REPORT OF STATE SUPERVISOR OF NATURAL GAS.

OFFICE OF SUPERVISOR OF NATURAL GAS,
INDIANAPOLIS, IND , January 1, 1894.

To HON. S. S. GORBY,
State Geologist, Indianapolis, Ind.:

SIR—In accordance with the laws of the State of Indiana, relating to the supervision of natural gas and the inspection of gas wells and gas plants, I have the honor to submit to you the following report on the conditions of the gas fields of the State, and the transactions of this department for the year 1893.

In the inspection of plants furnishing gas to private consumers, I have, in most instances, found the machinery in a fair to good condition and comparatively safe. But few accidents have occurred, and these resulted from defective house plumbing and were not the fault of the machinery of the plant.

The owners and managers of gas plants have met me in a fair spirit, and directions that have been given for repairs and improvements, in order to throw additional safe-guards around the consumer, have been cheerfully and readily followed. The men who have direct charge of the plants are becoming more competent by experience, and the most of them are beginning to appreciate the dangerous character of the powerful agent under their control.

A great deal of reckless and unnecessary waste of gas is yet practiced in some parts of the field, which I have been unable to stop, for the reason that the local officers who are charged with the prosecution of the laws neglect or refuse to act. Public sentiment in those localities is of such a character as to render it impossible to enforce any law looking to the preservation of this fuel.

The laws regulating the tubing and packing of wells and the plugging of abandoned wells are very generally obeyed.

In the large oil field that is being developed in the counties of Blackford, Jay, Wells and Grant, I regret to say that a great waste of gas is practiced. The methods used for obtaining oil are such that it is practically impossible to prevent waste of gas. It would be a fortunate

thing if some method could be devised whereby the production of oil, or gas either, could be had without destruction to the other products. With the present method the production of oil is bound to destroy the gas field. Another great waste of gas is practiced by the domestic consumers. The devices for burning, which are in use, are such that at least fifty per cent. more gas is consumed than is necessary. The present method of selling gas by the month, instead of by measure, is responsible for the continuation of this waste. I would recommend that a law be passed compelling all gas to be sold by meter measurements.

In the prosecution of my work I have everywhere met with kind and courteous treatment, and every assistance possible has been rendered me. I take this method of tendering my sincere thanks for the same.

Respectfully,

E. T. J. JORDAN,

Supervisor of Natural Gas.

AREA OF THE GAS FIELD.

While natural gas has been prospected for by the drilling of wells in nearly every county in the State of Indiana, yet outside of the areas mapped out and published with former reports from this department, no developments have been made of any scientific or commercial importance. The boundaries of the "belt," as it is called, have been very clearly defined. No discoveries have been made that would necessitate any change. Therefore the maps that accompany this report may be relied upon as accurate. Vast sums of money have been expended within this State in prospecting for this fuel, without any returns. Much of this could have been saved if the prospectors had understood the conditions necessary for the production of natural gas. These conditions have been fully set forth in former reports from this office, and are worthy the careful study of all who are interested in the production of this fuel. It would be a superfluity to repeat them here.

The perpetuation of the natural gas fields is a question of vital interest to Indiana, as this State has been benefited to the extent of millions of dollars within the past few years by the discovery of this valuable fuel.

THE HISTORY OF GAS.

The history of natural gas fields shows that they are of but temporary duration. Indeed, it is but natural that the accumulations of centuries should be exhausted in time by the constant and immense drains to which all the fields have been subjected. Nature can not manufacture it as fast as it is being consumed, and the natural flow of the wells must soon become exhausted. Gas in the great fields of Pennsylvania and Ohio is a thing of the past, if the natural flow of the wells is to be relied upon for the supply. Matters are in a distressing condition in those States, and especially in northwestern Ohio, as all the towns are left burdened with debt, and with no other resources at their command. Their era of prosperity is at an end, so far as it depended upon natural gas. In many of these towns, as a natural result of the criminal waste of nature's most valuable fuel and the unnatural business excitement and wild speculation that obtained for years, it may be truthfully said that "their last days shall be worse than their first." It remains to be seen whether the same disastrous conditions will mark the end of natural gas in Indiana.

