per day	1,354	$1.25 to $2 per day.
Boys under 16 years					1	$50 per month		

TOTAL EXPENDITURES FOR MATERIALS.

The total expenditures during 1889 in Pennsylvania for materials in building rigs, drilling wells, operating, shutting in, and caring for wells, pipe, couplings, etc., in building and repairing pipe lines, fitting, torpedoing, etc., were $4,963,780. Of this amount $984,344 were expended in Venango county and but $712,027 in Westmoreland county. This would seem to be an error, since there were 59 wells completed in Westmoreland county during 1889 and but 39 wells in Venango county. This difference is easily explained when we consider that a great many of the wells in Westmoreland county were drilled by contract, which expense is not included in the total of expenditures given in the table below.

TOTAL EXPENDITURES FOR MATERIAL DURING 1889, BY COUNTIES.

COUNTIES.	Total.	Building rigs.	Drilling wells.	Operating, shutting in, and caring for wells.	Pipe, couplings, etc., in building and repairing pipe lines.	Used in fitting.	TORPEDOES.		All other material.
							Number.	Value.	
Total	$4,963,780	$113,022	$326,674	$188,550	$855,192	$227,926	55	$6,167	$3,246,249
Allegheny	53,125	900	5,000	.....	44,442	1,935	1	68	780
Beaver	907,730	12,000	32,800	22,400	6,130	54,360	1	40	780,000
Butler	168,961	5,417	17,075	20,780	15,914	5,006	.....	.....	104,769
Cambria	485	.....	.....	400	85	.....	.....	.....	.....
Clarion	40,898	2,078	1,950	1,847	33,455	408	1	60	1,100
Elk	78,095	950	5,000	4,700	65,607	1,200	4	338	300
Erie	3,636	.....	600	800	1,122	.....	3	160	954
Forest	3,500	.....	.....	900	2,400	.....	.....	.....	200
Greene	700	.....	.....	.....	500	.....	.....	.....	200
Indiana	4,850	2,300	2,400	.....	.....	.....	1	150	.....
Jefferson	2,440	325	2,000	.....	.....	.....	2	115	.....
McKean	1,657,794	19,093	54,500	27,541	45,658	83,700	39	4,986	1,422,316
Potter	249,423	5,364	8,800	1,896	9,642	6,062	.....	.....	208,659
Venango	984,344	34,495	70,600	70,246	69,661	50,433	.....	.....	688,909
Warren	236	.....	.....	.....	236	.....	.....	.....	.....
Washington	104,536	10,500	43,057	14,247	31,511	2,473	3	250	2,498
Westmoreland	712,027	19,600	82,892	22,793	528,829	22,349	.....	.....	35,564

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN PENNSYLVANIA IN 1889.

Below will be found a condensed statement of the figures regarding the development, production, and consumption of natural gas in Pennsylvania in 1889:

Total amount received for natural gas produced in 1889	$8,287,383
Coal displaced (tons of 2,000 pounds)	6,863,062
Value of same	$11,593,989

USES.

Total number of fires for cooking and heating	280,484
Total number of iron rolling mills supplied	58
Total number of steel works supplied	15
Total number of glass works supplied	69
Total number of gas companies supplied	8
Total number of other industrial establishments supplied	1,604

WELLS.

Number of wells drilling December 31, 1888	18
Number of wells drilling December 31, 1889	31
Number of wells completed in 1889	239
Producing wells completed in 1889	207
Dry holes completed in 1889	32
Number of wells producing December 31, 1888	810
Number of wells producing December 31, 1889	999
Number of wells abandoned in 1889	47
Total cost of drilling wells, including drive pipe, casing, etc	$683,709
Labor	$208,454
Materials	$231,824

CAPITAL.

Number of acres of natural gas land:	
Owned	25,411
Leased	252,019
Total	277,430
Total value of land	$7,589,968
Total value of rigs, wells, etc	3,757,961
Total value of pipe lines	18,955,018
Total value of other property and improvements	4,095,885
Total capital invested in lands, wells, etc., and used in the business	34,398,832

LABOR AND WAGES.

Number of foremen or overseers	145
Number of mechanics	399
Number of laborers	2,529
Number of boys under 16 years	1
Number of office force, males	202
Number of office force, females	6
Total number of employés	3,282
Wages paid foremen or overseers	$126,424
Wages paid mechanics	207,210
Wages paid laborers	571,445
Wages paid boys under 16 years	50
Wages paid office force, males	185,567
Wages paid office force, females	2,013
Total wages paid employés	1,092,709

EXPENDITURES FOR MATERIALS, ETC.

Total amount expended in building rigs	$113,022
Total amount expended in drilling wells	326,674
Total amount expended in operating, shutting in, and caring for wells	188,550
Total amount expended in pipe, couplings, etc., in building and repairing pipe lines	855,192
Total amount expended in fitting	227,926
Total amount expended for torpedoes	6,167
Total amount expended for all other materials	3,246,249
Total expenditures for materials	4,963,780

OHIO.

There are in Ohio four geological horizons supplying natural gas in commercial quantities. These are in the order of their occurrence, the most recent being named first, (1) the Berea grit, (2) the Ohio shale, (3) the Clinton limestone, and (4) the Trenton limestone.

The Ohio shale yields low-pressure gas in small quantities. Its area is limited to a belt along Lake Erie between Black river and the Pennsylvania line. It was the gas from this horizon which was utilized at Fredonia, New York, as early as 1821, and that burned at the lighthouse at Barcelona, near Westfield, had its source in these shales. At a much later date, but still more than a score of years ago, Erie, Pennsylvania, began to use natural gas in a small way, all the supply being derived from the shales that make the underlying rocks of this region. The lake shore towns of Ohio were not far behind in following the example of Erie. Painesville and Cleveland in particular made a trial of the shales as a source of gas, and secured a small but useful supply 20 years ago. Many wells were drilled along the shale belt in the oil excitement of 1860–1865, but none of these were in any reasonable degree successful, except in disclosing the presence of gas within the formation. The gas from this shale is essentially marsh gas, with small percentages of the more complex hydrocarbons, and is usually free from sulphur, differing in this respect from the gas from the limestone field. It is low pressure, its closed pressure never probably exceeding 100 pounds. Shale gas wells are small producers, the maximum production never passing 100,000 cubic feet a day, very few of them reaching 20,000, and many giving no more than 10,000, and some being as low as 1,500. The gas supply from this shale, though small, is reasonably permanent. Wells do not exhaust a large territory, and the drilling is simple and inexpensive. They require little or no casing, and after a dwelling is piped for gas it will be comparatively inexpensive to drill a new well a few rods from the old one when the first is exhausted. This fact as to the permanence of shale gas has little or no bearing on the question of the permanency

of the supply of gas from high-pressure wells. Shale gas differs essentially in the conditions attending its occurrence and production, and furnishes no rules for judging the gas from other horizons in Ohio. The 3 other horizons named furnish high-pressure gas, though they are by no means of equal importance.

The gas territory depending upon the Berea grit for its supply is in the southeastern and middle eastern counties of the state bordering on Pennsylvania and West Virginia. It is of little importance compared with the territory farther west. Professor Orton, who supplied most of the information about the occurrence of natural gas in Ohio, suggests that though the drill taps the gas in the Berea grit its source is the Ohio shale, which underlies this whole territory with a thickness never less than 600 feet, and for much of the area is three or four times greater than that.

As stated above, the Berea grit, which Professor Orton thinks is the same as the Gantz sand of Washington, Pennsylvania, furnishes but small supplies of gas. At the close of 1889 Cambridge was the only town in the state that derived its supply from this rock. The wells were small, none exceeding 750,000 feet a day. Some high-pressure wells (500 pounds) of large production were struck near Marietta. Near the close of the year a little gas was also produced from this rock near East Liverpool, and at Mount Vernon a well yielding 100,000 feet a day was drilled. The famous Neff wells, in the northern part of Coshocton county, the first of which were drilled in 1865, still continue to produce, though the daily yield is small.

The gas is still utilized in the manufacture of lampblack, this special manufacture originating here. Mr. Neff worked out unaided all the questions connected with it years before it was attempted elsewhere. The wells now require constant care, but their record is an important one, as it shows how long the gas may be eked out even when the salt water accompanies it.

During the year 1889 the developments in the Clinton limestone region were of great importance. The first display of gas in this rock was at Fremont, the shallow wells of that town deriving their gas from the Clinton. It was at Lancaster, however, that a large supply of high-pressure gas was first struck in this formation, which is at Lancaster some 1,000 feet above the Trenton. The Clinton is at Lancaster some 2,000 feet deep. It is a highly crystalline limestone, included between 2 beds of red rock, the upper one being the famous fossil ore. At Newark and Thurston gas was also found in the Clinton. The supply at Newark seemed larger than at Lancaster.

The most important gas horizon in Ohio is the Trenton limestone, which is the rock in which the supplies of the Findlay and adjacent fields are found. The discovery of gas at Findlay in this horizon in 1885 was of great importance geologically and commercially. It discloses the fact, before unsuspected, that the limestone of the lower silurian age, and at the bottom of this great division of geological time, contained immense stores of gas. Commercially it has resulted in bringing into the section of Ohio in which it has been found a vast amount of capital for investment in manufacturing industries and in stimulating the search for gas in Indiana. The first discovery of gas in Findlay in recent times was made in October, 1836, in digging a well. In 1838 gas from another water well was conducted by wooden tubes into the fireplace in one of the living rooms of the house of Daniel Foster and burned from an old gun barrel. It was not until 1884, following the great discoveries in Pennsylvania, that the Findlay Natural Gas Company, the pioneer company in the search for gas in this region, began to drill. In November of that year gas was struck in the limestone rock at a depth of 1,100 feet.

Though the Findlay gas field was developed by drilling the first well in November, 1884, and by the wells of 1885, it was not until the "drilling in" of the great Karg well, on January 20, 1886, that the possibilities of the field were made evident, and it was shown that this territory could produce wells of the first class, even when judged by the standard of the great Pennsylvania wells. The excitement following the striking of this well can hardly be conceived. Its immense production, the force with which the gas escaped and its velocity, the light of the blazing gas, which could be seen at night 40 miles distant, all conspired to lead to that vigorous search for gas which immediately followed.

In composition this gas reaches the highest standard of excellence, as is apparent from the following table of analyses made for the United States geological survey by Professor C. C. Howard, of Columbus:

COMPOSITION OF NATURAL GAS FROM THE TRENTON LIMESTONE, OHIO.

CONSTITUENTS.	Findlay.	Fostoria.	Saint Marys.
Total	100.00	100.00	100.00
Hydrogen	1.64	1.89	1.74
Marsh gas	93.35	92.84	93.85
Olefiant gas	0.35	0.20	0.20
Carbonic oxide	0.41	0.55	0.44
Carbonic acid	0.25	0.20	0.23
Oxygen	0.39	0.35	0.35
Nitrogen	3.41	3.82	2.98
Sulphureted hydrogen	0.20	0.15	0.21

At the close of 1889 the chief fields of the Trenton limestone gas were in Hancock, Wood, Auglaize, and Mercer counties. The largest wells ever struck in this field were in 1889, though as a whole the field was declining. The Mellott well, near Stuartsville, 6 miles north of Findlay, had an open pressure in the casing of 28 pounds. This

stands for a daily production of about 28,000,000 cubic feet. A new well recently drilled by the Northwestern company near Bairdstown, Wood county, is reported to have shown the amazing open pressure of 45 pounds in the casing. This stands for about 33,000,000 cubic feet per day. The Karg well was long counted the wonder of the world, its daily volume at its best being about 14,000,000 feet.

The industrial development of northwestern Ohio, as the result of the discovery of gas, has been remarkable. Leaving out of account those of less than 1,000 inhabitants, the towns using gas at the close of 1889 were Springfield, Greenville, Wapakoneta, Van Wert, Delphos, Sandusky, and Bellevue. Findlay, Lima, Bowling Green, Fostoria, Fremont, Tiffin, Carey, Kenton, Saint Marys, Troy, Piqua, Sidney, Celina, and other towns had been previously supplied. The Northwestern Ohio Gas Company has also laid a large line to the Michigan boundary, designed to furnish domestic fuel to Detroit.

The uses to which natural gas was put will be seen from the tables given below. Findlay had at the close of the year 154 glass pots, nearly half of them added in 1889. A large volume of other manufacturing interests has also been brought in. An equal or, at least, a similar enlargement has gone forward in Tiffin and in Fremont. Fostoria is also well to the front in this remarkable expansion. Bowling Green has also made some noteworthy advances.

Fostoria and Tiffin both own pipe lines to the great gas fields, built by public funds. The gas that they obtain from wells of their own drilling on lands that they have leased for this purpose they supply, at either nominal or very low rates, to the manufacturing companies, counting on the growth of the towns for their returns. The gas furnished on these terms is naturally used in a lavish way.

Toledo is supplied by 2 pipe lines, owned by the Northwestern Ohio company, and, in addition, the city is preparing at great outlay of funds, to be raised by bonding the town, to build a line for itself from the Hancock county field, where it has leased gas lands and drilled wells on a large scale.

PRODUCTION.

In the following table will be found a statement of the total production of natural gas in Ohio during 1889, by counties. The value of this gas, as reported, was $1,120,997; the amount of coal displaced by its use was 1,660,456 tons, valued at $5,123,569, and the amount of wood displaced 24,130 cords, valued at $92,100. The total value, therefore, of the coal and wood displaced, which is $5,215,669, is regarded as the value of gas consumed in Ohio in 1889. As will be seen from the table, the largest production from any county was Hancock, in which Findlay is located, and which has been one of the most productive gas regions in the United States. Almost one-third of all the gas found in Ohio in 1889 was produced in this county.

No value is given for gas produced in Knox, Coshocton, and Marion counties, it having all gone to waste.

PRODUCTION OF NATURAL GAS IN OHIO IN 1889, BY COUNTIES.

COUNTIES.	Total value.	COAL DISPLACED.		WOOD DISPLACED.	
		Tons.	Value.	Cords.	Value.
Total	$1,120,997	1,660,456	$5,123,569	24,130	$92,100
Allen	3,475	.....	.....	2,000	5,000
Ashtabula	3,655	870	5,075	.....	.....
Auglaize	135,112	59,000	178,250	21,250	85,000
Brown	30	7	30	.....	.....
Butler	60	24	110	.....	.....
Clark	50	15	60	.....	.....
Columbiana	4,782	2,720	4,620	.....	.....
Cuyahoga	1,200	233	1,150	.....	.....
Darke	1,300	400	1,300	.....	.....
Fairfield	36,000	20,150	41,400	.....	.....
Guernsey	15,530	9,012	18,048	.....	.....
Hancock	432,745	1,185,869	3,585,453	400	1,000
Hardin	150	30	210	.....	.....
Harrison	30	20	30	.....	.....
Henry	2,100	605	2,420	.....	.....
Hocking	250	100	250	.....	.....
Logan	584	172	600	.....	.....
Lorain	2,955	1,222	2,622	.....	.....
Lucas	7,469	1,650	7,563	.....	.....
Mercer	256,924	110,900	272,525	.....	.....
Muskingum	6,000	.....	.....	.....	.....
Ottawa	1,000	300	1,050	.....	.....
Sandusky	5,360	2,815	6,575	.....	.....
Washington	1,500	400	1,600	.....	.....
Williams	1,610	800	2,550	.....	.....
Wood	22,483	166,553	625,450	480	1,100
Wyandot	178,643	96,589	364,628	.....	.....

USES.

As given in the following table, the total number of fires using natural gas for cooking and heating in Ohio in 1889 was 70,050. Of this total number almost four-fifths were in Hancock, Mercer, Wood, and Wyandot counties. The number of iron rolling mills supplied was 5, steel works 5, glass works 31, and other industrial establishments 278. Of the glass works supplied, 11 were located in Hancock county, or in the vicinity of Findlay, and 16 in Wood county, in the neighborhood of Bowling Green.

It will be seen from the table that no use was made of gas produced in Knox, Coshocton, and Marion counties, it having been allowed to waste, as previously stated.

USES TO WHICH NATURAL GAS PRODUCED IN OHIO IN 1889 WAS PUT.

COUNTIES.	*Fires for* cooking and heating.	*Iron* rolling mills.	Steel works.	Glass works.	Other industrial establishments.
Total	70,050	5	5	31	278
Allen	200				
Ashtabula	125				1
Auglaize	8,191		2		28
Brown	2				
Butler	4				
Clark	4				
Columbiana	152				3
Cuyahoga	71				
Darke	73				63
Fairfield	3,416				5
Guernsey	1,303				1
Hancock	18,893	4		11	70
Hardin	6				
Harrison					1
Henry	150				
Hocking			1		
Logan	46				
Lorain	77				2
Lucas	458				
Mercer	14,007	1	2	2	49
Muskingum	500				
Ottawa	20				5
Sandusky	273				4
Washington	100				
Williams	135				
Wood	10,144			16	43
Wyandot	11,700			2	3

WELLS.

The total number of wells producing natural gas in Ohio at the close of 1889 was 448, which was 161 more than at the beginning of the year. During the year 196 wells were completed, of which 180 were productive and 16 dry holes, and 38 wells were abandoned. The total cost of completing these 196 wells was reported as $331,212, of which $66,836 was expended for labor and $81,778 for materials. These amounts do not include work done by contract, as no separation could be made of the cost into amounts expended for labor and materials.

WELL RECORD, BY COUNTIES.

COUNTIES.	DRILLING WELLS.		WELLS COMPLETED IN 1889.			NUMBER OF WELLS PRODUCING.		Number abandoned in 1889.	Total cost of drilling wells, including drive pipe, casing, etc.	DETAIL OF COST.	
	December 31, 1888.	December 31, 1889.	Total.	Producing.	Dry holes.	December 31, 1888.	December 31, 1889.			Labor.	Materials.
Total	4	10	196	180	16	287	448	38	$331,212	$66,836	$81,778
Allen						4	4				
Ashtabula			4	4		11	15		1,650	1,000	650
Auglaize			12	12		22	33	1	23,400	3,345	4,055
Brown						3	3				
Butler	1		1	1		4	2	3	1,000		
Clark						2	2				
Columbiana			2	2		10	10	2	1,630	1,030	600
Coshocton						4	4				
Cuyahoga			8	8		10	18		3,211	200	100
Darke						5	4	1			
Fairfield		1	4	2	2	2	4	2	19,100		
Guernsey			9	8	1	16	24	1	8,500	4,000	2,000
Hancock	2	5	78	78		31	117	1	132,562	12,245	34,760
Hardin			8	4	4		3	5	13,000	800	2,200
Harrison			3	2	1	1	3	1	6,000		
Henry						2	2				
Hocking						2	1	1			
Knox						2	2				
Logan			1	1		4	4	1	1,150		
Lorain			8	7	1	21	25	3	4,388	1,920	2,463
Lucas			3	2	1	9	8	4	4,030		
Marion						4	4				
Mercer	1	2	23	23		19	41	1	65,950	32,500	25,500
Muskingum						1	1				
Ottawa						2	2				
Paulding			1		1				1,500	500	1,000
Sandusky			2	2		3	5		3,800	1,800	2,000
Seneca			1		1				1,516	916	600
Washington						1	1				
Williams			1	1		3	3	1	5,000		
Wood		2	22	21	1	58	70	7	28,025	3,860	3,765
Wyandot			5	2	3	31	33	3	5,800	2,720	2,080

In the following table will be found a statement of the number of wells completed in each month of 1889 in Ohio, together with the number which were producing and the number of dry holes:

WELLS COMPLETED IN OHIO IN 1889.