About the time that natural gas began to fail in Ohio and Pennsylvania, the great fields of Indiana were discovered, and their vast extent, as well as the apparent stability of the supply of the wells, seemed to warrant the belief that at last a permanent supply had been found. As a result of this discovery and the failure of the Ohio fields, the factories accepted the offer of the cities and towns in the Indiana gas field and removed their plants to this State. The loss of these factories to northwestern Ohio caused a terrible panic and collapse throughout that gas belt, and fortunes sank from sight as values declined to their normal condition. Over $300,000,000 has been invested in this State in manufactories, and others are now being erected throughout the gas belt. Pipe lines were run to the gas field from Chicago, and from many of the principal cities and towns in the State, and every effort has been made to control as much of the territory as possible. Slowly the ends of these pipe lines have been converging to a given point until now but little of the gas territory remains to be developed. There is no question but the time will eventually come, although a long way off as yet, on account of the vast extent of the fields, when every inch of Indiana gas territory will have been developed, and then the supply will rapidly diminish.

THE FAILURE HAS BEGUN.

Indeed the failure has already begun. Already wells are being abandoned every month, and the rock pressure in many parts of the field is rapidly diminishing. The average field pressure has slowly but surely fallen off, and now stands reduced from 320 pounds, original pressure, to 240 pounds average pressure over the field.

To preserve a full supply of fuel gas to their patrons the different companies and the manufactories have been obliged every year to reach out to remoter fields, drilling many new wells and extending great pipe line plants at very heavy cost.

The limit of extension is nearly reached. Many wells are wet; nearly all show moisture when heavily drawn upon, and must be held back or risk the danger of being flooded out.

At the rate of pressure reduction that is now going on, and by a continuance of the present extravagant and wasteful method of consumption it is only a question of a very short time when artificial pressure will have to be used to force the gas through the pipe lines. The use of pumps for artificial pressure is fraught with most serious risk of reducing the gas pressure below the water pressure, and so destroy the wells.

The question of perpetuating or husbanding the supply of the field becomes a vital one. Indiana has the largest and best gas field ever discovered, and as no new fields are in prospect, it seems that these are the last fields that will ever be brought into requisition for manufacturing purposes.

With these gloomy conditions of the supply staring us in the face, we should awake to a realization of the fact that natural gas is a temporary blessing. It is the plain duty of every good citizen to coöperate to the fullest extent to preserve the supply of gas so long as it is possible to do so. It is the plain duty of managers of companies, or those engaged in furnishing supplies of this fuel, to sound the note of alarm, and to point out the way by which the flow of gas can be prolonged, and this great source of comfort and convenience continued over the longest possible period. A system of the strictest economy should be enforced and the remainder of the precious fluid should be distributed to the consumers as ordered by special acts of the Legislature.

AN ERA OF PROSPERITY.

Immediately upon the discovery of natural gas in Indiana an era of prosperity began that has been unparalleled. Immense manufacturing establishments were located, and, in time, when these were started and their fires, fed by Nature's best fuel, started, great train loads of their products were sent out from the gas belt every day. Villages became prosperous towns, and towns grew in a few months into thriving cities, and lots were sold at high prices many miles from their centers. Much wild speculation has prevailed. A great deal of unnatural and unhealthy excitement in business has marked the history of some of these towns since the discovery of this fuel. However this has not been carried to that extent that it was in the towns of Ohio. The business men in these towns, profiting by the fate of the towns in the State above mentioned, have been more conservative. One of the worst features of the excitement that prevailed, was the belief in the ideas that natural gas was to be perpetual. This belief fostered extravagance and waste. It can be shown from facts obtained and recorded in this department that the waste of gas, during the first four years after its discovery in the fields of Indiana, amounted to more than twenty millions of dollars. And this estimate, too, is made on the extremely low prices at which gas has been sold throughout the State.

This condition of affairs continued, as I say, for four years before the people, who were vitally interested, were willing to admit the fact that natural gas was failing, and failing rapidly, too. The pressure began to go down in all the principal centers, and, in fact, nearly all over the field. The supply in many places began to fall short, and there was much suffering during the hard winter of 1892–3. A great many factories, in the towns deriving their supplies from this gas field, were shut off from the lines and asked to burn coal

These stern conditions have at last aroused the people to view the situation in its true light. Much of the extravagance and waste has been stopped. Men are seeking to find out the best means for husbanding

what remains of this valuable fuel. Some wholesome laws were passed by the Legislature for the preservation of gas. In regard to these laws, I regret to say that in some localities they have not been enforced as rigidly as they should be, and the fault has been with the local officers charged with enforcing the laws. Many of these officers are aspirants, and are afraid of their popularity.

One of the wastes of gas that still prevails is in the domestic consumptions. With the appliances for burning gas, that are almost universally used, at least 50 per cent. more gas is used than is necessary to produce the required amount of heat.

CUBIC FEET OF GAS BURNED IN ONE HOUR.

The following table is given to show the amount of gas that is consumed through different sized mixers, and at different pressures. The tests which produced these results were made with a Westinghouse meter, and may be relied upon as correct:

This table was given in my last report, and published in the eighteenth Geological Report of Indiana, but by a mistake of the printer, an error was made which rendered it valueless.

SIZE OF MIXER.

PRESSURE.	No. 3—$\frac{3}{32}$-inch.	No. 5—$\frac{5}{32}$-inch.	No. 7—$\frac{7}{32}$-inch.	No. 9—$\frac{9}{32}$-inch.	
$\frac{3}{16}$-pounds. . .	36 cu. ft.	66 cu. ft.	96 cu. ft.	156 cu. ft.	The fractions of an inch given in the size of the mixers denote the diameters of the orifice through which the gas passes at the point of admixture with the air.
$\frac{1}{4}$ " . . .	41 "	76 "	108 "	164 "	
$\frac{5}{16}$ " . . .	45 "	84 "	116 "	178 "	
$\frac{3}{8}$ " . . .	48 "	96 "	134 "	196 "	
$\frac{7}{16}$ " . . .	55 "	100 "	144 "	208 "	
$\frac{1}{2}$ " . . .	60 "	108 "	156 "	228 "	
$\frac{9}{16}$ " . . .	64 "	114 "	168 "	240 "	
1 " . . .	68 "	120 "	179 "	256 "	

It will be seen from the above table that the greater the pressure in a mixer, the greater number of cubic feet of gas is consumed with only a fixed amount of air. Natural gas, like any other fuel, requires a certain amount of air, in order to have a perfect combustion. It follows, then, that the higher the pressure the greater the amount of gas that passes through the mixer and the more imperfect is the combustion. With the imperfect appliances now in use, the greatest amount of heat is not obtained. This is not only wasteful, but it is dangerous from the fact that this half burned gas is liable to escape into houses and cause suffocation or explosion.

With the mixers now in general use, a pressure of from six to ten ounces in the low pressure mains, will furnish as much, if not more gas, than can be perfectly consumed. Under the conditions existing in most, if not all, of the towns and smaller cities of the Indiana gas field, a pressure of from one to five pounds is carried.

IMPROVED MIXERS AND BURNERS.

On this branch of the subject I am willing to risk criticism by repeating what I have said in my former reports. Too much can not be said on this question. All who are interested in the perpetuity of this fuel should be taught to know what extravagances and waste are being practiced and the causes. Consumers have been slow to adopt improved mixers and burners. In many of the towns the gas plants are not arranged for the proper and equal distribution of the gas. Improved appliances and devices cost money, and so long as the present method of paying for the gas by the month or year is permitted, just so long will the present waste continue.

The remedy is to compel, by legislation if necessary, consumers to pay for the gas used by meter measurement. When this method shall become the rule, consumers will find it to their interest to adopt the improved methods for burning this fuel, and will economize its use in every way possible. Until this is done I can see but little hope for economy in the consumption of this precious fuel. The waste will continue, and the end will be correspondingly hastened. The supply of gas is certainly failing. It may not be possible to tell just how long it will last, but the final exhaustion is inevitable. The period of exhaustion has been entered upon in the Indiana field, and the end is close at hand. The theory of the generation of this fluid in commercial quantities is not now believed or advocated by any person who has studied the conditions as they exist. Indeed, it is more than probable that this generation ceased many ages ago. There is a given amount stored within the areas of the gas-bearing rocks. This storehouse is tapped in Indiana by many hundreds of wells, and millions of cubic feet are drawn out every day. As the gas is withdrawn water or oil comes in and takes its place. Turn whichever way we may in our explorations and theorizing, the fact of the final exhaustion of this fuel stares us in the face.

THE INITIAL PRESSURE.