MONTHS.	Total number of wells completed in each month.	Number of wells producing.	Number of dry holes.
Total	196	180	16
January	17	16	1
February	11	11	
March	11	9	2
April	13	12	1
May	10	10	
June	17	17	
July	12	11	1
August	33	31	2
September	24	22	2
October	19	15	4
November	14	13	1
December	15	13	2

In the following table is given the number of wells producing at the close of December, 1888, and at the close of each month of 1889, together with the number of wells abandoned during the year:

PRODUCING AND ABANDONED WELLS.

MONTHS.	Total number producing.	Total number abandoned.
1888.		
December 31	287	9
1889.		
January 31	291	6
February 28	302	1
March 31	303	3
April 30	314	2
May 31	330	.....
June 30	347	.....
July 31	359	1
August 31	390	1
September 30	411	4
October 31	428	5
November 30	440	1
December 31	448	5

CAPITAL.

The total capital employed in the production of natural gas in Ohio in 1889 was $12,953,750, of which $3,241,679 represented the value of gas land owned and leased and $9,712,071 the value of other property. Of the capital invested in gas industry in Ohio by far the largest part was invested in 4 counties, Hancock, Mercer, Wood, and Wyandot. Findlay is in Hancock county; Dayton, Greenville, and Celina are supplied from the Mercer fields; Bowling Green is in Wood county, and Carey and Upper Sandusky are in Wyandot county.

In many cases the capital reported represents the value of the land and wells drilled without any production; that is, the venture which was exploited being a failure in securing a commercial supply of gas.

Of the $12,953,750 of capital, $3,241,679 is reported as the value of the 112,252 acres of gas land owned and leased. This would be at the rate of $28.88 an acre, which is probably, as has been explained elsewhere, an underestimate. It will also be noted, although natural gas land is reported as being owned in Allen, Knox, and Ottawa counties, no value is placed upon it in the column of value of lands. Its value is probably included in the value of the wells. In Hocking, Marion, and Muskingum counties no land is reported. The reason for this omission can not be ascertained.

The total value of property other than lands was $9,712,071, of which $1,702,051 represents the value of rigs, wells, etc., $6,418,342 the value of pipe lines, and $1,591,678 the value of all other property. As there were 448 wells producing in this state at the close of 1889, this would make the estimated value of each well about $3,799, which is probably a fair estimate, all things considered.

The total value of pipe lines is given as $6,418,342. The total number of feet of pipe line in this state was 6,124,615, which would make the value per foot about $1.05, which is a little more than the reported value of pipe line per foot in Pennsylvania.

The value of property other than pipe lines and wells is reported in this state as $1,591,678.

CAPITAL INVESTED IN THE NATURAL GAS INDUSTRY IN OHIO IN 1889.

COUNTIES.	Total capital.	NUMBER OF ACRES OF NATURAL GAS LAND.				VALUE OF PLANT.		
		Total acreage.	Owned.	Leased.	Value.	Rigs, wells, etc.	Pipe lines.	Other property.
Total	$12,953,750	112,252	3,712	108,540	$3,241,679	$1,702,051	$0,418,342	$1,591,078
Allen	11,000	320	.....	320	(a)	4,500	4,500	2,000
Ashtabula	21,200	106	1	105	1,850	6,992	9,843	2,515
Auglaize	998,400	8,193	1	8,192	362,850	54,350	506,000	75,200
Brown	4,350	2	2	.....	100	4,050	200	.....
Butler	2,075	1	1	.....	400	1,175	60	440
Clark	6,000	800	.....	800	4,000	600	.....	1,400
Columbiana	72,000	5,252	202	5,050	22,100	17,100	31,800	1,000
Coshocton	50,000	3,200	.....	3,200	25,000	6,000	500	18,500
Cuyahoga	14,626	171	171	.....	4,380	8,276	1,820	150
Darke	12,000	4	.....	4	400	575	4,000	7,025
Fairfield	24,645	7	7	.....	4,950	17,300	1,925	470
Guernsey	307,600	6,900	.....	6,900	40,050	119,450	130,000	18,100
Hancock	2,822,283	30,038	931	29,107	1,221,479	375,775	1,088,912	136,117
Hardin	20,500	1,300	.....	1,300	5,000	15,000	500	.....
Harrison	26,000	1,000	.....	1,000	10,000	6,705	160	9,135
Henry	15,000	2	2	.....	500	8,500	6,000	.....
Hocking	5,000	.....	.....	.....	.....	5,000	.....	.....
Knox	10,000	900	.....	900	(a)	10,000	.....	.....
Logan	11,400	1	1	.....	50	6,500	3,500	1,350
Lorain	42,725	3,058	358	2,700	19,150	19,450	2,625	1,500
Lucas	69,199	203	3	200	4,182	21,467	37,317	6,233
Marion	6,325	.....	.....	.....	.....	6,175	150	.....
Mercer	3,748,975	5,992	380	5,612	49,900	135,600	3,126,100	437,375
Muskingum	125,000	.....	.....	.....	.....	125,000	.....	.....
Ottawa	4,500	1	1	.....	.....	4,000	500	.....
Paulding	1,500	3,000	.....	3,000	1,250	250	.....	.....
Sandusky	65,100	741	427	314	51,000	7,900	6,200	.....
Seneca	2,515	3,000	.....	3,000	1,000	500	.....	1,015
Washington	4,100	10	.....	10	100	4,000	.....	.....
Williams	60,500	1,610	.....	1,610	37,324	16,000	7,176	.....
Wood	2,474,898	9,451	870	8,581	340,570	651,926	719,583	762,819
Wyandot	1,914,334	26,989	354	26,635	1,034,094	41,935	728,971	109,334

a No value as natural gas land.

LABOR AND WAGES.

The total number of employés reported in connection with production, transportation, and distribution of natural gas in Ohio in 1889 was 983, to whom were paid $241,218 in wages. The same remarks will apply here that have been made elsewhere, to the effect that labor engaged in drilling wells, laying pipe, etc., by contract, and wages paid are not included in this table. The same remark also can be made as to the difficulty that arises in connection with the classification given in this table.

LABOR AND WAGES, BY COUNTIES.

COUNTIES.	TOTAL.		FOREMEN OR OVERSEERS.		MECHANICS.		LABORERS.		BOYS UNDER 16 YEARS.		OFFICE.			
											Males.		Females.	
	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.
Total	983	$241,218	50	$40,702	97	$32,997	757	$125,938	3	$438	63	$40,337	4	$806
Allen	3	1,280			1	300	1	200			1	780		
Ashtabula	6	2,405	1	1,000	4	936	1	469						
Auglaize	36	16,522	6	4,667	7	4,588	18	3,115			5	4,152		
Columbiana	6	881	3	391			2	390			1	100		
Coshocton	1	500	1	500										
Cuyahoga	3	110			1	80	2	30						
Darke	2	88	2	88										
Guernsey	22	4,989	1	900	1	250	16	1,758	1	360	3	1,781		
Hancock	415	95,283	11	7,419	26	21,626	307	59,231	1	69	8	6,642	2	256
Hardin	1	150			1	150								
Harrison	1	360	1	360										
Henry	2	300			1	150					1	150		
Logan	4	170			2	75	1	35			1	60		
Lucas	5	1,787	2	1,200	1	300	2	287						
Mercer	91	30,961	8	11,195	33	3,600	34	4,442			15	11,364	1	360
Ottawa	1	50			1	50								
Paulding	10	500	2	120	8	380								
Sandusky	2	650	1	500			1	150						
Williams	3	155	1	60	1	25	1	70						
Wood	83	34,613	10	7,266	9	487	51	17,145			13	9,715		
Wyandot	286	49,464	9	5,036			260	38,616	1	69	15	5,593	1	150

In the following table is a more detailed classification of labor employed in Ohio in the natural gas industry in 1889 than that given in the preceding one:

CLASSIFIED WAGES IN OHIO, BY COUNTIES.

CLASS OF LABOR.	Total.	ALLEN.		ASHTABULA.		AUGLAIZE.		COLUMBIANA.	
		Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	983	3		6		36		6	
Bookkeepers	9	1	$65 per month			1	$5 per day		
Clerks, male	40					4	$2 per day	1	$50 per month.
Clerks, female	17								
Telegraph operators	1								
Superintendents	7			1	$83.33⅓ per month	2	$5 per day		
Foremen or overseers	44					4	$1.50 to $2.50 per day	3	$1 to $2.50 per day.
Electricians	8								
Plumbers or fitters	12	1	$2 per day			4	$2 per day		
Drillers	32			2	$2.50 per day				
Tool dressers	12								
Carpenters									
Fieldmen	6					2	$1.75 per day		
Mechanics	37			2	$1.50 to $2.50 per day	1	$1.50 per day		
Laborers	755	1	$1.50 per day	1	$1.50 per day	18	$1.25 to $1.50 per day	2	$1 per day.
Boys under 16 years	3								

CLASSIFIED WAGES IN OHIO, BY COUNTIES—Continued.

CLASS OF LABOR.	COSHOCTON.		CUYAHOGA.		DARKE.		GUERNSEY.		HANCOCK.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	1		3		2		22		415	
Bookkeepers									2	$90 per month.
Clerks, male							3	$52 to $70 per month.	6	$55 to $100 per month.
Clerks, female									2	$50 per month.
Telegraph operators										
Superintendents	1	$41.67 per month								
Foremen or overseers					2	$2 per day	1	$3 per day	11	$2.50 to $3 per day.
Electricians										
Plumbers or fitters										
Drillers									5	$3.50 per day.
Tool dressers										
Carpenters										
Fieldmen										
Mechanics			1	$2 per day			2	$1.25 to $5 per day	21	$3.25 to $4 per day.
Laborers			2	$1.25 to $2 per day			15	$1.25 to $1.50 per day	367	$1.25 to $2.25 per day.
Boys under 16 years							1	$14 to $25 per month	1	$12 to $14 per month.

CLASS OF LABOR.	HARDIN.		HARRISON.		HENRY.		LOGAN.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	1		1		2		4	
Bookkeepers					1	$2.75 per day	1	$60 per month.
Clerks, male								
Clerks, female								
Telegraph operators								
Superintendents								
Foremen or overseers			1	$1 per day				
Electricians								
Plumbers or fitters					1	$1.75 per day		
Drillers								
Tool dressers								
Carpenters								
Fieldmen								
Mechanics	1	$50 per month					2	$1.50 per day.
Laborers							1	$1.50 per day.
Boys under 16 years								

CLASS OF LABOR.	LUCAS.		MERCER.		OTTAWA.		PAULDING.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	5		91		1		10	
Bookkeepers			1	$1 per day				
Clerks, male								
Clerks, female			14	$2 per day				
Telegraph operators			1	$30 per month				
Superintendents	2	$50 per month						
Foremen or overseers							2	$2 per day.
Electricians			8	$2.50 to $3 per day				
Plumbers or fitters								
Drillers			16	$2.25 per day				
Tool dressers			8	$3.25 per day			4	$2.50 per day.
Carpenters								
Fieldmen			4	$3.50 per day				
Mechanics	1	$1.50 per day			1	$2 per day	4	$2 per day.
Laborers	2	$1 per day	39	$1 to $2 per day				
Boys under 16 years								

CLASSIFIED WAGES IN OHIO, BY COUNTIES—Continued.

CLASS OF LABOR.	SANDUSKY.		WILLIAMS.		WOOD.		WYANDOT.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	2		3		83		286	
Bookkeepers					2	$57 per month		
Clerks, male					11	$1 per day	15	$32 to $50 per month.
Clerks, female							1	$50 per month.
Telegraph operators								
Superintendents			1	$2.50 per day				
Foremen or overseers	1	$2 per day			10	$1.60 to $4.83 per day	9	$2.25 to $3 per day.
Electricians								
Plumbers or fitters					6	$1.25 to $2.50 per day		
Drillers					9	$3 to 3.50 per day		
Tool dressers								
Carpenters								
Fieldmen								
Mechanics			1	$2 per day				
Laborers	1	$1.50 per day	1	$1.50 per day	45	$1.50 to $3 per day	260	$1.50 per day.
Boys under 16 years							1	$14 per month.

The total expenditures in 1889 for materials in connection with the natural gas industry in Ohio are given as $5,722,865. For reasons already given, that is, the impossibility of getting at the expenditures at wells that have proved failures, and also the fact that work done by contract in some instances is not included in this table, it will be assumed that the figures given below are not the actual expenditures.

Of the amount $5,722,865 expended for material, $26,019 was expended in building rigs and $66,751 in drilling wells. As 196 wells were drilled in this state in 1889, it is evident that these figures are very much below the actual expenditures. The expense in operating, shutting in, and caring for wells was $44,710; that of building and repairing pipe lines $4,261,054, torpedoes $8,228, and used in fitting $970, and of all other materials $1,315,133.

TOTAL EXPENDITURES FOR MATERIALS DURING 1889, BY COUNTIES.

COUNTIES.	Total.	Building rigs.	Drilling wells.	Operating, shutting in, and caring for wells.	Pipe, couplings, etc., in building and repairing pipe lines.	Used in fitting.	TORPEDOES.		All other materials.
							Number.	Value.	
Total	$5,722,865	$26,019	$66,751	$44,710	$4,261,054	$970	86	$8,228	$1,315,133
Allen	2,500				2,500				
Ashtabula	1,260		650	210	185	200			15
Auglaize	38,860	1,140	1,260	100	35,400		6	960	
Columbiana	1,000	250	250	400	100				
Cuyahoga	380			50	150	150	1	30	
Fairfield	978	500		478					
Guernsey	9,010	2,260	4,200	1,700	200		2	250	400
Hancock	1,117,747	6,345	34,715	9,741	686,567		34	3,295	377,084
Hardin	5,800	650	800	3,500	80	120	5	450	200
Harrison	335				160		2	175	
Henry	175				50		1	125	
Logan	715				580		1	135	
Lorain	2,483	475	1,493	200	300		1	15	
Lucas	405	100					2	205	100
Mercer	2,795,351	450	5,346	400	2,788,855		3	300	
Ottawa	15				15				
Paulding	1,000				1,000				
Sandusky	1,025				1,025				
Seneca	600		600						
Williams	2,766			50	2,716				
Wood	909,929	5,974	8,287	11,636	54,700	500	12	832	828,000
Wyandot	830,531	7,875	9,150	16,245	686,471		16	1,456	109,334

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN OHIO IN 1889.

Below is a condensed statement of the figures regarding the development, production, and consumption of natural gas in Ohio in 1889:

Total amount received for natural gas produced in 1889	$1,120,997
Coal displaced (tons of 2,000 pounds)	1,660,456
Value of same	$5,123,569
Wood displaced (cords)	24,130
Value of same	$92,100

USES.

Total number of fires for cooking and heating	70,050
Total number of iron rolling mills supplied	5
Total number of steel works supplied	5
Total number of glass works supplied	31
Total number of other industrial establishments	278

WELLS.

Number of wells drilling December 31, 1888	4
Number of wells drilling December 31, 1889	10
Number of wells completed in 1889	196
Number of producing wells completed in 1889	180
Number of dry holes completed in 1889	16
Number of wells producing December 31, 1888	287
Number of wells producing December 31, 1889	448
Number of wells abandoned in 1889	38
Total cost of drilling wells, including drive pipe, casing, etc	$331,212
Labor	66,836
Materials	81,778

CAPITAL.

Number of acres of natural gas land:	
Owned	3,712
Leased	108,540
Total	112,252
Total value of land	$3,241,679
Total value of rigs, wells, etc	1,702,051
Total value of pipe lines	6,418,342
Total value of other property and improvements	1,591,678
Total capital invested in lands, wells, etc., and used in the business	12,953,750

LABOR AND WAGES.

Number of foremen or overseers	59
Number of mechanics	97
Number of laborers	757
Number of boys under 16 years	3
Number of office force, males	63
Number of office force, females	4
Total number of employés	983
Wages paid foremen or overseers	$40,702
Wages paid mechanics	32,997
Wages paid laborers	125,938
Wages paid boys under 16 years	438
Wages paid office force, males	40,337
Wages paid office force, females	806
Total wages paid employés	241,218

EXPENDITURES FOR MATERIALS, ETC.

Total amount expended in building rigs	$26,019
Total amount expended in drilling wells	66,751
Total amount expended in operating, shutting in, and caring for wells	44,710
Total amount expended in pipe, couplings, etc., in building or repairing pipe lines	4,261,054
Total amount expended in fitting	970
Total amount expended for torpedoes	8,228
Total amount expended for all other materials	1,315,133
Total expenditures for materials	5,722,865

INDIANA.

It is estimated that at the close of 1889 there were in Indiana about 2,500 square miles of what might be regarded as productive gas territory; that is, territory in which gas had been or probably would be obtained in paying quantities. The largest continuous body of this productive gasterritory is in the eastern central portion of the state, adjoining Ohio, extending from Wabash county on the north to Decatur county on the south, and from Randolph and Jay counties on the east to Howard, Tipton, and Hamilton counties on the west. The upper portion of this body of gas territory is widest, being some 70 miles across, gradually tapering to a point.

Outside of this largest body of gas territory a number of isolated patches have been found.

The accompanying table, prepared by Dr. A. J. Phinney for the American Manufacturer and Iron World, shows the area of the various gas fields in Indiana by counties at the close of 1889. It must be considered, however, as only approximately correct, though it embraces all the territory within which gas had been found in paying quantities. While it is probable that some gas territory can be found outside of the counties named, it is equally true that for every square mile of such outside productive territory there will be found an equal area of unproductive rock within the counties as mapped out.

At the beginning of 1889 a careful study of the field showed some 2,525 square miles of productive territory, arranged by counties as follows:

TABLE SHOWING THE NUMBER OF SQUARE MILES OF PRODUCTIVE GAS TERRITORY IN INDIANA AT THE BEGINNING OF 1889, BY COUNTIES.

	SQUARE MILES.
Blackford	180
Decatur	40
Delaware	350
Grant	350
Hamilton	200
Hancock	200
Henry	90
Howard	160
Jay	150
Madison	440
Marion	70
Miami	20
Randolph	80
Rush	40
Shelby	20
Tipton	120
Wabash	10
Wayne	5
Total	2,525

A small productive area was found in 1889 near Brookville, Franklin county, and another to the southeast of Winchester, Randolph county. Small areas were also discovered at Eagletown and Carmel, in the southwestern part of Hamilton county.

While all of the territory included in the estimate above given is probably productive, it is not all equally so. Rush, Decatur, and Shelby counties contained, with one or two exceptions, only wells of feeble flow. In other localities the production was only moderate, but every county named above has furnished a number of vigorous wells.

The great reservoir of natural gas in Indiana is the Trenton limestone. The chief structural feature of the state is the Cincinnati arch, which, while it does not make itself manifest on the surface, is no less an arch. It is claimed by Dr. Phinney that the portion of the arch in Indiana is the continuation of the main body, while the Findlay arch of Ohio is the smaller fork or branch. This arch is confined to the Trenton limestone and underlying formations. It is from 25 to 50 miles wide on its summit, and its slopes dip gradually away on either side.