The following is the pressure found in named localities during the year 1893. At many of the places, however, the pressure given was only obtained from new wells at a distance of from two to four miles from the towns, the wells in the towns and immediate vicinity showing a much less pressure, many wells being practically exhausted:

Town.	County.	Pressure, Pounds.
Greenfield	Hancock	250
Carthage	Rush	120
Noblesville	Hamilton	240
Sheridan	Hamilton	240
Kokomo	Howard	250
Marion	Grant	250
Gas City	Grant	300
Fairmount	Grant	300
Elwood	Madison	300
Frankton	Madison	300
Anderson	Madison	240
Alexander	Madison	300
Summitville	Madison	300
Chesterfield	Madison	290
Muncie	Delaware	240
Albany	Delaware	280
Eaton	Delaware	290
Hartford City	Blackford	260
Montpelier	Blackford	250
Camden	Jay	225
Dunkirk	Jay	275
Greensburg	Decatur	175
Fountaintown	Shelby	210
Waldron	Shelby	225

These pressures were found in the most instances in new wells. In their immediate neighborhood are fonnd older wells showing a much less pressure, some even below 100 pounds.

The wells connected with the pipe lines conveying gas to Indianapolis, Crawfordsville, Frankfort, Lafayette, Logansport, Peru, Wabash, Huntington, Bluffton, Fort Wayne, Decatur, Portland and Shelbyville show pressures from 225 to 260 pounds

The wells and the pipe lines leading to Chicago and Richmond are better, showing 280 and 290 pounds pressure. These companies, in order to keep up the necessary supply of gas, are compelled to drill many new wells each year to take the place of those that have become exhausted. Each year these companies have been compelled to acquire new leases and extend their lines, until there is but very little territory to be obtained. If, in drilling these new wells, the pressure of the original wells could be obtained, there might be some hope of the perpetuity of the gas. But such is not the case. The new wells are coming in with a constantly decreasing pressure, and of necessity will be much shorter lived than the original wells. All this goes to prove that the field is slowly but surely becoming exhausted. This exhaustion will be in an accelerated ratio as we approach the final end.

The gravity of the situation can only be understood when it is known that from 225 to 250 pounds pressure at the head of the main lines is

absolutely necessary to force the gas to the different cities that lie outside, but are obtaining their fuel from the gas field, with sufficient pressure to distribute it through the low pressure city lines to the consumers. And this pressure, too, is needed when all the reducing stations and district valves are wide open and every facility afforded for free circulation.

There remains now but a small average margin above the limit of low pressure. At the annual rate of pressure reduction, and by a continuance of the present extravagant and wasteful method of consumption, this small margin will be spent or exhausted in a very short time. When this shall have happened, artificial pressure by means of pumps will be resorted to for the purpose of distribution. It has been the experience of the gas areas of other States, that when the initial pressure must be supplemented by artificial means, that the end is very near at hand. A careful study of the conditions of the field in Indiana as they exist to-day will show that we have almost reached that point.

What must we do? Are we willing to go back to the use of wood and coal? After having enjoyed the conveniences and luxuries of natural gas for so long a time to do so would be a great hardship. In order to avoid doing so, or at least to put off the evil day as long as possible, consumers should be willing to adopt any method that would preserve this fuel, and perpetuate its use for the longest possible period of time.

THE REMEDY FOR PRESENT EVILS.

In order to do this, I have the following suggestions:

First. All gas should be sold by meter measurements, and this should be enforced by law.

Second. Natural gas should not be used in the manufacture of bricks, tiles, nor in the rolling mills or melting furnaces of glass factories. In these factories a coarser and less valuable fuel can be used.

The highest and best purpose to which natural gas can be applied is the domestic use. It is in this use that it does the greatest good to the greatest number, and it is for this use that it should be preserved.

The present consumption in the domestic use of gas, as I have said, is, without doubt, fully fifty per cent. greater than is actually necessary. This profligate waste of such valuable fuel is inexcusable. Now, if it is possible to check this extravagance, I believe the supply can be made to last several years. There is but one way to stop this reckless and criminal wastefulness, and that is to require each consumer to pay for just what the consumer uses—no more and no less. This can be done only by the use of a meter. Natural gas is a commodity, and a very valuable commodity, and every other commodity in the commercial world is sold by weight or measure. Experience has shown that this is the only just and equitable way of selling natural gas. The price per thousand feet should be approximately the same as charged in cities where conditions

are similar. The following are the net meter rates per thousand feet charged in other cities: Detroit, Piqua, Lima, Dayton, Springfield, Toledo, Buffalo and Columbus, 25 cents; Pittsburgh, Allegheny and Erie, 22½ cents; Jamestown and Corry, 21$\frac{6}{10}$ cents; Fostoria and Logansport, 20 cents; Indianapolis, Richmond and Fort Wayne, when sold to manufacturers by meter, 10 cents.