As stated, this Cincinnati arch is the reservoir for the gas. The Trenton limestone being higher on this arch than in territory adjacent, the gas has not only found its way into it, but has sought the highest portion that was sufficiently porous to act as a reservoir. Over the greater portion of the arch, where the upper surface of the Trenton limestone lies lower than about 125 feet below sea level, it contains a porous stratum which is usually found near its upper surface at a depth ranging from 4 to 50 feet. This porous stratum is continuous over the whole gas area and over a large area adjacent to it, and where not filled with gas or oil contains salt water. Its thickness varies from 1 to 30 feet. Dr. Phinney thinks it probable that the different portions of the Indiana field are in communication through this porous rock. Professor Orton has shown that the gas-bearing porous stratum of the Trenton limestone is magnesian, while the more compact rock is a carbonate.

It has been noticed that the most vigorous wells are not as a rule found in the higher portion of the field. Wells situated high on the arch are also liable to suffer if drilled too deep or if the drill is sunk too deep into the Trenton rock before torpedoing the well.

PRODUCTION.

The total amount received for natural gas produced in Indiana in 1889 was $1,362,472, as returned on the various schedules. The total amount of coal displaced by this gas was 716,461 tons, valued at $2,002,762. There were also 44,888 cords of wood displaced, valued at $72,940. This would make the total value of natural gas, estimated by fuel displacement, $2,075,702. It has been more difficult to arrive at the value of natural gas in Indiana than in any other state. Much of the gas was used in industrial establishments, which either received it free or at a nominal rate, and it has been almost impossible for parties using it to estimate the amount of fuel displaced. As stated elsewhere, the above figures can only be regarded as the best approximation under the circumstances.

PRODUCTION OF NATURAL GAS IN INDIANA IN 1889, BY COUNTIES.

COUNTIES.	Value of natural gas supplied and used.	COAL DISPLACED.		WOOD DISPLACED.	
		Tons.	Value.	Tons.	Value.
Total	$1,362,472	716,461	$2,002,762	44,888	$72,940
Bartholomew	35	7	35	.....	.....
Blackford	88,881	59,075	240,610	600	1,200
Dearborn	50	15	50	.....	.....
Decatur	11,350	4,722	18,269	463	1,130
Dekalb	2,250	750	2,250	.....	.....
Delaware	129,415	159,348	228,762	3,340	5,100
Grant	142,859	77,009	221,655	7,500	14,800
Hamilton	17,754	11,345	27,317	1,600	4,000
Hancock	18,484	15,000	45,606	3,350	6,787
Henry	97,909	42,592	143,276	5,020	9,745
Howard	82,055	54,352	162,101	1,760	2,135
Jay	39,700	23,000	110,000	400	600
Jennings	250	75	300	.....	.....
Madison	592,614	198,535	556,708	18,355	22,443
Marion	10,630	3,320	10,630	.....	.....
Miami	9,250	5,600	19,600	.....	.....
Randolph	15,748	8,561	25,030	2,500	5,000
Rush	10,209	4,707	14,238	.....	.....
Shelby	300	80	300	.....	.....
Tipton	55,955	32,250	98,825	.....	.....
Wabash	30,884	13,956	69,000	.....	.....
Washington	150	50	150	.....	.....
Wayne	5,740	2,112	8,050	.....	.....

USES.

The reports show that 109,015 heating and cooking fires, 6 iron rolling mills, 11 glass works, 1 gas company, and 439 other industrial establishments consumed natural gas in 1889 in Indiana. No gas is reported as having been used in Carroll and Harrison counties.

USES TO WHICH NATURAL GAS PRODUCED IN INDIANA IN 1889 WAS PUT.

COUNTIES.	Fires for cooking and heating.	Iron rolling mills.	Glass works.	Gas companies.	Other industrial establishments.
Total	109,015	6	11	1	439
Bartholomew	3				
Blackford	6,342				40
Dearborn	1				1
Decatur	1,133				
Dekalb	150				1
Delaware	10,040	1	2		43
Grant	9,592		4		99
Hamilton	2,056				10
Hancock	4,863				12
Henry	7,407	5			19
Howard	7,520				31
Jay	3,087		1		15
Jennings	20				
Madison	41,784		4		85
Marion	953				
Miami	940				14
Randolph	1,256			1	7
Rush	670				1
Shelby					1
Tipton	8,207				52
Wabash	2,602				16
Washington	10				
Wayne	379				1

WELLS.

The total number of wells completed in Indiana during 1889, as reported in schedules received, was 307, of which 293 were producing and 14 dry holes. It will be noticed from the table given below that the largest number was drilled in Madison county, which is the most productive natural gas territory in Indiana, it having produced almost one-half of all the gas in the state.

WELL RECORD, BY COUNTIES.

COUNTIES.	DRILLING WELLS.		WELLS COMPLETED IN 1889.			NUMBER OF WELLS PRODUCING.		Number abandoned in 1889.	Total cost of drilling wells, including drive pipe, casing, etc.	DETAIL OF COST.	
	December 31, 1888.	December 31, 1889.	Total.	Producing.	Dry holes.	December 31, 1888.	December 31, 1889.			Labor.	Materials.
Total	20	39	307	293	14	287	576	17	$431,535	$34,028	$39,582
Bartholomew			1	1		1	2		1,000	(a)	
Blackford		1	26	26		4	30		33,325	(a)	
Carroll		1	2	2			2	2	4,223	4,011	212
Dearborn						6	5	1			
Decatur		1	10	10		29	39		11,787	1,600	1,490
Dekalb			1	1		2	3		2,250	(a)	
Delaware		5	41	41		29	70		57,767	1,016	3,220
Grant	2	1	19	18	1	32	50		22,870	(a)	
Hamilton	2	2	7	7		15	22		11,015	2,020	3,850
Hancock	2		15	15		7	21	1	26,285	(a)	
Harrison		1	7	5	2		4	1	11,007	7,500	3,507
Henry	5	3	24	22	2	15	41		37,750	(a)	
Howard		3	21	19	2	22	39	2	31,575	4,500	11,500
Jay		1	8	8		14	20	2	11,450	600	400
Jennings			3	3			3		4,500	(a)	
Madison	8	11	61	61		55	116	6	90,350	1,600	550
Marion						10	10				
Miami			2	2		3	5		2,100	(a)	
Randolph		1	19	14	5	10	24		24,275	2,981	5,445
Rush		3	14	13	1	7	20		16,075	5,100	4,500
Shelby		1	1	1			1		900	(a)	
Tipton	1	3	15	15		7	22		22,608	1,600	2,000
Wabash			8	7	1	8	14	2	6,918	1,500	3,018
Washington						5	5				
Wayne		1	2	2		6	8		1,505	(a)	

a Contract.

The total number of producing wells in Indiana at the close of 1888 was 287, and 576 at the close of 1889, 17 having been abandoned.

The total cost of completing the 307 wells which were drilled in Indiana during 1889 was $431,535, as reported, $34,028 having been expended for labor and $39,582 for materials, no report having been made of work done by contract.

In the following table is given the number of wells producing in Indiana at the close of December, 1888, and at the close of each month during 1889, together with the number of wells abandoned during 1889:

PRODUCING WELLS.

MONTHS.	Total number producing.	Total number abandoned.
1888.		
December 31	287	4
1889.		
January 31	316	.....
February 28	330	1
March 31	344	2
April 30	358	1
May 31	371	1
June 30	399	.....
July 31	426	.....
August 31	451	.....
September 30	472	4
October 31	501	.....
November 30	535	2
December 31	576	2

The following table is a statement of the number of wells completed during each month of 1889 in Indiana also the number of the same that were productive and the number of dry holes:

WELLS COMPLETED IN INDIANA IN 1889.

MONTHS.	Total number of wells completed in each month.	Number of wells producing.	Number of dry holes.
Total	307	293	14
January	29	28	1
February	14	14	.....
March	18	17	1
April	14	14	.....
May	17	15	2
June	24	24	.....
July	28	27	1
August	27	25	2
September	29	27	2
October	26	25	1
November	35	34	1
December	46	43	3

CAPITAL.

The total capital employed in the production of natural gas in Indiana in 1889 was $8,205,813, of which $1,090,218 represented the total value of land and $7,115,595 the value of other property. For the value and credence to be given these figures reference is to be had to the general discussion on the subject of capital in the early part of this report.

LABOR AND WAGES.

The number of employés engaged in the production, transportation, and distribution of natural gas in 1889 in Indiana was 2,007, who received $341,851 in wages. The amount received per man per year, on the supposition that each man employed worked the whole year, is very small, about $170; but it must be remembered that a great many persons were employed only for a brief period, as in laying pipe and drilling wells. Indeed, the number of persons necessary to be employed the whole time in the natural gas industry is very small, the chief work being in connection with drilling wells and laying pipe line. When this is done the chief labor is over.

CAPITAL INVESTED IN THE NATURAL GAS INDUSTRY IN INDIANA IN 1889.

COUNTIES.	Total capital.	NUMBER ACRES OF NATURAL GAS LAND.				VALUE OF PLANT.		
		Total acreage.	Owned.	Leased.	Value.	Land.	Rigs, etc.	Pipe lines.
Total	$8,205,813	77,493	12,294	65,199	$1,090,218	$1,396,949	$4,792,548	$926,698
Bartholomew	2,288				25	1,598	165	500
Blackford	1,479,595	9,139	137	9,002	171,045	40,575	1,222,775	45,200
Carroll	7,585					4,223	3,149	213
Dearborn	7,800	60		60	325	2,200	275	5,000
Decatur	85,530	387	202	185	7,805	54,774	20,021	2,920
Dekalb	28,000	31	31		4,500	8,500	5,000	10,000
Delaware	716,123	4,180	4,092	88	185,001	346,035	176,408	8,679
Grant	667,241	7,939	596	7,343	47,020	316,212	296,959	7,050
Hamilton	97,170	323	321	2	16,805	32,065	46,300	2,000
Hancock	131,660	122	20	102	3,832	37,288	51,290	39,250
Harrison	15,500	8,800		8,800	2,000	8,000		5,500
Henry	211,398	838	231	607	47,975	72,850	74,119	16,454
Howard	1,229,699	5,178	162	5,016	339,070	106,040	215,734	568,855
Jay	235,400	1,431	1	1,430	5,800	36,800	150,900	41,900
Jennings	7,000				500	4,500	2,000	
Madison	2,037,664	22,176	5,971	16,205	54,150	143,224	1,744,733	95,557
Marion	63,506				30,000	13,506		20,000
Miami	59,500	603	341	262	33,100	8,400	13,000	5,000
Randolph	85,773	431	49	382	4,560	34,600	38,340	8,273
Rush	46,595	138	137	1	1,695	30,754	12,154	1,995
Shelby	1,500					900	500	100
Tipton	678,034	9,713	1	9,712	84,780	45,300	525,199	22,755
Wabash	284,452	6,000		6,000	50,000	38,000	188,452	8,000
Washington	6,000					6,000		
Wayne	20,800	4	2	2	230	4,605	5,065	10,900

LABOR AND WAGES, BY COUNTIES.

COUNTIES.	TOTAL.		FOREMEN OR OVERSEERS.		MECHANICS.		LABORERS.		BOYS UNDER 16 YEARS.		OFFICE.			
											Males.		Females.	
	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.
Total	2,007	$341,851	153	$58,865	324	$97,091	1,408	$134,388	2	$160	115	$49,287	5	$2,060
Bartholomew														
Blackford	123	5,467	16	488	17	580	79	2,605			8	1,794		
Carroll														
Dearborn														
Decatur	16	1,170	3	340	1	90	8	615			4	125		
Dekalb	2	2,000	1	1,700							1	300		
Delaware	120	13,565	12	1,444	22	3,869	76	5,982			9	1,770	1	500
Grant	418	49,523	6	5,741	25	9,072	379	28,786			8	5,924		
Hamilton	59	3,316	10	1,309	9	970	29	490			11	547		
Hancock	102	4,467	7	1,005	4	60	79	2,567			12	835		
Harrison														
Henry	92	4,920	13	1,124	6	290	71	3,098			2	408		
Howard	159	36,636	7	4,130	13	3,816	125	20,490	2	160	10	7,320	2	720
Jay	45	7,913	5	1,778	5	1,390	30	2,145			5	2,600		
Jennings	6	600	2	250			4	350						
Madison	219	90,203	24	12,867	68	40,186	102	15,129			24	21,541	1	480
Marion														
Miami	26	3,925	4	860	7	1,560	14	1,105			1	400		
Randolph	68	3,685	3	820	21	1,920	40	475			3	110	1	360
Rush	57	4,843	3	160	17	3,560	29	825			8	298		
Shelby														
Tipton	456	100,451	33	21,909	102	26,524	316	48,046			5	3,372		
Wabash	38	8,477	3	2,700	6	3,004	27	1,080			2	1,693		
Washington														
Wayne	4	690	1	240	1	200					2	250		

In the following table is a more detailed classification of labor employed in Indiana in the natural gas industry in 1889 than that given in the preceding one:

CLASSIFIED WAGES IN INDIANA, BY COUNTIES.

CLASS OF LABOR.	Total.	BLACKFORD.		DECATUR.		DEKALB.	
		Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	2,007	120		16		2	
Treasurers	1						
Bookkeepers	80	2	$38.33⅓ per month	4	$50 per month	1	
Clerks, male	41	6					
Superintendents	29						
Foremen or overseers	121	16	$55 to $60 per month	3	$3 per day	1	
Inspectors	5						
Station agents	10						
Engineers	6						
Plumbers or fitters	160			1	$3 per day		
Drillers	38						
Carpenters	5						
Teamsters	10						
Linemen	33						
Mechanics	92	17	$1.50 per day				
Laborers	1,374	79		8	$1.25 to $1.59 per day		
Boys under 16 years	2						

CLASS OF LABOR.	DELAWARE.		GRANT.		HAMILTON.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	120		418		59	
Treasurers						
Bookkeepers	2	$3 per day	5	$41 to $147 per month	11	$3.50 per day.
Clerks, male	5	$1.50 to $2 per day	2	$2 per day		
Superintendents	5	$1.50 to $5 per day	3	$75 to $100 per month		
Foremen or overseers	6	$2 to $2.75 per day	4	$2 per day	10	$1 per day.
Inspectors						
Station agents						
Engineers	2	$3.50 per day	1	$200 per month		
Plumbers or fitters	7	$1.25 to $2.50				
Drillers	9	$1,236 (a)	4	$3.50 per day		
Carpenters	3	$1.50 to $2.50 per day				
Teamsters						
Linemen	4	$1.50 per day				
Mechanics	6	$1 to $3.50 per day	21	$2 to $3.50 per day	9	$1.50 to $3 per day.
Laborers	71	$1 to $2.50 per day	378	$1 to $2 per day	29	$1 to $1.25 per day.
Boys under 16 years						

CLASS OF LABOR.	HANCOCK.		HENRY.		HOWARD.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	102		92		159	
Treasurers						
Bookkeepers	12	$2 per day	2	$2 per day	11	$2.50 per day.
Clerks, male						
Superintendents						
Foremen or overseers	7	$1.50 to $2 per day	13	$1.50 to $2.50 per day	8	$1 to $3.50 per day.
Inspectors						
Station agents						
Engineers						
Plumbers or fitters						
Drillers						
Carpenters						
Teamsters						
Linemen						
Mechanics	4	$2 to $2.50 per day	6	$1.25 to $2 per day	13	$1.50 to $1.75 per day.
Laborers	79	$1.25 to $1.50 per day	71	$1 to $2 per day	125	$1.25 to $1.50 per day.
Boys under 16 years					2	$0.38 per day.

a Contract.

CLASSIFIED WAGES IN INDIANA, BY COUNTIES—Continued.

CLASS OF LABOR.	JAY.		JENNINGS.		MADISON.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	45		6		219	
Treasurers						
Bookkeepers	5	$50 per month			9	$118 to $200 per month.
Clerks, male					26	$25 to $250 per month.
Superintendents	1	$3 per day			12	$2 per day.
Foremen or overseers	4	$2 to $3.50 per day	2	$2.50 per day	11	$2 to $3 per day.
Inspectors					5	
Station agents					10	
Engineers						
Plumbers or fitters	3	$1.25 to $2 per day			22	$1.50 to $2.50 per day
Drillers						
Carpenters	1	$1.50 per day			1	$2.50 per day.
Teamsters						
Linemen					10	
Mechanics					1	
Laborers	31	$1 to $1.75 per day	4	$1.25 per day	112	
Boys under 16 years						

CLASS OF LABOR.	MIAMI.		RANDOLPH.		RUSH.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	26		68		57	
Treasurers						
Bookkeepers	1	$33.33⅓ per month	4	$30 per month	6	$2 to $3 per day.
Clerks, male					2	$1 per day.
Superintendents					1	$2 per day.
Foremen or overseers	4	$3.33⅓ per day	3	$1.25 to $4 per day		
Inspectors						
Station agents						
Engineers					3	$1.50 to $2 per day.
Plumbers or fitters						
Drillers			2	$2 per day	12	$3 to $4 per day.
Carpenters						
Teamsters						
Linemen			19	$1.25 to $1.37 per day		
Mechanics	8	$1.25 to $2.66⅔ per day			4	$1.50 to $4.50 per day.
Laborers	13	$1.50 to $2 per day	40	$1.25 per day	29	$1.25 per day.
Boys under 16 years						

CLASS OF LABOR.	TIPTON.		WABASH.		WAYNE.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	456		38		4	
Treasurers					1	
Bookkeepers	2	$75 to $100 per month	2	$70 to $105 per month	1	
Clerks, male						
Superintendents	6	$3 per day	1	$125 per month		
Foremen or overseers	26	$2.25 per day	2	$25 to $75 per month	1	$20 per month.
Inspectors						
Station agents						
Engineers						
Plumbers or fitters	127	$2 per day				
Drillers	7	$2.83 per day	4	$3 per day		
Carpenters						
Teamsters	10	$3 per day				
Linemen						
Mechanics			2	$2.50 per day	1	$2 per day.
Laborers	278	$1.25 per day	27	$1.50 per day		
Boys under 16 years						

MATERIALS USED.

The total expenditure for materials in the production and distribution of natural gas in Indiana during 1889 was $1,921,072, of which $3,800 was spent in building rigs, $42,710 in drilling wells, $38,712 in operating, shutting in, and caring for wells, $1,761,203 in pipe lines, $40,190 in fitting, $10,275 for torpedoes, and $24,182 for all other materials.

The amount of wages paid in Indiana in connection with the natural gas industry in 1889 was $341,851, and the amount paid for materials $1,921,072, making a total of $2,262,923. The value of natural gas used in Indiana in 1889, measured by fuel displacement as given above, was $2,075,702. This would indicate a loss of $187,221 as measured by fuel displacement, and $900,451 as measured by the value of natural gas supplied. It is probable that, taking the whole operations of the state together, the loss was as great as this, but was more than compensated to the state by the bringing in of new industries.

TOTAL EXPENDITURES FOR MATERIALS DURING 1889, BY COUNTIES.

COUNTIES.	Total.	Building rigs.	Drilling wells.	Operating, shutting in, and caring for wells.	Pipe, couplings, etc., in building and repairing pipe line.	Used in fitting.	TORPEDOES.		All other materials.
							Number.	Value.	
Total	$1,921,072	$3,800	$42,710	$38,712	$1,761,203	$40,190	82	$10,275	$24,182
Bartholomew	98			98					
Blackford	1,212,381				1,210,506	1,000	3	375	500
Carroll	462						1	250	212
Dearborn	130						1	130	
Decatur	11,861	750	850	1,975	2,211	625	13	1,790	3,660
Dekalb	120						1	120	
Delaware	69,607	250	23,800	3,132	29,451	4,793	7	917	7,324
Grant	55,597			485	48,200	6,112			800
Hamilton	11,072	300	2,100	1,225	7,222	200			25
Hancock	33,726		650	225	31,871	275	4	505	200
Harrison	100						2	100	
Henry	38,303				33,778		7	825	3,700
Howard	52,969	1,650	1,500	18,663	27,416	2,990	6	750	
Jay	13,660	100	600	500	8,700	3,250	5	510	
Jennings	125						1	125	
Madison	345,041		1,000	3,867	324,393	15,155	1	100	526
Miami	13,750			150	13,000	600			
Randolph	24,781		1,675	5,947	14,859		15	2,275	25
Rush	8,359			1,845	4,469		10	1,045	1,000
Shelby	50						1	50	
Tipton	14,677			100	3,462	5,015			6,100
Wabash	13,310	750	10,535	500	1,200	75	2	150	100
Wayne	833				465	100	2	258	10

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN INDIANA IN 1889.

Below is a condensed statement of the figures regarding the development, production, and consumption of natural gas in Indiana in 1889:

Total amount received for natural gas produced in 1889	$1,362,472
Coal displaced (tons of 2,000 pounds)	716,461
Value of same	$2,002,762
Wood displaced (cords)	44,888
Value of same	$72,940

USES.

Total number of fires for cooking and heating	109,015
Total number of iron rolling mills supplied	6
Total number of glass works supplied	11
Total number of gas companies supplied	1
Total number of other industrial establishments supplied	439

WELLS.

Number of wells drilling December 31, 1888	20
Number of wells drilling December 31, 1889	39
Number of wells completed in 1889	307
Producing wells completed in 1889	293
Dry holes completed in 1889	14
Number of wells producing December 31, 1888	287
Number of wells producing December 31, 1889	576
Number of wells abandoned in 1889	17
Total cost of drilling wells, including drive pipes, casing, etc	$431,535
Labor	$34,028
Materials	$39,582

CAPITAL.

Number of acres of natural gas land:	
Owned	12,294
Leased	65,199
Total	77,493
Value of land	$1,090,218
Value of rigs, wells, etc	1,396,949
Value of pipe lines	4,792,548
Value of other property and improvements	926,098
Total capital invested in lands, wells, etc., and used in the business	8,205,813

LABOR AND WAGES.

Number of foremen or overseers	153
Number of mechanics	324
Number of laborers	1,408
Number of boys under 16 years	2
Number of office force, males	115
Number of office force, females	5
Total number of employés	2,007
Wages paid foremen or overseers	$58,865
Wages paid mechanics	97,091
Wages paid laborers	134,388
Wages paid boys under 16 years	160
Wages paid office force, males	49,287
Wages paid office force, females	2,060
Total wages paid employés	341,851

EXPENDITURES FOR MATERIALS, ETC.

Total amount expended in building rigs	$3,800
Total amount expended in drilling wells	42,710
Total amount expended in operating, shutting in, and caring for wells	38,712
Total amount expended in pipe, couplings, etc., in building and repairing pipe lines	1,761,203
Total amount expended in fitting	40,190
Total amount expended for torpedoes	10,275
Total amount expended for all other materials	24,182
Total expenditures for materials	1,921,072

NEW YORK.

The first use of natural gas in this state in an economic way was, as is stated under "History of the use of natural gas in the United States", on page 507, for lighting the streets of Fredonia, New York. Gas was obtained and used for this purpose as early as 1821.

In 1823 Professor Eaton measured the product of a gas spring immediately west of the village of Vernon, Oneida county. Dr. P. Hays, in the New York Medical and Physical Journal, some time prior to 1842 gives an account of inflammable springs in Oneida county, and in 1839 Professor Hall, in a New York geological report, describes the occurrence of gas at Manchester, on the east side of Onondaga lake, the gas issuing from clefts in the rock. At Gasport, on the Erie canal, in Niagara county, about 6 miles east of Lockport, Professor Eaton prior to 1842 describes the occurrence of gas springs.

Along the shore of Lake Erie, in the vicinity of Westfield, Chautauqua county, gas was found and utilized as early as 1826. The gas issued along the bed of a creek in a small ravine about 1.5 miles north of the village, 1 mile

east of the harbor, and not over 900 feet from the lake shore. In a report published in 1856 regarding this well it is said:

> The flow is perfectly uniform during summer and winter, and the gas is equal if not superior to the best quality of manufactured gas, burning with a bright, pleasant flame, free from odor or smoke. An application to the government of the United States for a contract to supply the lighthouse at the harbor called Barcelona with this gas was accepted, and in 1828 or 1829 the works necessary for carrying out the project were erected.
>
> The means used for collecting and conducting the gas to the lighthouse (over 1 mile from the spring) were of the rudest and most imperfect kind, the gasometer being formed of the half of a fish barrel inverted over a portion of the spring and the mains consisting of small pump logs running to the base of the lighthouse, from which the gas was conveyed to the summit by an ordinary lead pipe, supplying, without the aid of accumulation or artificial pressure or other mechanical means save the force of the natural flow, nearly double the amount of gas required for the consumption of 140 6-foot burners, furnishing a bright, steady, unfailing light for lighthouse purposes, a light pronounced by all to be the best light on Lake Erie, for a period of over 26 years.
>
> The only improvement that has ever been made in these works has been that of substituting a lead pipe three-quarters of an inch in diameter when the logs had become so much decayed as to be unfit for use. The gasometer remains the same.

It is further reported that a company was formed for utilizing this gas. Pipes were laid and 3,000 gas-burners used. This gas is still used in a very small way.

The most important gas district in New York, in fact the only one which has been drawn upon for the distribution of gas generally to consumers, is that in Allegany county. This area corresponds closely to the Allegany oil district. While many of the oil wells of this district produce gas in greater or less amounts, the principal gas wells have been found along the fringe and a little beyond the boundary of the oil-producing territory. At one time in this district of the 102 wells owned by the Empire Gas and Fuel Company, limited, 73 produced oil, 4 oil and gas combined, and 25 gas alone.

The geological horizon of the Allegany oil and gas sand, or what is commonly and locally known as the Richburg sand, is without doubt the same as that of the main producing oil and gas sand of the Bradford region. The top of this sand is undulating, and in many localities has excessive dips, in one case as much as 160 feet to the mile, while the greatest observed dip in this sand in the Bradford region proper is 18 feet.

The character of the sand in Allegany is such that, while beyond doubt the supply of gas will be gradually exhausted, no sudden cessation of production will occur. The decline will be more gradual than that of other gas districts which draw their gas supplies from coarser and more open gas rocks. One report from a company producing a large amount of gas states that the decline in pressure in the last 6 years has been 75 per cent and very gradual. In the vicinity of Ceres the wells lost 33.33 per cent in pressure in 2 years. At wells in the vicinity of Wellsville and Bolivar 2 initial pressures are reported, 350 and 100 pounds. In a year the pressure of the former was reduced to 200 pounds and of the weaker to 80 pounds. The depth of gas wells in this district is from 1,000 to 1,500 feet.

Some of the gas from the Allegany district is piped to Buffalo, but most of it is used locally. A large amount of it is consumed in drilling oil wells and at the pipe-line stations in pumping oil. In drilling wells it is customary to pay so much per foot drilled for the supply of gas used as fuel under the boilers. From 8 to 10 cents a foot seems to be the average price for a 1,450-foot well, which would be $116.

Adjoining Allegany county on the east is Steuben and on the west Cattaraugus, while directly west of Cattaraugus is Chautauqua. All of these counties are on the Pennsylvania line. The portion of New York due north of Cattaraugus county and between it and Lake Ontario is covered by Erie and Niagara counties. In all of these counties some gas has been found. Steuben county produces a little shallow gas, but the district gives no indications that it will ever become a large producer.

The Fredonia wells are in Chautauqua county, and are of but little importance except historically. The production of gas is only about 4,500 cubic feet a day.

Little or no gas is produced in Cattaraugus county, the gas used at Salamanca being supplied by the United Natural Gas Company, whose supply comes from Allegany county, New York, and McKean, Potter, and Butler counties, Pennsylvania. The displacement of coal by this gas in 1889 was 11,650 tons, worth $150,000.

In Erie county a number of gas wells were drilled in 1889, but few were able to supply even the demands of their owners for fuel.

The chief source of supply of gas for Buffalo, as also for Cattaraugus county, is from the lines of the United Natural Gas Company, which draw their supplies largely from Pennsylvania.

At North Tonawanda, in Niagara county, a local company was formed in 1888 for the purpose of ascertaining if gas could be found in paying quantities. A well was drilled to a depth of 3,009 feet at North Tonawanda which produced a small amount. Another well was drilled to a depth of 565 feet, the gas from which was piped to the proprietor's residence and used by him for heating purposes. A third well was drilled to 575 feet, the production of which was also temporarily ample for a residence. None of the ventures proving sufficiently productive, further developments were discontinued.

At Sandy Creek, Oswego county, a local company drilled 2 wells in 1889, consumers being supplied in December, 1889, for the first time.

At West Bloomfield, Ontario county, 14 wells were drilled in 1889. These wells range from 400 to 500 feet in depth and terminate in Hamilton shale. During 1890 one of the oldest wells was drilled through to 800 feet, when the pressure was increased to 300 pounds. The gas obtained is a sulphur gas, with no indications of petroleum. The initial pressure of all wells, excepting 2, was less than 25 pounds. In one case it was 118 and in another 212 pounds to the square inch. It was contemplated to continue drilling the 1890 well deeper, with the hope of finding a still more productive sand.

PRODUCTION OF NATURAL GAS IN NEW YORK IN 1889.

In the following table will be found a statement as to the total production of natural gas in New York in 1889. The reported value of the gas produced in this state, counting as value the amount of money received for it, was $204,325. The amount of coal displaced, however, was 130,159 tons, valued at $530,026. This latter is therefore regarded as the value of the gas consumed in New York in 1889. As stated elsewhere, the chief production of natural gas in New York was in Allegany county, the value of gas produced in this county, measured by fuel displacement, being $504,288, the value of gas produced in all the other counties of the state being but $25,738.

Considerable of the natural gas produced in Allegany county was used in drilling oil and other gas wells, and another large amount at oil pumping stations. This is not reported in the total of fuel displacement, but its value is included in the amount estimated as used in pumping oil and drilling and operating wells given under the general discussion of the question of "Production in the United States".

PRODUCTION OF NATURAL GAS IN NEW YORK IN 1889, BY COUNTIES.

COUNTIES.	Total value.	COAL DISPLACED.	
		Tons.	Value.
Total	$204,325	130,159	$530,026
Allegany	185,261	124,907	504,288
Chautauqua	2,500	.....	.....
Erie	7,179	2,178	11,519
Niagara	450	124	619
Ontario	6,186	1,800	8,100
Oswego	500	150	750
Steuben	2,249	1,000	4,750

USES.

The uses to which natural gas produced in New York in 1889 was put are shown in the following table. From this it will appear that most of the gas consumed was in heating and cooking fires; no iron mills or glass works were supplied, and only 11 industrial establishments.

USES TO WHICH NATURAL GAS PRODUCED IN NEW YORK IN 1889 WAS PUT.

COUNTIES.	Fires for cooking and heating.	Industrial establishments.
Total	4,362	11
Allegany	3,392	5
Chautauqua	30	.....
Erie	240	2
Niagara	12	1
Ontario	288	1
Oswego	150	2
Steuben	250	.....

WELLS.

The total number of wells in New York producing natural gas at the close of 1889 was 119, as compared with 69 at the beginning of the year. The number of wells completed in 1889 was 65, of which 55 were producing and 10 were dry holes. During the year 3 wells were abandoned. The total cost of drilling these wells, as reported, was $74,752. The amount paid by the producers for labor in drilling wells, not including any sums paid to contractors, who drilled by the foot, was $23,604. The amount paid for materials under the same circumstances was $14,256.

WELL RECORD, BY COUNTIES.

COUNTIES.	DRILLING WELLS.		WELLS COMPLETED IN 1889.			NUMBER OF WELLS PRODUCING.		Number abandoned in 1889.	Total cost of drilling wells, including drill pipe, casing, etc.	DETAIL OF COST.	
	December 31, 1888.	December 31, 1889.	Total.	Producing.	Dry holes.	December 31, 1888.	December 31, 1889.			Labor.	Materials.
Total	*a*5	12	65	55	10	69	119	3	$74,752	$23,604	$14,256
Allegany		1	18	16	2	51	63	1	16,869	3,600	5,517
Chautauqua						5	5				
Erie		9	16	16		6	22	1	28,600	2,500	500
Fulton		1	1	1			1				
Lewis			1		1				1,550	1,050	500
Niagara			4	4		1	5		11,200	6,600	1,000
Ontario			14	12	2	6	18		4,812	2,154	2,658
Oswego			2	2			2		3,000	2,200	800
Steuben		1	9	4	5		3	1	8,781	5,500	3,281

a Data by counties not obtainable.

In the following table is shown the number of wells completed in each month during 1889, together with the number of dry holes and the number of completed wells that were producing:

WELLS COMPLETED IN NEW YORK IN 1889.

MONTHS.	Total number of wells completed in each month.	Number of dry holes.	Number of wells producing.
Total	65	10	55
January	5		5
February	2	1	1
March	4	1	3
April	4	3	1
May	2	1	1
June	5	1	4
July	11	1	10
August	5	1	4
September	8	1	7
October	3		3
November	5		5
December	11		11

In the following table is given the number of producing wells at the close of each month from the close of 1888 to the close of 1889. This number gradually increased from the close of 1888, when it was 69, to the close of 1889, when it was 119. The table also shows the total number of wells abandoned, which was 3.

WELLS PRODUCING IN NEW YORK IN 1889.

MONTHS.	Total number producing.	Total number abandoned.
1888.		
December 31	69	1
1889.		
January 31	74	1
February 28	73	1
March 31	76	
April 30	77	
May 31	75	
June 30	79	
July 31	89	
August 31	93	
September 30	100	
October 31	103	
November 30	108	
December 31	119	

CAPITAL.

The total capital employed in the development, production, and transportation of natural gas in the state of New York in 1889 was $1,162,429. Of this amount $298,120 represented the value of the land and $864,309 the value of all other property.

The largest value of land in any one county it will be noted is in Ontario, where it is given as $132,000, while the value of land in Allegany county, where the production of gas was very much greater, is given as $68,720. This comes from the fact that the value of the 18 producing wells that belonged to the single company operating in Ontario county is included in the value of the lease. Assuming that these wells were worth $2,500 apiece, the total value of land in this state would be reduced by $45,000 and the value of rigs, wells, etc., increased by the same amount, though there would be no difference in the totals. With this change in the reported values of the land the same remark that has been made elsewhere regarding it will apply here. This value is very much underestimated, that given being probably only the amount of money paid for the lease and not the worth of the land as producing territory.

The total value of the rigs, wells, etc., as given in the schedules received, was $169,753, to which should be added $45,000, assumed as the value of wells in Ontario county, which is included in the column of the value of land. This would make the total value of wells, rigs, etc., $214,753. As there were 119 wells in this state at the close of 1889, the value of each well would be $1,805. While this is probably an underestimate, it is nevertheless true that the average value of gas wells is not so great as that of oil wells. The reasons will be obvious. Among other reasons, gas is a commodity that is used as produced; it can not be stored; it is an expensive product to transport to points of consumption, and its value at point of consumption is not great, while the life of the well, its production, decreases very rapidly and the territory is sooner exhausted than an oil territory of equal extent. The total value of pipe lines in this state, including rights of way, was $580,519. As there were 1,783,069 feet of pipe line in this state at the close of 1889, it would make the value per foot laid, including royalty, only 33 cents, which is evidently an underestimate, unless the value of the pipe in the ground is regarded as very much less than the actual cost. It is probable that this is the view taken.

CAPITAL INVESTED IN THE NATURAL GAS INDUSTRY IN NEW YORK IN 1889.

COUNTIES.	Total capital.	NUMBER OF ACRES OF NATURAL GAS LAND.				VALUE OF PLANT.		
		Total acreage.	Owned.	Leased.	Value.	Rigs, wells, etc.	Pipe lines.	Other property.
Total	$1,162,429	49,870	533	49,337	$298,120	$169,753	$580,519	$114,037
Allegany	713,085	3,688	15	3,673	68,720	64,903	475,925	103,537
Chautauqua	17,500	.....	.....	.....	1,200	11,300	3,000	2,000
Erie	169,600	371	371	.....	51,300	56,800	56,500	5,000
Fulton	9,500	50	50	.....	500	7,959	50	1,000
Lewis	5,000	4,864	.....	4,864	4,400	600	.....	.....
Niagara	19,650	300	.....	300	12,000	7,200	450	.....
Ontario	154,594	25,097	97	25,000	132,000	.....	22,594	.....
Oswego	20,500	5,000	.....	5,000	13,000	3,000	4,000	500
Steuben	53,000	10,500	.....	10,500	15,000	18,000	18,000	2,000

LABOR AND WAGES.

The total number of employés engaged in the natural gas industry in New York in 1889 was 357, to whom $34,235 was paid in wages. The remarks made heretofore regarding the value of these statistics must be borne in mind when studying them. A great deal of labor employed in contract work is not included in this table, this labor being that employed directly by the producers of natural gas and paid by them.

LABOR AND WAGES, BY COUNTIES.

COUNTIES.	TOTAL.		FOREMEN OR OVERSEERS.		MECHANICS.		LABORERS.		OFFICE.			
									Males.		Females.	
	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.	Number.	Wages.
Total	357	$34,235	11	$4,152	37	$4,443	296	$17,687	12	$7,868	1	$85
Allegany	116	18,498	4	2,730	14	1,082	92	10,054	6	4,632	.....	.....
Chautauqua	2	1,096	.....	.....	.....	.....	2	1,096	.....	.....	.....	.....
Erie	66	3,309	1	150	4	600	60	2,439	1	120	.....	.....
Lewis	8	3,322	1	50	4	1,001	.....	.....	2	2,186	1	85
Ontario	62	3,460	1	772	2	110	58	2,098	1	480	.....	.....
Oswego	76	2,050	3	300	12	1,200	60	500	1	50	.....	.....
Steuben	27	2,500	1	150	1	450	24	1,500	1	400	.....	.....

In the following table will be found a statement of the number of employés, range of wages, etc., giving the classes of labor more in detail:

CLASSIFIED WAGES IN NEW YORK, BY COUNTIES.