When the time comes that consumers will be compelled to pay for what they use, then, and not till then, will economy be practiced. Then it will be that the consumer will provide himself with the most approved appliances for the economical use of this fuel. There is a growing disposition to introduce meters into all the distributing systems of the natural gas companies. When this fuel was first brought into use, the supply was so abundant, that the reckless wastes, of which I have spoken, were tolerated. When it was taught, and generally believed by consumers that the supply was inexhaustible, the necessity for economy was not felt. When it cost the same by the month or year, whether much or little was consumed, there was no inducement to economize.

Under that condition of things the low prices for gas that have since prevailed, and the method of payment was fixed. No inducement was offered to the uses of gas to adopt economical methods. The prices in most places have been merely nominal. The extremely small cost at which this fuel could be procured was one of the causes that led to the reckless extravagance and waste that has been practiced. Whatever costs but little is not apt to be highly valued. Meters are now constructed so as to be adapted to this fuel. The objection that was at first urged against the use of meters, viz.: that the meters were very imperfect, will no longer hold good.

The day has passed away when any nice regard for economy in the use of natural gas is deemed foolish and futile. The warnings that the supply of this precious stock of heat and power is limited and that it is fast becoming exhausted, are so plain that no one can any longer fail to recognize them.

GAS FORMATION HAS CEASED.

I have before stated that it is held by all scientists and others who have given the matter any thought, that gas is not being generated at the present time in any appreciable quantities, and certainly not in quantities sufficient to meet the enormous drain that is being made on the different fields to-day. This being true, the necessity for husbanding the supply in every conceivable way becomes apparent. The highest interest of every consumer is to make the product last as long as possible. Any waste or prodigality in the use of this most valuable fuel becomes at once a crime against the public good. "The greatest good

to the greatest number" should be kept in view in the use and management of this fuel.

By prodigality and mismanagement the final failure of the product has been hastened all too rapidly. This failure can not be overlooked. It is shown by the diminished initial pressure and by the presence of salt water.

An advance in price on the part of all municipal corporations for all the uses they undertake to supply is now the proper policy. The prices at which this fuel has hitherto been furnished has led to the undervaluing and wasting of gas. The supply will do towns more good by serving them longer if they are required to pay a higher price for the gas.

Natural gas is merely a transient phase of the stored power of the earth. It is folly to talk of its taking anything like a permanent place in the work of the world. The claim that it can do so springs only from enthusiasm and is unsupported by the facts. There is in reality but little of it, and this is found in but limited regions and can not last long whenever its utilization is undertaken by the eager and masterful activities of our day.

If proper management of the field by the enforcement of wholesome laws, and if economy in the use of gas is everywhere insisted upon and practiced, that portion of gas that yet remains stored in the Trenton limestone of Indiana may be made to last several years. It is to this end that all should work. It is to the highest interest of every one to prolong the use of this luxury. It is in our power to make the last days of natural gas in Indiana its best days. If, on the other hand, the wasteful practices in consumption shall be maintained, if improper and ruinous management of wells in the field shall still prevail, there is sure to be, and at a no very distant day, an entire failure and a great disappointment. When this day comes our disappointment will be the greater and our regret the more bitter when we realize that our condition is the result of our short sighted management and profligacy.

TO PERPETUATE THE FIELDS.

Now that the final exhaustion of the supply of natural gas is an admitted fact, many persons are directing their attention to the finding of a substitute that shall combine all of its luxury and convenience. Plants for the manufacture of fuel gas have been built in many cities, and are in operation with some degree of success. However, none, as far as I have been able to learn, have succeeded in manufacturing a fuel that is equal to natural gas. The inventive genius of the American people is unlimited, and I predict their success in this direction. Natural gas has been a great object lesson to great communities as to the advantage of gaseous fuel, and it can hardly be that this lesson will be given in vain.

It has prepared the world for something much better than itself. Natural gas has done a very important work.