CLASS OF LABOR.	Total.	ALLEGANY.		CHAUTAUQUA.		ERIE.	
		Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	357	116		2		66	
Secretaries	7	2	$75 to $90 per month				
Clerks, male	4	3	$55 per month			1	$60 per month.
Clerks, female	1						
Telegraph operators	3	3	$2 per day				
Superintendents	5	5	$2 to $3.25 per day				
Foremen or overseers	10	3	$50 to $75 per month			1	$75 per month.
Agents	1	1	$90 per month				
Engineers	2						
Drillers	10						
Men at well	3						
Teamsters	13						
Linemen	3	3	$2 per day				
Watchmen	5	5	$2 per day				
Mechanics	33	14	$3 to $3.75 per day			4	$2.50 per day.
Laborers	257	77	$1.50 to $1.65 per day	2	$1.75 per day	60	$1.50 per day.

CLASS OF LABOR.	LEWIS.		ONTARIO.		OSWEGO.		STEUBEN.	
	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.	Number.	Range of wages.
Total	8		62		76		27	
Secretaries	2	$95 per month	1	$40 per month	1	$2.50 per day	1	$33.33⅓ per month.
Clerks, male								
Clerks, female	1	$45.50 per month						
Telegraph operators								
Superintendents								
Foremen or overseers	1	$1 per day	1	$65 per month	3	$1 per day	1	$50 per month.
Agents								
Engineers			2	$3.25 per day				
Drillers	2	$3.75 per day	8	$2.00 per day				
Men at well	2	$2.25 per day	1	$30 per month				
Teamsters			13	$3.25 per day				
Linemen								
Watchmen								
Mechanics			2	$2.25 per day	12	$2 per day	1	$37.50 per month.
Laborers			34	$1.50 per day	60	$1.50 per day	24	$1.50 per day.

The total expenditures during 1889 for material in development of gas territory and production and transportation of natural gas were $511,141. This is very nearly equal to the total value of the gas, measured by the coal displaced, and two and a half times the total value of production measured by the amount of money received. The explanation of this apparent discrepancy is that in this statement of total expenditures for materials is included the expenditure at a number of wells drilled during the year that were not producers, and also a large amount spent in laying pipe lines, all of which is charged to expense for materials in 1889, on which returns will be expected for a number of years.

TOTAL EXPENDITURES FOR MATERIALS DURING 1889, BY COUNTIES.

COUNTIES.	Total.	Building rigs.	Drilling wells.	Operating, shutting in, and caring for wells.	Pipe, couplings, etc., in building and repairing pipe line.	Used in fitting.	TORPEDOES.		All other materials.
							Number.	Value.	
Total	$511,141	$17,336	$22,405	$5,810	$131,144	$16,094	41	$2,330	$316,022
Allegany	422,499	15,140	15,099	3,415	65,870	9,094	4	368	313,522
Erie	56,325			175	46,000	6,500	6	1,150	2,500
Fulton									
Lewis	500	100	400						
Niagara	4,380	850	3,000	50	360		3	180	
Ontario	4,328	546	1,415	1,870			26	497	
Oswego	7,575	200	2,500	300	4,000	500	1	75	
Steuben	15,534	500			14,974		1	60	

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN NEW YORK IN 1889.

Below is a condensed statement of the figures regarding the development, production, and consumption of natural gas in New York in 1889:

Total amount received for natural gas produced in 1889	$204,325
Coal displaced (tons of 2,000 pounds)	130,159
Value of same	$530,026
USES.	
Total number of fires for cooking and heating	4,362
Total number of industrial establishments supplied	11
WELLS.	
Number of wells drilling December 31, 1888	5
Number of wells drilling December 31, 1889	12
Number of wells completed in 1889	65
Producing wells completed in 1889	55
Dry holes completed in 1889	10
Number of wells producing December 31, 1888	69
Number of wells producing December 31, 1889	119
Number of wells abandoned in 1889	3
Total cost of drilling wells, including drive pipe, casing, etc	$74,752
Labor	$23,604
Materials	$14,256
CAPITAL.	
Number of acres of natural gas land:	
Owned	533
Leased	49,337
Total	49,870
Total value of land	$298,120
Total value of rigs, wells, etc	169,753
Total value of pipe lines	580,519
Total value of other property and improvements	114,037
Total capital invested in lands, wells, etc., and used in the business	1,162,429
LABOR AND WAGES.	
Number of foremen or overseers	11
Number of mechanics	37
Number of laborers	296
Office force, males	12
Office force, females	1
Total number of employés	357
Wages paid foremen or overseers	$4,152
Wages paid mechanics	4,443
Wages paid laborers	17,687
Wages paid office force, males	7,868
Wages paid office force, females	85
Total wages paid employés	34,225
EXPENDITURES FOR MATERIALS, ETC.	
Total amount expended in building rigs	$17,336
Total amount expended in drilling wells	22,405
Total amount expended in operating, shutting in, and caring for wells	5,810
Total amount expended in pipe, couplings, etc., in building and repairing pipe lines	131,144
Total amount expended in fitting	16,094
Total amount expended for torpedoes	2,330
Total amount expended for all other materials	316,022
Total expenditures for materials	511,141

MISSOURI.

There have been quite extensive explorations in this state for natural gas, but none of the wells sunk have yielded considerable quantities of the fuel, and the probabilities now are that it will not be found in commercial quantities.

Quite a number of gas springs are known to exist in various parts of the state, especially in the vicinity of Saint Louis, in the eastern part of the state, and Kansas City, in the southwestern section. In Saint Louis, near these springs, gas has been obtained in limited quantities in a number of wells, most of it coming from either the

glacial or alluvial drift, but in no case has gas been obtained from rock reservoirs such as those from which the commercial gas in Pennsylvania, Ohio, and Indiana is obtained.

The natural gas in the neighborhood of Saint Louis, to which the most attention has been directed, was that of the Cotton Compress Company. This gas was first struck in 1875, at the bottom of a driven well some 27 feet deep. The supply at first was comparatively abundant for a shallow well, but it soon diminished, until it was only sufficient to illuminate the engine-room. In many wells drilled in Saint Louis to obtain water for the breweries puffs of gas have been found at depths varying from 200 to 1,500 feet.

The existence of gas springs in Kansas City has also been known for many years, and gas is frequently found in connection with the digging or driving of wells in this neighborhood. Quite a number of wells have been drilled in this neighborhood with the hope of obtaining a supply of gas. In a well drilled in the Excelsior brick yard a flow of gas was obtained at 180 feet; in another well, on Seventeenth street, at of 344 feet; in the Kellogg well, near the natatorium, at the depth of 810 feet, and in other wells at depths from 250 to 800 feet, gas having been found at the latter depth in the Tustin well, which is the deepest drilled in Kansas City, it having been sunk to the depth of 1,700 feet.

The only gas that was obtained in Missouri in commercial quantities in 1889 was from Kansas City, Jackson county. The depth of wells is about 480 feet. The sand from which the gas is produced is a reddish sandstone from 10 to 40 feet thick, containing occasionally a thick, black oil. The rock seems to be somewhat similar to that in which oil and gas is found at Paola, Kansas.

Natural gas was supplied to the power house of a cable company at a rental of $1,000 per 100 horse power per annum. Furnaces were supplied for $75 per year, and an 8-room house at $100 per annum.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN MISSOURI IN 1889.

The statistics of the production of natural gas in Missouri in 1889, so far as the same could be procured, are as follows:

Value of natural gas supplied and used	$27,825
Coal displaced (tons)	11,859
Value of same	$35,687
Number of fires for cooking and heating	339
Number of industrial establishments	2
Number of producing wells completed	14
Number of dry holes completed	5
Total number of wells completed during 1889	19
Number of producing wells December 31, 1888	5
Number of producing wells December 31, 1889	13
Number of wells abandoned in 1889	8
Total cost of wells completed in 1889	$30,000
Value of land	$176,800
Value of rigs, wells, etc	90,800
Value of pipe lines	44,200
Value of other property	1,500
Total capital invested in the natural gas industry in 1889	$313,300
Number of persons employed (excluding contract work)	2
Total wages paid employés	$85
Total amount expended in building rigs	$500
Total amount expended in pipe, couplings, etc., in building or repairing pipe lines	12,200
Total amount expended for all other materials	1,500
Total expenditures for materials	14,200

KANSAS.

The only district in Kansas in which gas has as yet been found in sufficient quantities to justify its use is in the counties along the eastern border of the state, in Miami, Linn, Bourbon, and possibly others. Gas has also been found in Washington and Marshall counties, on the Nebraska border, and it is possible that it may be found in the shales and sandstones of the western part of the state. It is in the eastern tier of counties, say from Atchison to Cherokee, and especially in the 3 counties above named, that we are to look for commercial supplies of gas.

The surface outcrop on the eastern border of Kansas has two lines of demarcation, forming three distinct geological divisions. The first line occurs near the extreme southeastern corner of the state, where the outcrop of the subcarboniferous strata is bounded by a line drawn from northeast to southwest parallel with the Ozark range of mountains. To the north and west of this line the lower coal measures form the surface rocks and extend north until near the east center of Miami county, where another line of demarcation occurs between the lower and upper series of coal measures, which trends southwest parallel to the former; thence the upper coal measures extend to the north line of the state and west to the Big Blue river. The dip of the rocks in all this region trends about due northwest, or in the direction of a line drawn at a right angle with the Ozark uplift, and amounts to about 6 feet per mile when following the true direction of the dip.

Though gas had been found in prospecting for oil and had been noticed escaping from springs as early as 1864, and again in 1874, it was not until 1882 that what could be termed a gas well was struck at Paola, in Miami county. In 1865 the Saint Louis or Ernstein Oil Company bored two wells for oil some 10 miles east of Paola. The tools were lost at 700 feet, the wells showing some oil. In 1882 a well was bored on the Westfall place, near Paola, which gave gas in considerable quantity. Quite a number of wells have since been bored near the town.

The Paola district has been so thoroughly discussed in connection with the report on petroleum in Kansas that it need not be reported here. It is sufficient to say that most of the gas used in Paola is produced from wells near the town, the pressure of gas in the original field, some 7 miles from Paola, not being sufficient to force the gas through the pipe line to the point of consumption. It may be said that the wells in this district are shallow wells, the gas sand being reached at from 300 to 400 feet.

Possibly the most important developments in connection with the production of natural gas in Kansas have been in the vicinity of Fort Scott, Bourbon county. Over 30 wells have been drilled in this town or its vicinity, gas having been found at various depths. In well No. 1, on the Stewart farm, in Fort Scott, which was drilled to a depth of 281 feet, gas was first struck at a depth of 25 feet. At a depth of 192 feet 10 inches another gas rock was struck, in which gas was found; and the third horizon was in a coal bed at a depth of 277 feet 3 inches. The higher and lower gas veins amounted to nothing, the middle one being that from which gas is obtained. The gas sand is located in the lower coal measures.

The gas when first struck shows a pressure of about 75 pounds. Water soon makes its appearance, and the wells gradually cease to be of value. The gas belt extends through a strip of land about half a mile long and about 1,500 to 2,500 feet wide.

The gas is gradually giving out in this section. That furnished by the Fort Scott Gas Company, which had 1 well in 1889, is a mixture of coal gas and natural gas, and is sold at 50 cents per 1,000 cubic feet. In 1887 and 1888 12 wells were used to supply this town, but all have since been abandoned.

Some gas has been found in Kansas City. Quite a number of wells were put down in this town, some producing gas and some oil, and are about 400 feet deep.

In Labette county a well was drilled in 1881 which has been yielding a supply of gas sufficient for 1 house ever since. This well is 763 feet deep. The rock penetrated was limestone, with thin layers of sandstone. The first vein of gas is found at a depth of 203 feet, the second at 449 feet. The gas pressure is as strong now as when first struck. A few domestic fires are supplied.

Gas was found in a gray shale at a depth of 1,230 feet at Lyons, Rice county. The flow, however, was not very strong, and it has not been utilized.

There is also 1 well at Iola, in Allen county, which supplied some 25 domestic fires in 1889.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN KANSAS IN 1889.

The statistics of the production of natural gas in Kansas for 1889 are as follows:

Value of natural gas supplied and used	$13,660
Coal displaced (tons)	4,538
Value of same	$15,873
USES.	
Number of fires for cooking and heating	798
Number of industrial establishments supplied	2
WELLS.	
Number of producing wells completed	14
Number of dry holes completed	2
Total number of wells completed in 1889	16
Number of wells producing December 31, 1888	5
Number of wells producing December 31, 1889	25
Number of wells abandoned in 1889	2
Total cost of drilling wells, including drive pipe, casing, etc., in 1889	$9,800
Labor	$6,450
Materials	$3,350
CAPITAL.	
Number of acres owned	2
Number of acres leased	2,000
Total number of acres of natural gas land	2,002
Value of natural gas land	$10,200
Value of rigs, wells, etc	22,500
Value of pipe lines	27,200
Value of other property	100,100
Total capital invested in natural gas industry in 1889	160,000

LABOR AND WAGES.

Total number of employés	3
Wages paid employés	$2,100
Number of mechanics	1
Wages paid mechanics	$900
Number of laborers	1
Wages paid laborers	$200
Number of office force	1
Wages paid office force	$1,000

EXPENDITURES FOR MATERIALS, ETC.

Amount expended in building rigs	$4,500
Amount expended in drilling wells	6,500
Amount expended in operating and caring for wells	1,800
Amount expended in pipe, couplings, etc., in building or repairing pipe lines	1,555
Amount expended for torpedoes	350
Total expenditures for materials in 1889	14,705

CALIFORNIA.

Though natural gas has been found in many parts of the state of California, it is only in the neighborhood of Stockton, in San Joaquin county, and in the oil regions of southern California that it is produced in commercial quantities. In southern California it occurs in connection with the petroleum, and all the capital, labor, etc., is reported as expended in relation with the production of oil. It is estimated that in this section the amount of gas used is equal to some 20 tons of coal for every day in the year, or a total of 7,300 tons. This coal would be worth some $10 a ton, making the value of natural gas produced in southern California in 1889 $73,000.

Natural gas has been known to exist in Sonoma county as early as 1859, and at one or more wells the gas has been collected and used for domestic purposes.

In Contra Costa county natural gas has been observed to bubble up in several mineral springs, and it is also said that it has been found in considerable quantity at Nicasio, Marin county. The gas found near Kelseyville, Lake county, has been used to make steam, and gas has also been found in certain localities in Solano, Sacramento, Tehama, and Mendocino counties, but not, so far as has been learned, in any commercial quantities. In San Joaquin, in the vicinity of the city of Stockton, in Humboldt, and in Los Angeles counties occurs the gas which has been used commercially. The gas found in Los Angeles and Humboldt counties has chiefly been in the sinking of oil wells. The wells on Oil creek, in Humboldt county, sunk in 1866, have since constantly given off gas, and wells sunk in other parts of this county about the same date and since have given continuous flows of gas in some quantity, but from none of the wells in Humboldt county has the flow been sufficient to supply more than two or three burners or to furnish a dwelling house with fuel and light, and that but for a short time.

By far the most important gas-producing district of California, however, is in the neighborhood of Stockton, in San Joaquin county. In the vicinity of this city a large number of artesian wells have been bored. The first of these, the celebrated Court House well, was bored during the years 1854 to 1858. The water coming from the bottom of the well (1,000 feet) brought up with it considerable gas. Quite a number of wells have been bored in this neighborhood, nearly all of which produce gas to a greater or less extent. A well in Castoria township bored in 1883 to a depth of 1,140 feet discharges considerable gas, which is collected in a tank and used for lighting, heating, and cooking in the house of the proprietor. The supply of gas is very much more than sufficient for the purposes named. At the old water works enough gas is collected to cushion the pumps, and at the new water works all 3 wells carry gas. The gas from well No. 1 is passed over gasoline to enrich it in carbon, and is used for lighting the engine room. Altogether 11 ordinary burners are in use, the gas being used directly as it comes from the well. The gas from wells No. 2 and No. 3 is not used. The McDougald well produces a large amount of gas. By actual measurement it registered between 7,000 and 8,000 cubic feet per 24 hours. About 14 miles west of Stockton a well was sunk to a depth of 1,435 feet in 1883 and quite a copious flow of gas was struck.

In December, 1883, the Standard Gas Light and Fuel Company was incorporated at Merced, with the object of developing natural gas in the San Joaquin valley, and in the summer of the next year the California Well Company was organized at Stockton for a similar purpose. The Crown Mills well, an old artesian well, was bored out and sunk to a depth of 1,220 feet, when a large flow of gas was discovered, showing by careful measurements 18,000 cubic feet in 24 hours. A well bored by the California Well Company near Stockton gave a total of 81,000 to 82,000 cubic feet in 24 hours.

In Los Angeles county a considerably greater quantity of gas has been found than in Humboldt. At the Puente wells the gas issues from the wells under a very slight pressure. The quantity is small, and it is drawn directly from the wells to the furnace. As an experiment the gas escaping from No. 5 well was cased in tight, when the pressure increased to about 100 pounds per square inch. It is a remarkable fact in connection with the gas in these wells that it continues to escape from the petroleum for some time after the latter is tanked, and it also appears that the gas thus evolved is capable under some circumstances of redepositing a quantity of liquid

petroleum. In Pico cañon, in this same county, there are 2 wells, known as Pico No. 12 and Pico No. 13, the first of which pumps about 18 barrels and the second some 40 barrels a day. These produce a larger quantity of gas than any other wells in this oil section.

The following is an analysis of the gas from a well of the Stockton Natural Gas Company:

ANALYSIS OF NATURAL GAS FROM THE WELL OF THE STOCKTON NATURAL GAS COMPANY.

	PER CENT.
Marsh gas	83.00
Hydrogen	0.06
Oxygen	0.06
Carbonic dioxide	0.05
Carbonic oxide	Trace.
Total	83.17

At the close of 1889 there were 6 producing wells in California. The Asylum well, for which the legislature appropriated $40,000, was boring. The Stockton Gas Light and Heat Company was boring a well adjacent to the Haas well. Stockton county was also drilling a well. The Stockton Gas Company, which owned the Haas well, was putting down a second, and an additional well was being drilled on San Joaquin street, and others were to be drilled.

The wells actually in operation in San Joaquin county in 1889 were the Northern Natural Gas Company's well, which was supplying 10 domestic fires; the Crown Mills well, which was producing from 30,000 to 40,000 cubic feet of natural gas a day, and which was used in lighting the mills and for fuel in the flour mills of the company owning the well; the well of the Citizens' Natural Gas Company, which was drilled in December, 1889; the Haas company's well, which is reported as producing 29,200,000 cubic feet in 1889, supplying only 5 domestic fires; the Paper Mill well of the California Paper Company, producing, as reported, 4,380,000 cubic feet of gas, of which about one-half was consumed in useful work, and the Saint Agnes Academy well, which supplied 8 domestic fires.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN CALIFORNIA IN 1889.

The statistics of the production of natural gas in California in 1889 are as follows:

Value of natural gas supplied and used	$12,680
Coal displaced (tons)	3,517
Value of same	$12,680
USES.	
Total number of domestic fires	23
Number of industrial establishments supplied	5
WELLS.	
Total number of producing wells completed in 1889	1
Total number of wells producing December 31, 1888	5
Total number of wells producing December 31, 1889	6
Total cost of drilling wells, including drive pipe, casing, etc., in 1889	$5,135
CAPITAL.	
Number of acres of natural gas land owned	6
Value of natural gas land	$1,900
Value of rigs, well, etc	$49,635
Value of pipe lines	$215
Total capital invested in natural gas industry in 1889	$51,750

The total expenditure in 1889 was $90 for building and repairing pipe lines.

ILLINOIS.

Gas has been found in Illinois in the following counties: Champaign, Lasalle, Bureau, Livingston, McLean, Dewitt, Macon, Coles, Clark, Montgomery, and Madison, having been first discovered at Champaign in 1853. No field of importance has been developed in this state. The most important wells are at Urbana, Champaign county, Mendota, Lasalle county, and Litchfield, Montgomery county. The Illinois wells, as compared with the great wells in Pennsylvania, are shallow, occurring for the most part in drift, and, though some have yielded gas for years, they are gradually giving out.

The most important gas territory until recently was at Litchfield, in Montgomery county. In this place gas and oil were found at a depth of 650 feet, below the lower coal measures, bordering on the devonian. Gas was first discovered in this place in 1882 and was piped into Litchfield in the fall of 1885, some 4 miles of pipe being laid.

In Randolph county the Sparta Natural Gas Company, which had 1 well prior to 1889, drilled 2 wells in that year, one being dry and the other productive. The depth of the wells is from 848 to 864 feet. A small amount of oil

was found in each well before reaching the gas sand. It is quite heavy and black, resembling the West Virginia lubricating oils. The gas from these wells supplied 400 domestic fires and 3 industrial establishments.

At another point in Randolph county gas was struck prior to 1889, and was still producing in the census year. Other drilling was done in this county without success.

In Lasalle county, near Streator, gas has been found in quite a number of wells at a depth of about 100 feet, but it has not been utilized.

Near Mendota, in the same county, 20 wells were sunk in 1888 by the Mendota Natural Gas Company. These wells were drilled to a depth of 160 to 260 feet. Gas was found in all of them, but 17 of the wells gave out at intervals of from 1 to 2 months after gas was struck and the leases reverted to the owners. 3 small wells continued to produce, but only sufficient to supply the residences of the farmers on whose land the wells were drilled. The gas was found in pockets or layers of sand or gravel in the drift or bowlder clay.

In Whiteside county, at Rock Falls, a well was drilled to a depth of 1,014 feet without securing gas.

At Vandalia, in Fayette county, a well was sunk to a depth of 1,150 feet, when it was abandoned, there being no indications of gas-bearing rock.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN ILLINOIS IN 1889.

The statistics of the production of natural gas in Illinois in 1889 are as follows:

Total value of natural gas supplied and used	$8,658
Coal displaced (tons)	7,245
Value of same	$10,615
USES.	
Number of fires supplied for cooking and heating	940
Number of industrial establishments	20
WELLS.	
Number of producing wells completed	2
Number of dry holes completed	2
Total number of wells completed in 1889	4
Number of wells producing December 31, 1888	9
Number of wells producing December 31, 1889	10
Number of wells abandoned in 1889	1
CAPITAL.	
Number of acres owned	44
Number of acres leased	19,000
Total number of acres of natural gas land	19,044
Total value of land	$3,200
Value of rigs, wells, etc	23,620
Value of pipe lines	18,400
Total capital invested in wells, etc., and employed in the business	45,220
LABOR AND WAGES.	
Number of foremen or overseers	1
Wages paid foremen or overseers	$750
Number of laborers	3
Wages paid laborers	$172
Number of office force (males)	1
Wages paid office force	$300
Total number of employés	5
Total wages paid employés	$1,222
EXPENDITURES FOR MATERIALS.	
Total amount expended for materials in operating, shutting in, and caring for wells	$1,600
Total amount expended for materials used in building and repairing pipe lines	16,000
Total amount expended for materials in 1889	17,600

KENTUCKY.

The chief source of supply of natural gas in Kentucky is from Meade county, in what is known as the Brandenburg district. Some gas was also found in 1889 in Henderson, Breckinridge, and Daviess counties. The first well drilled in Kentucky which produced gas in any considerable quantity was the Moreman well, drilled in 1863 on the Moreman farm, near Brandenburg, Meade county, not far from the Ohio river. Quite a number of other wells drilled for oil about the same time or later produced considerable quantities of gas and brine. In 1872 the

Moreman Salt Works was established, and the gas from the well utilized to make salt from the associated brine. But little use, however, was made of this gas until discoveries in 1885 and 1886 in southern Ohio and Indiana caused great interest to be developed in searching for natural gas in Kentucky. Most of the wells sunk outside of Meade and the counties named above proved unprofitable, but they contributed facts of value regarding the gas and oil horizons in Kentucky.

As the Trenton limestone was the horizon in which oil and gas were found in such quantities in Ohio and Indiana, the discussion regarding the oil and gas strata of Kentucky had reference to this horizon.

The elevation or depression of the base of the Trenton above or below sea level is found in the following table, taken from an admirable article by Professor Moritz Fischer, of the Kentucky geological survey, published in the Natural Gas Supplement of the American Manufacturer. It is from this article by Mr. Fischer and from a paper by Professor Edward Orton that information regarding the gas-bearing strata of Kentucky is obtained.

DISTANCE OF THE BASE OF THE TRENTON LIMESTONE ABOVE OR BELOW SEA LEVEL IN KENTUCKY.

LOCALITIES.	Feet.	Remarks.
Cincinnati	308+	Near arch of the Cincinnati anticlinal.
Lexington	715+	
High Bridge	765+	
Harrodsburg	692+	
Danville	720+	
Louisville	584−	Western slope of the Cincinnati anticlinal.
Lagrange	24−	
Bardstown	163−	
Lebanon	36+	
Frankfort	495+	West of arch of the Cincinnati anticlinal.
Maysville	82−	East slope of the Cincinnati anticlinal.
Richmond	226+	

The oil and gas bearing Trenton limestone of northern Ohio and Indiana is covered by 350 feet of Utica shale, a formation entirely wanting in Kentucky.

A little heavy, dark oil, with weak brine, has been found at a depth of 70 feet near Lexington, Kentucky, in Trenton rock. Near North Middletown, Bourbon county, Kentucky, a well in Lower Hudson 98 feet deep yields 100 gallons of good lubricating oil per week. The oil is black, and has a gravity of 23½° B. The Lower Hudson west and northwest of Cincinnati gives promise of a fair supply of low-pressure gas. A weak flow is obtained in Lewisburg, near Covington, and lately productive wells have been found near Cincinnati, in Cheviot, at Lawrenceburg, and Aurora, Indiana. This horizon is likely to be found in the river counties west of Covington, and may prove quite remunerative. Weak flows of gas have been obtained from wells sunk in the neighborhood of Louisville on both sides of the Ohio river. Data obtainable are not sufficient to locate the horizon or productive formation. It would seem to lie in either upper or middle Hudson, at least for the Third street well, Louisville, and the wells located at Old Deposit, near Louisville, one of the latter giving a flame 20 feet high. The flow increased since gas was first struck. The Clinton and Niagara district has been penetrated by a number of wells, but gives no encouragement to the prospector. These wells being near the outcrop of the formations, their evidence is not conclusive.

The black shale is the most promising oil and gas horizon in the state, having an average of 10 per cent of bitumen. This shows an enormous amount of hydrocarbons stored in it. The following data were furnished by Major William T. Davis, of Louisville, Kentucky:

SECTION OF MOREMAN WELL, BRANDENBURG, MEADE COUNTY, KENTUCKY.

LOCALITIES.	Feet.	Remarks.
Saint Louis	50	Gas and strong brine; well sunk 1864; flows with undiminished force.
Keokuk	450	
Lick shales	5	

SECTION OF DOE RUN WELL, ROCK GAS COMPANY, NEAR BRANDENBURG, MEADE COUNTY, KENTUCKY.

LOCALITIES.	Feet.	Remarks.
Keokuk	475	Gas and strong brine; daily flow 1,000,000 cubic feet.
Lick shales	15	

SECTION OF MAJOR DAVIS WELL, TOBACCO LANDING, HARRISON COUNTY, INDIANA, 5 MILES EAST OF BRANDENBURG, KENTUCKY.

LOCALITIES.	Feet.	Remarks.
Keokuk	375	Gas and strong brine, measured by Mr. Ashburner, showing a daily flow of 805,000 cubic feet; flow increased slightly since.
Lick shales	25	

These are constant wells, and the field deserves careful attention as the most promising source of a supply for Louisville. Adjacent to the Cumberland anticlinal much oil has been obtained from the black shale. Wells 100 to 250 feet deep have sometimes produced 300 barrels a day.

The gas from the Meade county field is a shale gas, its source being the black or Ohio shale, which under various names has long been known as a gas producer. It is from this horizon that the gas from Fredonia, in western New York, is obtained. Wells have been drilled by the hundreds along the lake shore in western New York and Ohio in search of gas for household use. There is not a single township along the line of the outcrop of this formation, from Silver Creek, in New York, to Huron river, in Ohio, in which wells have not been drilled for gas. Erie, in Pennsylvania, and Conneaut, Ashtabula, Painesville, and Cleveland, in Ohio, may be all named as places using gas from this horizon.

While the Meade county gas is, without doubt, derived from the black shale, agreeing in composition with the gas from these measures in the Ohio field, Professor Orton points out that all the important conclusions as to the characteristics of shale, as drawn from the experience with the gas from New York and Ohio, are promptly set aside by the experience with the Meade county gas. Unlike the Ohio shale gas, the Meade county gas is reservoir or high-pressure gas. It is associated with and driven by a salt-water column. Its wells have attained a maximum production of 2,000,000 cubic feet per day. They are greatly improved by the use of torpedoes. The rock pressure is low, it is true, but this evidently results from the shallow depth at which the gas rock is found, for the depth is always a function of the rock pressure in reservoir wells. In the heart of the new field the rock pressure ranges from 100 to 125 pounds per square inch, the depth of the wells ranging from 300 to 500 feet below the surface. Again, the gas wells of this district produce salt water freely in connection with the gas, without, in all cases at least, being overrun by it.

Commenting on these facts, Professor Orton says:

> All this is confusing to a high degree. It seems at first sight as if such an experience destroyed all possibilities of scientific or practical provision in the search which our cities and towns are so eagerly pressing; but a closer examination shows us that only a single change has occurred in the character of the shale. Through the accidents of its history it has become a porous rock, and consequently a reservoir for gas, oil, and salt water. All the other changes above noted follow at once upon the transformation of the shale from an approximately impervious rock to a porous rock.

Though, as stated above, the first gas well in this district was the Moreman well of 1863, the real development of this section as a gas-producing district began with the boring of well No. 1, known as the Major Davis well of the Union Gas Company, drilled in 1887 near Tobacco Landing, on the Indiana side. A daily flow of 805,000 cubic feet of dry gas was obtained from this well at a depth of about 400 feet. At least 3 other wells, 1 unproductive, have been drilled by this company. The total production of these wells is 2,500,000 cubic feet daily.

The Kentucky Rock Gas Company has drilled a number of wells on the Fountain, McGehee, Bickerstaff, and other farms in this immediate district, and it is this group of wells that mainly gives character to the field.

The first well to be drilled by this company was the one known as the Bickerstaff well No. 1. It found the shale at a depth of 386 feet, and gas was found in good volume at 392 feet. The well was completed in January, 1888, and was allowed to burn without check until March, when it was shut in. On being opened a few weeks thereafter it was found to contain salt water. The water gained rapidly upon the gas, greatly reducing its flow. This is a type of several wells that have been drilled within the limits of the company; in some, indeed, the salt water making the conspicuous feature of the production.

Another and better type is represented in the Bickerstaff well No. 2. In this the shale was found at 342 feet and gas in large volume at 368 feet. The well was torpedoed with 45 pounds of dynamite of 75 per cent strength, and the flow of gas was greatly increased thereby. The gas proves to be entirely dry, and its production exceeds 2,000,000 cubic feet per day.

This company did not complete its arrangement to supply customers until December, 1889, at which time it had 10 wells in operation, drilling none during 1889. They estimate the total production of their wells for the year 1889 as 1,095,000 cubic feet, of which only about 10 per cent was consumed, the remainder going to waste.

The only other county in Kentucky in which natural gas was used was in Breckinridge county. About the middle of 1889 developments were commenced in this county, several wells being drilled, 4 of which were dry holes.

In Henderson county 4 wells were drilled, 2 of which were dry, the others showing a closed pressure of from 50 to 60 pounds, which soon dropped to 40 or 50 pounds. None of the gas was utilized, there being no market and the quantity thought insufficient to warrant piping.

A well was drilled in Daviess county in December, 1889. Gas was found at a depth of 850 feet. The well is filled with salt water, the gas rising through it. No use was made of this gas.

In the following tables will be found the statistics of the production of natural gas in Kentucky by counties:

PRODUCTION OF NATURAL GAS IN KENTUCKY IN 1889, BY COUNTIES.

COUNTIES.	Value of natural gas supplied and used.	COAL DISPLACED.	
		Tons.	Value.
Total	$2,580	615	$2,580
Breckinridge	100	20	100
Meade	2,480	595	2,480

The gas produced in Kentucky in 1889 was used as follows: in Breckinridge county 2 industrial establishments were supplied; in Meade county 6 fires for cooking and heating and 2 industrial establishments were supplied.

WELL RECORD, BY COUNTIES.

COUNTIES.	WELLS COMPLETED IN 1889.			NUMBER OF WELLS PRODUCING.		Wells abandoned.	Total cost of drilling wells, including drive pipe, casing, etc.	DETAIL OF COST.	
	Total.	Producing.	Dry holes.	December 31, 1888.	December 31, 1889.			Labor.	Material.
Total	29	21	8	20	37	13	$26,750	$1,500	$1,000
Breckinridge	5	2	3	.....	2	3	.....	.....	.....
Daviess	2	2	.....	.....	2	1	2,500	1,500	1,000
Henderson	4	2	2	.....	2	2	4,100	.....	.....
Meade	18	15	3	20	31	7	20,150	.....	.....

COMPLETED WELLS IN 1889.

MONTHS.	Total number of wells completed in each month.	Number of dry holes.	Number of wells producing.
Total	29	8	21
January	2	2	.....
February	.....	.....	.....
March	1	.....	1
April	3	2	1
May	2	.....	2
June	5	1	4
July	2	1	1
August	2	.....	2
September	1	.....	1
October	4	.....	4
November	4	1	3
December	3	1	2

PRODUCING WELLS.

MONTHS.	Total number producing.	Total number abandoned.
1888.		
December 31	20	.....
1889.		
January 31	20	2
February 28	20	.....
March 31	21	.....
April 30	22	2
May 31	24	.....
June 30	26	3
July 31	27	1
August 31	29	.....
September 30	30	2
October 31	32	.....
November 30	35	1
December 31	37	2

CAPITAL INVESTED IN THE NATURAL GAS INDUSTRY IN KENTUCKY IN 1889.

COUNTIES.	Total capital.	NUMBER OF ACRES OF NATURAL GAS LAND.				VALUE OF PLANT.		
		Total acreage.	Owned.	Leased.	Value of land.	Rigs, wells, etc.	Pipe lines.	Other property.
Total	$2,146,400	23,215	3,800	19,415	$275,550	$128,950	$800,700	$941,200
Breckinridge	19,000	3,000	.....	3,000	1,000	18,000	.....	.....
Daviess	5,800	1,000	.....	1,000	3,000	2,800	.....	.....
Henderson	4,100	3,800	3,800	.....	2,050	2,050	.....	.....
Meade	2,117,500	15,415	.....	15,415	269,500	106,100	800,700	941,200

LABOR AND WAGES, MEADE COUNTY.

EMPLOYÉS.	Number.	Wages.
Total	21	$13,016
Foremen or overseers	3	3,360
Mechanics	14	8,056
Laborers	3	520
Office, males	1	1,080

TOTAL EXPENDITURES FOR MATERIALS DURING 1889, BY COUNTIES.

COUNTIES.	Total.	Building rigs.	Operating, shutting in, and caring for wells.	Pipe, couplings, etc., used in fitting and repairing pipe lines.	TORPEDOES.		All other materials.
					Number.	Value.	
Total	$15,044	$500	$1,700	$6,000	15	$1,444	$6,000
Breckinridge	350	.....	.....	.....	2	350	.....
Henderson	100	.....	.....	.....	3	100	.....
Meade	15,194	500	1,700	6,000	10	994	6,000

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN KENTUCKY IN 1889.

Below is a condensed statement of the figures regarding the development, production, and consumption of natural gas in Kentucky in 1889:

Total amount received for natural gas produced in 1889	$2,580
Coal displaced (tons)	615
Value of same	$2,580
USES.	
Total number of fires for cooking and heating	6
Total number of industrial establishments supplied	4
WELLS.	
Number of producing wells completed in 1889	21
Number of dry holes completed in 1889	8
Number of wells completed during 1889	29
Number of wells producing December 31, 1888	20
Number of wells producing December 31, 1889	37
Number of wells abandoned in 1889	13
Total cost of drilling wells completed in 1889	$26,750
Labor	$1,500
Materials	$1,000
CAPITAL.	
Number of acres owned	3,800
Number of acres leased	19,415
Total	23,215
Total value of land	$275,550
Total value of rigs, wells, etc	128,950
Total value of pipe lines	800,700
Total value of other property and improvements	941,200
Total capital invested in lands, wells, etc., and used in the business	2,146,400

LABOR AND WAGES.

Number of foremen or overseers	3
Number of mechanics	14
Number of laborers	3
Number of office force (males)	1
Total number of employés	21
Wages paid foremen or overseers	$3,360
Wages paid mechanics	8,056
Wages paid laborers	520
Wages paid office force (males)	1,080
Total wages paid employés	13,016

EXPENDITURES.

Building rigs	$500
Operating, shutting in, and caring for wells	1,700
Pipe, couplings, etc., in building or repairing pipe lines	6,000
Torpedoes	1,444
All other materials	6,000
Total expenditures for materials	15,644

WEST VIRGINIA.

While gas has been found in some quantities in this state from the time Washington secured possession of the "burning springs" in Kanawha valley, most of the gas consumed in the state at present is piped from Washington county, Pennsylvania. A great many wells have been bored in various parts of the state, but as a rule they have not furnished gas in commercial quantities. But little natural gas was reported as produced in this state in 1889, and this all in Kanawha county. Gas was produced in other counties, but was not used, all going to waste.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN WEST VIRGINIA IN 1889.

The statistics of the production of natural gas in West Virginia in 1889 are as follows:

Value of natural gas supplied and used	$2,000
Amount of coal displaced (tons)	600
Value of same	$2,000

USES.

Total number of fires for cooking and heating	5
Total number of iron rolling mills supplied (*a*)	6
Total number of other industrial establishments supplied	1

WELLS.

Number of producing wells completed	5
Number of dry holes completed	1
Total number of wells completed in 1889	6
Total number of wells producing December 31, 1889	4
Total number of wells abandoned	1
Cost of labor	$1,600
Cost of materials	400
Total cost of completing wells in 1889	2,000

CAPITAL.

Total number of acres of leased land	218
Value of natural gas land	$11,280
Value of rigs, wells, etc	103,395
Value of pipe lines	25
Total capital invested in the natural gas industry	114,700

LABOR AND WAGES.

Number of mechanics	6
Wages paid mechanics	$1,800

a These mills procured their gas from Pennsylvania.

TEXAS.