I may be permitted while on this subject to repeat from a former report from this Department, and say that "the exemption from the soot and dust is inseparable from the burning of bituminous coal in our cities, and the positive addition that gaseous fuel makes to the comfort and convenience of the entire community when used as a domestic fuel and as a source of steam power, are results in themselves too valuable to be abandoned when these small and treacherous stocks of buried power are exhausted. The conversion of the coal now burned in a large city into gas before being used would result in an immense economy in fuel, besides affording the incidental advantages alluded to above, and this economy of stored power is an object to which the civilized world will soon be obliged to address itself in good earnest."

Progress is the order of this age, and no backward step will be taken in the matter of fuel. That portion of the human race that has experienced the comfort and convenience of natural gas will never be content to go back to wood and coal, burned in the old way, as a source of heat and power.

In many of the gas fields, as has been before stated, when the gas is exhausted in the porous rock, oil takes its place. A theory has been advanced by some that the gas fields can be perpetuated by forcing air down the wells into the rock by means of powerful pumps. Some of the cities and towns of northwestern Ohio, I have been informed, are now engaged in very expensive experiments in order to test this theory. The Trenton rock in those fields being oil-bearing, is porous and saturated with oil deposits. It is thought that by forcing the air through this rock it becomes carbonated, and after being thus filtered, returns to the surface of the earth where it is piped and consumed. A large plant to test this theory is being put in at Findlay, Ohio, and its promoters are very sanguine of success.

THE PROCESS EXPLAINED.

A late newspaper, published at Findlay, Ohio, has this to say in explanation of the process: "By the new process the pressure at all times would be governed to suit the changes of temperature, and so avoid shortage of gas at the time when most wanted.

"These sanguine anticipations are not in line with the old croakers who never developed an original thought, or lost an opportunity to obstruct every progressive step suggested. The fact still remains (notwithstanding every obstruction) that at no time since the introduction of practical science in general business have we been required to take a backward step in anything essential to the comfort, convenience and higher development of the human race. In keeping with such universal progress,

we must find some way to utilize this boundless supply of fuel which nature has stored in a reservoir below us, and which present methods fail to reach.

"The fact is now demonstrated in thousands of places that air forced through a reservoir of oil is carbonated, and becomes a better illuminating gas than any natural gas. Who will give an intelligent reason why air, forced through nature's oil reservoir, should not produce gas equally good and in proportionately larger quantities than is produced from artificial tanks of oil? Within the last few months interesting illustrations have been given at different places in Ohio and Indiana. Gas from a high pressure field was conveyed through a long pipe line, and permitted to return to the porous rock through a few wells connected with said pipe line in a low-pressure field, and from which surrounding wells within a half to a mile radius were supplied with gas. Every proposition on which this enterprise depends is already proved in various similar operations, and the promoters of the enterprise have every reason to anticipate in the near future a general revolution from the old to the new method of producing gas."

In regard to this theory the facts at hand are not sufficient to warrant me in hazarding an opinion of its practicability in the production of fuel. That air can be forced through the porous portions of the Trenton rock is undoubtedly true. Demonstrations of this have been shown in the Indiana field. A high pressure pipe line passing through low pressure locality, and having low pressure wells connected with it, will cause an increase, in the well pressure in the immediate territory surrounding such wells. This has been experienced at Noblesville, in Hamilton County, and at Kempton, in Tipton County. In fact this condition may be observed on any pipe line that has wells connected therewith whose initial pressure is lower than the line pressure. This fact is so well known that many gas companies disconnect their low pressure wells that lie in the immediate neighborhood of wells belonging to rival companies. Without doing this they know that by this means they would be furnishing gas to their rivals without compensation. In regard to the air becoming sufficiently carbonated in its passage through the oil deposits contained in the pores of the Trenton limestone to make it a fuel equal to natural gas I have no means of knowing. I shall await with a great deal of interest the outcome of the experiments that are now being made. In partial support of what is expected to be accomplished by the supporters of this theory, it may be said, first, that within the greater portions of the gas fields of Ohio and Indiana large oil deposits are found in the porous rock, and second, that the forcing of air through this porous rock by artificial means is practical.

In view of the fact that the natural gas supply of Indiana will soon be exhausted experiments like the one above mentioned are looked to

with a great deal of interest. Should they be successful a vast amount of valuable fuel will be made available, and the wonderful era of prosperity that was inaugurated by the discovery of natural gas within the State of Indiana will be continued indefinitely. In that event, and with the supply of fuel regulated at pleasure, the gas belt of Indiana would become the greatest manufacturing center the world has ever seen.