At Dullnig's ranch, 6.5 miles south of San Antonio, in Bexar county, Texas, a number of wells were in process of drilling for natural gas at the close of 1889. In drilling a well prior to 1889 a small amount of gas was found, but this was not utilized for any other purpose than in drilling other wells and for lighting and cooking on the ranch. The quantity of gas was not sufficient for these purposes and drilling, so one-half wood was used. The

open pressure of the gas was 25 to 30 pounds; the confined pressure 70 to 100 pounds, as tested by a steam gauge. 5 wells were being drilled at the close of the year 1889, but had not been completed.

It is estimated that the value of the gas used in 1889 was $1,728, equivalent to a coal displacement of 288 tons.

NATURAL GAS STATISTICS IN TEXAS IN 1889.

Number of foremen or overseers	1
Wages paid foreman (225 days, at $4 a day)	$900
Number of mechanics	1
Wages paid mechanic (240 days, at $3 a day)	$720
Number of laborers	1
Wages paid laborer (240 days, at $1.50 a day)	$360
Total capital invested in lands, wells, pipe lines, etc., and used in business	$80,000
Number of acres of natural gas land owned	725
Present value of land	$72,500
Value of rigs, wells, engines, boilers, etc	$1,500
Value of other property and improvements	$6,000

PRODUCING WELLS.

The number of producing wells in Texas for December, 1888, and the year 1889, by months, was as follows: December, 1888, 1; in 1889, 1 each for January, February, March, April, May, June, July, August, September, October, November, and December.

ARKANSAS.

There has been quite an amount of drilling in Arkansas for natural gas, but so far it has not been found in commercial quantities. The Arkansas Natural Gas and Oil Company of Fort Smith put down several wells, but abandoned operations in 1888. The only well producing in this state in 1889, so far as returns have been received, was 1 sunk by the Fort Smith Natural Gas and Power Company in Upper township, Sebastian county. 2 wells were completed by this company in 1889, 1 in February, which was a dry hole, and 1 in September, which produced. 1 well was drilled in 1888, which is reported to have produced 500,000 cubic feet per day, having a closed pressure of 250 pounds per square inch. This well has been open and flowing since November, 1888, with no perceptible diminution of pressure. Both of these productive wells were drilled to a depth of 2,780 feet. The only use made of the gas was in the residence of the owner of the farm on which the gas was struck, this family using only a small proportion of the production and saving in fuel only some $75 by its use. In putting down the 2 wells that were drilled in 1889 the use of gas in drilling saved the company some $300. This company was compelled to abandon work near the close of 1889 from lack of capital. It is estimated, as stated above, that the total value of the gas consumed was $375, which would represent a coal equivalent of 107 tons.

NATURAL GAS STATISTICS IN ARKANSAS IN 1889.

Total capital invested in lands, wells, pipe lines, etc., and used in business	$24,000
Number of acres of land leased	2,000
Present value of land leased	$20,000
Value of rigs, wells, engines, boilers, etc	$3,500
Value of other property and improvements	$500
Total cost of drilling wells in 1889, including cost of rigs, drive pipe, casing, and tubing	$8,000
Amount of wages paid for labor	$2,500
Cost of materials	$5,500

NUMBER OF COMPLETED NATURAL GAS WELLS IN ARKANSAS IN 1889.

MONTHS.	Total number of wells completed in each month.	Number of dry holes.	Number of producing wells.	Initial pressure of new wells. (Pounds.) (a)	Estimated daily production of new wells. (Cubic feet.)
Total	2	1	1	250	25,000
January					
February	1	1			
March					
April					
May					
June					
July					
August					
September	1		1	250	25,000
October					
November					
December					

a Pressure closed.

One well was torpedoed during the year 1889, at a cost of $800.

PRODUCING WELLS.

The total number of producing wells in Arkansas for December, 1888, and the year 1889, by months, was as follows: December, 1888, 1; in 1889, 1 each for January, February, March, April, May, June, July, and August, and 2 each for September, October, November, and December. One well was abandoned in February, 1889.

UTAH.

Frequent statements are made as to the existence of natural gas in quantities in Utah, but so far the amount discovered has been very small, and this chiefly on the shores of Salt Lake, near Ogden.

In Salt Lake City small amounts of gas are frequently found in putting down driven wells. The gas seems to rise at short intermittent intervals to the amount of not over 2 or 3 cubic feet in 5 minutes; the production then becomes water for a while, and at an interval gas rises again.

At Lake Shore, the old Utah Central bathing resort, natural gas has been used in the manufacture of salt. 4 years ago 4 large jets of natural gas were burned under a vat 5 by 12 feet and 14 inches deep.

Only a small part of the gas is at present collected. The gas water is allowed to flow into a barrel, the gas collecting at the top, the water being driven out at the bottom. This gas is conveyed by a pipe and hose into a house near the place where it is produced, and used for cooking and heating.

At Ogden is a well which has been producing for 4 years, the gas being used for illuminating purposes, and also for cooking and heating stoves in the residence of the owner.

These wells are 148 feet deep, and were sunk for supplying water for irrigation. Two gasometers were constructed, and the gas supplied some 20 lights from burners using 2 to 5 feet per hour, and also sufficient for cooking and heating.

It is also reported that a well in Boxelder county produced considerable gas, but no information could be secured regarding it.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN UTAH IN 1889.

The statistics of the production of natural gas in Utah for 1889 are as follows:

Value of natural gas supplied and used	$150
Coal displaced (tons)	18
Value of same	$150
Number of fires for cooking and heating	6
Number of wells producing December 31, 1888	2
Number of wells producing December 31, 1889	2
Value of rigs, wells, etc	$2,970
Value of pipe lines	30
Total capital invested in natural gas industry	3,000

SOUTH DAKOTA.

Natural gas is very frequently found in various sections of South Dakota in sinking wells for water. So far as records have been received, gas in any considerable quantities was first struck near Ashton, South Dakota, at a depth of 78 feet, and was used for 6 weeks in the Bowman House, in Ashton, for cooking. The well filled with water and drowned out the gas. In this neighborhood quite a number of wells have been sunk, in most of which gas in small quantities has been found, varying in depth from 75 to 200 feet. The gas is found in a black shale and sandstone. In some instances the supply was just enough to show that gas existed in the rock; in other wells the quantity of gas at first appeared to be quite large, having a closed pressure of from 15 to 40 pounds.

The drill usually passes through about 15 feet of soil and clay, and then through 55 feet of hardpan, soapstone, and black shale, the gas sometimes being found in this shale and sometimes in a light-colored sandstone immediately under the shale. A small amount of oil is also found. In many instances no drilling is done, the casing being driven to the gas rock.

Several wells produced a small amount of gas in 1889, and it is reported that somewhere in the neighborhood of $4,000 was spent in sinking test wells for natural gas within a radius of 25 miles of Ashton.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN SOUTH DAKOTA IN 1889.

The statistics of the production of natural gas in South Dakota, so far as the same could be procured, are as follows:

Value of natural gas supplied and used	$25
Coal displaced (tons)	5
Value of same	$25
Number of fires for cooking and heating	1
Number of wells drilling December 31, 1888	1
Number of producing wells drilled during 1889	2
Number of wells producing December 31, 1889	1
Number of wells abandoned in 1889	1
Value of rigs, wells, etc	$1,273
Value of pipe lines	87
Total capital invested	1,360
Total number of employés	1
Wages paid employés	$73

NEW MEXICO.

It is reported that while a well was being sunk by the Cosmopolitan Petroleum Company in Navajo Church mining district, in Barnalillo county, New Mexico, for petroleum, gas was struck at some 300 feet from the surface. As petroleum was the object sought for, the well was drilled past the gas to a depth of 500 feet, when it was abandoned for lack of capital. Some $2,000 was paid in wages for this work, the total capital invested in lands, wells, pipe lines, etc., being $3,000.

TENNESSEE.

No natural gas was produced in Tennessee in 1889, though the conditions here are such as to make some reference to them of interest.

The coal measures of Tennessee are badly denuded. They contain no Catskill, Chemung, or Portage to supply the gas sands, oil sands, shale covers, etc., nor is there any Ohio or Indiana Utica shale to serve as a cap for the rich store of material escaping from the Trenton limestone. Referring to the prospect of securing gas in the central basin of Tennessee, the floor of which is made of outcropping Hudson river and Trenton limestones, Professor Safford, in a contribution to the Natural Gas Supplement, No. 2, of the American Manufacturer, says that they are charged with a measure of gas is proved by the fact that for the last 60 years and more wells bored in the limestones have yielded gas, often in quantities to astonish and bewilder the Tennessee borers. The wells have been usually driven for water, sometimes for salt water. They do not always yield a noticeable volume of gas, though it is common for them to do so. The gas wells are not confined to any special part of the basin. One bored within the limits of the city of Nashville supplied a flow of gas which, when ignited, burned with a volume of flame 8 feet high. It continued to flow for 6 weeks, the volume, however, growing less and less until it ceased to attract attention. This gas was for a time utilized in a house near by for lighting purposes. The well is only about 80 feet deep. It was started in the lower limestones of the Hudson river series and terminated in the Trenton. Another well, 20 or 22 miles southeast from Nashville, and wholly within the Trenton, bored for water in 1858, reached gas at a depth of less than 100 feet, which blew out strongly and burnt furiously, greatly alarming the owners, who fled and could not be induced to return for some time. About October 1, 1887, another well, 12 miles northeast from Murfreesboro, and in the Trenton, was also bored for water, and at about 100 feet yielded a similar exhibition of gas. And still another, on the eastern side of the basin, at a depth of 52 feet supplied a volume of gas which burned at the end of a 5-inch stovepipe with a flame 3 feet high, and so continued for several days without diminution. These are but a few examples of many that might be given. They illustrate the general character of burning wells of the basin. The gas is of low pressure, and is met with both in the Hudson river and Trenton rocks. Professor Safford thinks that the gas of such wells, some of them at least, if properly cared for, could in a small way be made useful for domestic purposes and for a considerable length of time. So far no high-pressure gas has been found. The deep wells sunk for the purpose have been failures. One at Nashville reached a depth of 1,250 feet without any special show of gas.

In the "Rim" the Hudson and the underlying Trenton are found under the characteristic strata of this section, which is the subcarboniferous. As a rule, more or less gas has been met with in drilling oil wells, which are found in front of the Cumberland table-land on the "Rim" area, but the amount is comparatively small. In several counties along the western base of the Cumberland table-land, as in White and Warren counties, moderate quantities of gas have been encountered in wells drilled for salt or petroleum. West of Nashville some gas has been found. Nearer Nashville, at the western edge of the Central basin, a well has been drilled, starting in the Niagara and descending into the Hudson and Trenton, in all a depth of 1,620 feet. At a depth of 250 feet in the Hudson gas was encountered which blazed up 4 or 5 feet when ignited. Below this no more gas was encountered.

2 wells were bored in 1887, 6 and 8 miles, respectively, from Chattanooga, with no important results. A little gas was met with in one of them, which, when fired, blazed up for a few minutes.

Relative to natural gas in Tennessee, Professor Safford reaches the following conclusions: "(1) the gas so far obtained in Tennessee has no practical value, and (2) the gas and oil, such as we have, come from the Hudson river and Trenton limestones."

Relative to operations in Tennessee in 1889, it may be said that near the close of 1888 the Chattanooga Oil and Gas Company drilled a well in Shirleyton to a depth of 1,700 feet. A small flow of gas was found at 900 feet which was sufficient to make a blaze about 10 feet in height through a 10-inch pipe. It seemed to hold its strength for several months after work was abandoned, and the gas continues to flow. At a distance of about 1,400 feet a small quantity of very dark strong oil was found, but the company, being organized solely for the purpose of experimenting, abandoned work at about 1,700 feet and nothing more was ever done. The gas was found in a sandstone, and the oil in a limestone. The well was located in the synclinal valley, described by State Geologist Dr. Safford, of the Vanderbilt university of Nashville, as a trough dug out from the diverging point of the Waldens ridge from the Cumberland mountains. It is in the west side of the valley, which has sandstone formation chiefly, while on the east side it is almost totally limestone. Another well was drilled by this company about 2 miles south of Chattanooga to the same depth, the entire work being in solid limestone. Altogether about $3,000 was expended, which exhausted the company's funds, and work ceased.

The Knoxville Natural Gas Company drilled a well at Oliver Springs, in Anderson county, in 1889. At about 1,800 feet a thin gas sand was found, which produced a small amount of gas that burned for several hours. Drilling was continued to 1,860 feet, when the venture was abandoned.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN TENNESSEE IN 1889.

The statistics of the production of natural gas in this state in 1889 are as follows, showing only capital invested and wells drilled and abandoned:

Number of completed wells producing	1
Number of dry holes completed	1
Total number of wells completed in 1889	2
Total number of acres of natural gas land owned	270
Total value of land	$2,700
Value of rigs, wells, etc	11,800
Total capital invested in natural gas industry	14,500

WISCONSIN.

So far as has been ascertained, the only natural gas produced in Wisconsin in the census year was in Oak Creek township, Milwaukee county. 3 wells were drilled during the year; 1 began producing in July, 1 in September, the third well drilled being a dry hole. The initial pressure of the gas was 40 pounds. This was rapidly reduced, however, to 4 pounds closed pressure, with 2½ ounces flowing pressure through a 4-inch pipe.

The estimated daily production of the well drilled in July was 885,000 cubic feet; of the one drilled in September, 200,000 cubic feet. The estimated total production of these wells for the year ended December 31, 1889, was 120,000,000 cubic feet.

At the close of 1889 no use had been made of this gas.

STATISTICS OF THE PRODUCTION OF NATURAL GAS IN WISCONSIN IN 1889.

The statistics of the production of natural gas in this state are as follows:

Number of wells drilled in 1889	3
Number of wells producing December 31, 1889	2
Number of dry holes	1
Total production of wells during the year ended December 31, 1889 (cubic feet)	120,000,000
Total number of employés	6
Total wages paid employés	$1,600
Number of foremen or overseers	1
Total wages paid foremen or overseers	$400
Number of laborers	5
Total wages paid laborers	$1,200
Total number of days each was employed	160
Total capital invested in lands, wells, etc., and used in the business	$4,100
Number of acres of gas lands leased	160
Value of natural gas land	$1,600
Value of rigs, wells, engines, boilers, etc	$2,500
Total cost of drilling wells in 1889, including cost of rigs, drive pipe, casing, and tubing	$2,500
Amount of wages paid labor	$1,600
Cost of materials	$900

COMPLETED NATURAL GAS WELLS IN WISCONSIN IN 1889.

MONTHS	Total number of wells completed in each month.	Number of dry holes.	Number of wells producing.	Initial pressure of new wells. (Pounds.) (a)	Estimated daily production of new wells. (Cubic feet.)
Total	3	1	2	.....	1,085,000
July	1	.....	1	40	885,000
August	1	1	.....	.....	.....
September	1	.....	1	40	200,000

a Pressure closed.

PRODUCING WELLS.

The number of producing wells in Wisconsin in 1889, by months, was as follows: 1 each for July and August, and 2 each for September, October, November, and December. 1 well was abandoned in August.

ASPHALTUM.

ASPHALTUM.

BY E. W. PARKER.

Gilsonite, elaterite, uintite, wurtzilite, albertite, grahamite, asphaltum, maltha, and brea are names given to various semisolid bitumens, which differ considerably from one another in their chemical composition, in their action with acids or other agents, and upon the application of heat; but as every one of them has been called asphaltum, it is deemed advisable for the purposes of the Eleventh Census to group them under that head. This is partly for convenience, but particularly because asphaltum is the common term applied to the class when used industrially, the varieties being designated by the producing locality, and because these substances, through somewhat different processes of manufacture, are used for the same purposes. Asphaltum will be distinguished in this report from asphalt, in that the latter term is usually applied to the manufactured article used for street paving, while the crude mineral is better known as asphaltum.

PRODUCTION IN PREVIOUS YEARS.

From 1882 to 1885, inclusive, the product was estimated at 3,000 short tons per year, having an average value of $10,500. In 1886 the production increased slightly, being 3,500 short tons, value $14,000. In 1887 a still further increase was noted; the product was 4,000 short tons, value $16,000. The production each year was limited to California. The figures for 1888, as published in the Mineral Resources of the United States, show a remarkable increase, due to the production in California of 50,000 tons of bituminous rock (a sandstone formation impregnated with asphaltum), which then came into the market as a competitor with other kinds of material for street paving. In addition to this, 450 tons of gilsonite, valued at $22,500, were produced in the territory of Utah. The value of the total product was estimated at $331,500, but in this aggregate the value of bituminous rock was taken at the price free on board cars. The value at the mines was about $165,000.

PRODUCTION IN THE YEAR 1889.

The product of bituminous rock for the year 1889 was about the same as that for 1888. California produced 47,968 short tons, valued at $126,885 at the mines; Utah, 3,163 short tons, valued at $15,000, and a small amount, 112 tons, valued at $252, was produced in Kentucky. The production of gilsonite in Utah increased slightly, being 492 short tons, valued at $29,400.

The tables following show the product of asphaltum and bituminous rock for the United States for the calendar year 1889, the number of men employed, the average wages per day, and the capital invested in the industry.

ASPHALTUM PRODUCED IN THE UNITED STATES IN 1889.

STATES.	Product. (Short tons.)	Value.
Total	51,735	$171,537
California (bituminous rock)	47,968	126,885
Kentucky (bituminous rock)	112	252
Utah (bituminous rock)	3,163	15,000
Utah (gilsonite)	492	29,400

EMPLOYÉS AT ASPHALTUM MINES.

DESIGNATION.	Average number employed.	Average wages per day.	Average number of days worked.
Total	136		
Above ground:			
Foremen	7	$3.30	156
Mechanics	2	3.25	243
Laborers (a)	110	2.07	244
Office force	2		
Below ground:			
Foremen	1	2.00	172
Miners	11	3.27	135
Laborers	3	2.00	173

a Includes the number employed at 2 mines in California, where work was performed by contract, operators paying 75 cents per ton for mining.

WAGES AND OTHER EXPENSES AT ASPHALTUM MINES.

Wages paid in 1889:		
Labor	$63,503	
Office force at the mines	3,000	
		$66,503
Paid to contractors		8,340
Paid for supplies		13,884
All other expenses (such as rent, insurance, taxes, interest, commissions, etc.)		9,610
Total		98,337

CAPITAL INVESTED.

In land	$2,429,300
In buildings, machinery, etc	37,100
In tools, implements, live stock, etc	139,600
Cash (not included in foregoing items)	45,500
Total	2,651,500

VARIETIES AND LOCALITIES.

Elaterite, albertite, and grahamite are very nearly alike in composition and physical properties. The first occurs principally in Derbyshire, England, and was so named by Hausmann, on account of certain elastic tendencies and its resemblance to India rubber. Albertite, a very similar mineral, occurs in Nova Scotia. Grahamite was found in West Virginia, but the deposit was small and has been exhausted.

Gilsonite and uintite (or uintahite) are the names given to the asphaltum of Utah, which is the purest that has yet been found, the crude mineral containing about 90 per cent of bitumen. It was discovered by Mr. S. H. Gilson, of Salt Lake City, and the name of gilsonite was bestowed upon the mineral in his honor. It is generally so known in commerce, as the Gilson Asphaltum Company of Saint Louis, which operates the deposits, places it on the market under that name. Mineralogists, however, prefer to treat it under the name of uintite, given it by Professor W. P. Blake in the first article published on the subject, from the producing locality, near the Uintah mountains. The gilsonite deposits in Utah lie in the northeastern part of the territory, near Fort Duchesne, and just east of the Uintah Indian reservation. Other fine deposits exist in the Uncompahgre Ute reservation, a short distance from the Colorado state line. During the last session of Congress an unsuccessful effort was made to open to settlement the land on which these deposits lie, which is that known as the "Twelve-Mile strip", embracing two rows of townships on the bank of White river. The mineral is found in veins having nearly a perpendicular dip, and are said to be of good thickness and in a position to be easily mined.

Near the locality from which gilsonite is obtained is a deposit of another peculiar form of bitumen, to which Professor Blake has given the name of wurtzilite. This mineral occurs in Wasatch county, Utah, between Salt Lake City and the Green River valley. When first discovered it was thought that a mineral form of caoutchouc had been found, but this was soon disproved by tests showing that it had no tensile elasticity and would not yield to the usual dissolving agents. It was then classed as a species of elaterite; but Dr. Henry Wurtz, after a thorough investigation, has shown it to be an entirely different mineral. No wurtzilite was mined commercially during the calendar year 1889.

Another species of bitumen, ozocerite, found near the town of Thistle, Utah, is very nearly related in composition, color, and physical properties to artificially prepared paraffin, but differs so widely from asphaltum that it is treated under a separate chapter.

Although for a number of years asphaltum in different forms has been known to exist in California in large quantities, it was not until 1888 that its production assumed any important proportions as an industry. In 1888 a large deposit of bituminous rock containing an unusually large percentage of asphaltum was discovered in Ventura county, and a company of San Francisco capitalists was organized for the purpose of developing and operating it. The owners styled this mineral "asphaltum", but as it contains but 24 per cent of bitumen, the other constituents being silica (about 64 per cent), oxide of iron, and calcium carbonate, it should be classed among the bituminous rock products, and is so treated in the tables of this report. Its high percentage of bitumen, however, increases its value, and the price ranges from $8 to $10 per ton, while the bituminous rock of San Luis Obispo and Santa Cruz counties is valued at about $2.50 per ton at the mines. Deposits of a nature similar to the Ventura product are also being operated in Santa Barbara county.

There are several deposits of bituminous rock in San Luis Obispo and Santa Cruz counties, and a number of companies are now engaged in its production. The peculiar features of asphaltum formations are strikingly illustrated in the deposits of California. It is clearly shown that they belong to no particular era or age. They are found at various altitudes, and with no uniform character in appearance, hardness, or chemical composition. Deposits of solid asphaltum and springs of viscid, oily material, commonly called "brea", occur in places not 1,000 feet apart, and yet in strata of unquestionably different periods of formation.

PRINCIPAL SOURCES OF THE WORLD'S SUPPLY.

Until the remarkable impetus given to the asphaltum industry in California and Utah in 1888 the island of Trinidad and the deposits of Seyssel, in France, and Val-de-Travers, in Switzerland, furnished the bulk of the world's supply. Cuba produces asphaltum of excellent quality, some of which has been imported into the United States. Venezuela has furnished a small portion of the supply in the past, and a few tons of bituminous limestone are imported annually from Germany and the island of Sicily. In the state of Tabasco, Mexico, large deposits of asphaltum are reported, but, although at a convenient place for shipment over the Mexican National railway, only a few small lots have been shipped.

ASPHALT AS A STREET PAVEMENT.

There are few subjects which have been more liberally discussed than that of street paving. Much study has been given to the subject and many comparative tests have been made, but it is not easy to decide which one of the various kinds used in the larger cities affords at the same time the smoothest travel, most durability, and greatest comfort and safety to horses. There is no doubt that asphalt pavements have some advantage over others; they are smooth, and consequently easy on vehicles, and are fairly durable. Asphalt pavements have been used in European cities for a number of years, and are now in use in over 50 cities in the United States, Buffalo (New York) and Washington (District of Columbia) being conspicuous examples.

The methods of preparing the various asphaltums are in a manner similar yet sufficiently distinct to justify a brief description of each process.

PROCESSES OF PREPARATION.

The bituminous limestone of France and Switzerland is prepared for street pavements by being first ground to a fine powder, then passed through iron cylinders, into which air, heated to a temperature of 500° fahrenheit, is introduced. It is thoroughly stirred as it passes through the cylinder and, when it reaches the opposite end, is removed in a plastic condition and spread upon a concrete foundation, compacted by rammers, and when cool the street is ready for use.

The Trinidad asphaltum, upon being unloaded at its point of destination, is placed in large tanks and heated over a slow fire for a few days, care being taken not to heat the mass sufficiently to cause distillation. By this process all foreign substances are eliminated; vegetable impurities rise to the top and are skimmed off, while the earthy contents (clay and sand) settle to the bottom, and the asphaltum is then in a condition for manufacture. For street paving the refined asphaltum is treated with a residuum of petroleum and mixed with fine, sharp sand in the proportion of 14 per cent by weight or 25 per cent in bulk of asphaltum. The mixing is thorough, and is made at a temperature of about 300° fahrenheit. While still hot and plastic it is spread upon the foundation already prepared and rolled by heavy steam rollers. The advantage claimed for this asphalt over the French and Swiss limestone material lies chiefly in the granular nature of the sand used in preparing it, which prevents the slipping of horses.

Gilsonite is prepared for this purpose by being first pulverized and mixed with petroleum oil. The mixture is then heated, care being taken to keep the temperature below 500° fahrenheit, as above that temperature gilsonite will decompose. This composite is mixed, while heated, with broken stone or gravel, and is then ready for the street. It has been ascertained that a mixture of about 80 per cent gravel makes the most durable pavement.

For the manufacture of street paving from the bituminous rock of Ventura and Santa Barbara counties, California, it is only necessary to mix it when heated with the sand of the locality where it is used. Sand is mixed with the asphaltum in the proportion of from 3 to 8 times by bulk of sand to 1 of asphaltum. This method effects a considerable saving in transportation expenses. There is no appreciable loss of time in placing it on the street, as it requires only an hour after laying to "set" and be ready for traffic. Once properly mixed and laid, it seems practically indestructible, as shown by a section of this pavement which had been in use for 18 months on one of the streets of San Francisco in the line of heaviest traffic.

The bituminous rock of San Luis Obispo and Santa Cruz counties is a sandstone thoroughly impregnated with bitumen. It is used almost entirely for street paving, and for that purpose is probably more easily and cheaply prepared than any of the asphaltum products. The only treatment necessary is to steam it, so as to thoroughly mix its ingredients and soften it for spreading to a uniform thickness and a smooth, even surface. Bituminous rock has supplied a limited local demand for 10 or 15 years, but it is only during the past 2 years that it has assumed any commercial importance as an industry. It is reported that pavements made of this material 15 years ago and used under heavy travel have recently been removed and found to have lost very little either in weight or thickness; also that it stands equally well the high temperatures of the interior cities and the cold, damp atmosphere of the coast. It is estimated that there are now 50 miles of bituminous-rock street pavement in the state of California.

FREIGHT RATES, ETC.

Although the production of bituminous rock in California and of gilsonite in Utah has assumed proportions of commercial importance, with indications of much greater activity in the near future, the island of Trinidad continues to be the main source of supply for the United States. In the eastern cities Trinidad asphaltum is used for street paving to the almost entire exclusion of other kinds. This is due entirely to the advantage it has in cost of transportation. The railroad freight rates from the Pacific coast practically shut out the bituminous rock of California from competition in the eastern states, and a similar condition may be said to affect the sale of Trinidad asphaltum in the cities of Europe, since the bituminous limestones of Val-de-Travers and Seyssel, having the advantage in freights, control the markets. The cost of preparing the different varieties of asphaltum for street pavement is nearly the same, and as all appear to be about equally durable, the exclusive use of any one of them is due merely to the advantage in freights.

COMPARATIVE PRICES.

The following statement shows the ruling prices for the different varieties of asphaltum during the year 1889:

PRICES OF ASPHALTUM IN 1889.

	PER TON.
Trinidad crude, at New York	$13.00
Trinidad refined, at New York	30.00
Hard Cuban, at New York	28.00
Gilsonite, at Saint Louis	60.00
California bituminous rock, at the mines	$2.50 to 10.00
Kentucky bituminous rock, at the mines	2.40
	CENTS PER POUND.
Prime Cuban, at New York	4.5 to 5.5

OTHER USES.

Although the greatest use for asphaltum is in the manufacture of street paving, it is by no means confined to that field. Large quantities are consumed in making floors for warehouses, cellars, wineries, breweries, etc. It renders the floors absolutely water tight, and is not affected by acids or gases. For lining dams, levees, and reservoirs a thin coat of asphaltum put on in a melted state presents a permanent water-tight surface, preventing loss by seepage, even when backed by only an earth embankment. As a coating for piling, wharf timbers, ground ends of telegraph poles, etc., it gives almost absolute protection against not only the action of air and water, but also the destructive work of insects and barnacles. It is used as a cement for sea walls and other marine architecture, where its waterproof character makes it especially valuable as a binding material. It is claimed to make wood conduits almost, if not quite, as durable as iron, and any iron or other metal work, such as anchors, etc., coated with it will not rust nor be affected by sea water. It is also used as a roofing material, and, being practically a nonconductor of electricity, serves a useful purpose as an insulator for electrical wires. Varnish is manufactured from refined asphaltum or gilsonite by simply heating with spirits of turpentine.

NEW DISCOVERIES.

Asphaltum deposits have been found in some of the northwestern counties of Alabama, and some progress has been made in the way of developing the properties, but none of the mineral had been mined up to the close of the year 1889. Other deposits are reported in Grayson and Hardin counties, Kentucky, on which partial developments

have been made, but the owners are waiting a more lucrative demand. In Burnet county, Texas, asphaltum is known to exist, but little authentic information is obtainable regarding its extent and character.

IMPORTS.

The increased demand for asphaltum during the past 20 years is shown by the quantities imported and entered for consumption in the United States during that time.

ASPHALTUM IMPORTED INTO THE UNITED STATES FROM 1867 TO 1889.

YEARS ENDED—	Quantity. (Short tons.)	Value. (a)
June 30, 1867	.....	$6,268
1868	185	5,632
1869	203	10,559
1870	488	13,072
1871	1,301	14,760
1872	1,474	35,533
1873	2,314	36,298
1874	1,183	17,710
1875	1,171	26,006
1876	807	23,818
1877	4,532	36,550
1878	5,476	35,932
1879	8,084	39,635
1880	11,830	87,889
1881	12,883	95,410
1882	15,015	102,698
1883	33,116	149,999
1884	36,078	145,571
Dec. 31, 1885	18,407	88,087
1886	32,565	108,528
1887	30,808	95,735
1888	36,494	84,045
1889	61,952	138,163

a Values are given for Trinidad asphaltum at the point of production. The prices at New York, freights included, are given in the previous table.

Acknowledgments are due to Captain F. V. Greene, of New York city, for the following valuable information regarding the importation of asphaltum from Trinidad and other foreign sources. In the statements given below the figures relating to Trinidad asphaltum were obtained by Captain Greene from the records of the company of which he is vice president, while those relating to imports from other sources are estimates made by him based upon his intimate knowledge of the business. Though not derived from any positive records, they are practically correct.

IMPORTS OF TRINIDAD ASPHALTUM BY ALL COMPANIES FROM 1880 TO 1890, INCLUSIVE.

	LONG TONS.
1880	3,913
1881	6,707
1882	14,263
1883	23,309
1884	19,630
1885	15,289
1886	27,757
1887	26,593
1888	35,137
1889	52,881
1890	54,692
Total	280,171

CUBA.

About 800 tons of asphaltum were imported from Cuba in 1881 and 1882, but there have been no importations of any consequence since 1882.

VENEZUELA.

During 1885 and 1886 about 500 tons were obtained from Venezuela, but no amount of any importance has been imported into this country from there since that time.

From Neuchatel, Switzerland, and Seyssel, France, the imports of bituminous limestone, sometimes called

"asphalte", are about 200 tons annually, and about 150 tons of a similar material are imported each year from Hanover and Brunswick, Germany. All of this material was used in laying sidewalks and for interior work. During 1887, 1888, 1889, and 1890 about 6,000 tons of bituminous limestone were imported from Sicily and used for street paving.

PAVEMENTS OF TRINIDAD ASPHALTUM.

The number of square yards of Trinidad asphaltum laid in the United States in the past decade is as follows:

NUMBER OF SQUARE YARDS OF TRINIDAD ASPHALT PAVING LAID IN THE UNITED STATES FROM 1880 TO 1890, INCLUSIVE.

	SQUARE YARDS.
1880	106,838
1881	116,629
1882	196,184
1883	387,510
1884	424,524
1885	403,882
1886	623,188
1887	799,335
1888	757,101
1889	1,130,863
1890	1,857,000
Total	a6,803,054

a Equivalent to 446 miles of roadway 26 feet wide.

Trinidad asphaltum is being used for street paving in the following 49 cities in the United States and Canada:

CITIES WHERE TRINIDAD ASPHALT PAVEMENTS ARE USED.

District of Columbia	Washington and Georgetown.
Georgia	Savannah.
Illinois	Chicago.
Indiana	Fort Wayne and Indianapolis.
Kansas	Topeka, Wichita, and Wyandotte.
Kentucky	Louisville.
Louisiana	New Orleans.
Maryland	Baltimore.
Massachusetts	Boston.
Michigan	Detroit.
Minnesota	Saint Paul.
Missouri	Kansas City, Saint Joseph, and Saint Louis.
Nebraska	Omaha.
New Jersey	Newark.
New York	Albany, Binghamton, Brooklyn, Buffalo, Lockport, Long Island City, New York, Rochester, Schenectady, Syracuse, Troy, and Utica.
Ohio	Cincinnati, Cleveland, Columbus, Toledo, and Youngstown.
Pennsylvania	Allegheny, Altoona, Erie, Harrisburg, Philadelphia, Pittsburg, Scranton, and Wilkesbarre.
Tennessee	Chattanooga.
Canada	Montreal, Quebec, and Toronto.

PERCENTAGE OF USES FOR TRINIDAD ASPHALTUM.

From the best information obtainable, the proportions of Trinidad asphaltum used for different purposes are about as follows:

PROPORTIONS OF USES OF TRINIDAD ASPHALTUM.

	PER CENT.
For laying sheet asphalt pavements	72
For manufacturing asphalt blocks and tiles for pavements	24
Total for paving	96
For roofing	3
For all other purposes	1
Total	100

The amount of asphalt blocks manufactured and laid as pavements has varied from 5,000 to 100,000 square yards per annum, and the total from 1880 to 1890, inclusive, is estimated at 500,000 square yards.

PAVEMENTS FROM BITUMINOUS LIMESTONE.

About 55,000 square yards of bituminous limestone pavement were laid in Washington, District of Columbia, during 1876 and 1877, and about 3,000 square yards in New York in 1883 or 1884. Nearly all of this was subsequently taken up and replaced by Trinidad asphaltum. In 1887 about 10,000 square yards were laid in Rochester, New York; in 1888 about 20,000 square yards in Saint Augustine, Florida, and, in 1890, 40,000 square yards in New York city. Captain Greene estimates that the total amount of bituminous limestone pavement now in use in the United States does not exceed 75,000 square yards.

ASPHALT PAVEMENTS IN EUROPEAN CITIES.

The asphalt pavements in Europe are all made from the bituminous limestones obtained from the localities mentioned previously in this report. The pavements are found in Berlin, London, Paris, and a few other cities, probably not exceeding 10 in all. The total area covered is, approximately, as follows, according to the authorities cited, and it is about one-fourth of that covered by Trinidad asphalt pavements in the United States:

AREAS OF BITUMINOUS LIMESTONE PAVEMENTS IN USE IN EUROPEAN CITIES.

	SQUARE YARDS.
Berlin	*a* 681,486
London	*b* 360,000
Paris	*c* 357,360
Other cities	*d* 300,000
Total	1,698,846

a United States Consular Reports, No. 120.
b Reports of paving companies.
c Annuaire Statistique de la Ville de Paris, 1885, page 26.
d Estimated.

OZOCERITE.

OZOCERITE.

BY E. W. PARKER.

Under the chapter on asphaltum mention is made of one of the forms of bitumen possessing such peculiar properties as to entitle it to treatment under a separate head. This is what is known as "mineral wax", or ozocerite. Asphaltum exists in a number of forms, from semiliquid to solid, having qualities similar to pitch or tar, but without any constant chemical composition, and its varieties are as numerous as the localities producing it. Ozocerite, on the other hand, belongs to the series of hydrocarbon compounds which includes marsh gas, petroleum, and paraffin. To the last mentioned it is very similar in appearance. It is colorless to white when pure, but frequently occurs leek green, yellow, and brown.

SOURCES OF SUPPLY.

Prior to 1888 the only locality producing mineral wax was in the province of Galicia, in Austria. Mining began there in 1862, and though at first it was found exceedingly difficult to obtain sufficient capital to push the enterprise, it has increased rapidly since that date, and at present there are 35 companies engaged in the industry in the province of Galicia alone. For 26 years production was limited to this locality, but in 1888 American ozocerite began to receive the attention of the trade, and considerable work was begun upon a newly discovered vein in Utah. The mineral had been known to exist in Utah for some years, but whether in paying quantity was not satisfactorily determined until August, 1888.

PRODUCTION.

During 1888 and 1889 most of the work done was in the way of development, but in the latter year there were incidentally produced 75,000 pounds of crude ozocerite. Of this product about one-third is lost in refining, the amount of refined ozocerite being 50,000 pounds, valued at $2,500. The product for 1888 was estimated at 65,000 pounds of crude mineral. The figures regarding expenses and capital for 1889 are withheld from publication for the protection of individual interests. The product for 1890 will probably exceed 300,000 pounds.

USES.

Refined ozocerite is used for nearly all the purposes to which ordinary beeswax is applicable. It possesses nearly all the properties of beeswax except stickiness, but in cases where that quality is essential it is necessary only to mix the mineral with ordinary beeswax. The uses of beeswax are so many and at the same time so well known that it is not considered necessary to discuss them in this report. Crude ozocerite, like other hydrocarbon compounds, is used to a considerable extent as an insulator for electrical wires.

IMPORTS.

The following table shows the quantity and value of crude and refined ozocerite imported into the United States from 1873 to 1889, inclusive:

IMPORTS OF MINERAL WAX, 1873 TO 1889, INCLUSIVE. (*a*)

YEARS ENDED—	Quantity. (Pounds.)	Value.
June 30, 1873	25,135	$4,244
1874	380	40
1875	7,430	1,026
1876	16,525	2,229
1877	101,604	11,720
1878	69,884	7,870
1879	44,963	6,016
1880	103,973	14,057
1881	98,911	12,792
1882	272,509	29,322
1883	565,658	52,774
1884	617,992	69,026
1885	1,056,438	123,976
Dec. 31, 1886	800,496	71,220
1887	718,769	59,084
1888	1,164,940	89,131
1889	1,078,725	86,682

a Up to and including 1883 imported under "wax, and manufactures of" and classed as "bay or myrtle, Brazilian and Chinese"; since as "mineral wax".