TRANSPORTATION OF GAS.

One of the great wastes of natural gas that exists in the Indiana gas field is the leakage from pipe lines. During the early days of this fuel, when most of the pipe lines were laid, experience had not then taught the necessity of using the best pipes and fittings. Cheap pipes and cheap connections was the rule. Especially is this true in what is known as "farmer lines," that is, lines that supply people who live in the country. These lines, as well as many that supply the towns and cities, were laid by persons of no experience, and were not tested as to their capacity to withstand high pressures. The result was that leaks were at almost every connection in many of those lines, and great wastage of gas. Much improvement, however, has been made in many of these plants. Better material and better work has been substituted. Especially is this true of the plants that have been put in more recently. Good material is now used, and lines are thoroughly tested before being subjected to the pressure from the gas wells. A fair estimate of the results of these improvements would be that the loss from leakage from the pipe lines has been reduced more than one-half. Not only was there a great loss of valuable fuel from this cause, but there was a great danger to life and property. Many accidents have occurred that has resulted in the loss of life and the destruction of much valuable property that can be directly traced to leakage in pipe lines and mains.

All pipes used for the conveyance of natural gas should be tested by hydrostatic pressure up to at least 300 pounds to the square inch, and the pipe should be rapped with a hammer while under pressure.

The weight in pounds of one foot of cast-iron pipe may be calculated by the following formula:

$W=(D^2-d^2)\times 2.45.$

When D = outside diameter of pipe in inches.

d = inside diameter of pipe in inches.

W = weight of a lineal foot of pipe in pounds.

Example: Required, the weight of one foot of six-inch pipe, metal half inch thick; square of outside diameter (6 inches x 6 inches) = 36 inches, less square of inside diameter (5 inches x 5 inches) = 25 inches, = 11 × constant, 2.45 = 26.95, or weight in pounds of one foot of six-inch pipe.

Cast iron pipe may be generally used for low pressure, but it should

not be used for high pressure mains. In conveying gas under a pressure of fifty to two hundred and fifty pounds to the square inch, only the best of lap-welded wrought iron or steel pipes should be used. And on this kind of pipe where the threads are cut the metal should be made thick, so that the pipe shall not be reduced in strength at that point. One source of great weakness is in the special fittings. They should all be made of the best malleable iron or steel. Many companies are now having their fittings made to order, much heavier than those generally found in the market. Even the best wrought iron and steel pipes should be subjected to a hydrostatic pressure of at least three times as great as any pressure that it will be subjected to in use.

By a special act of the General Assembly of Indiana of 1891, the pressure in high pressure pipe lines is limited to three hundred pounds. In the putting in of gas plants, or in their extension or improvement, every means should be adopted in order to make them absolutely safe. Human lives, as well as property, are too valuable to be endangered by the insecure handling of this powerful agent, through mistakes and criminal notions of economy.

By the way of suggestions as to what should be observed in the laying of gas plants, or in the improvement of the same, I quote some recommendations from a report to the court of a commission at Pittsburgh, Penn., appointed to investigate the safety of the plants in that city during the earlier years of the use of gas. They say:

"There should be stop-valves located not over three thousand feet apart on all high pressure mains, so that a line can be shut off in sections in case of accidents.

"A uniform pressure should be kept on each line.

"Each high pressure feeder to a low main should have an efficient pressure regulator, and in addition thereto not less than two blow-off valves, each of sufficient capacity to relieve the line of any excess of pressure.

"All low pressure lines should be connected with each other, and to the high pressure mains in such a manner as to form a circuit. If the lines are connected in this manner, with sufficient feeders from the high pressure mains, and all dead ends avoided, the pressure we designate in the next finding as low pressure will, in our opinion, be adequate to supply all possible consumers of gas except the large manufactories, which are provided for direct from high pressure mains.

"A greater pressure than ten pounds should not be allowed on low pressure lines."

"In each public building located near a low-pressure main or mains, a mercury gauge should be placed, connected with the main or mains, and open at all reasonable hours to the inspection of citizens."

"All tees, angles, gates, etc., should be of the best in the market, and

they and all sleeves should be covered with suitable boxes with perforated covers."

I wish to add the above recommendations in addition to, and partly as a repetition of what I have always urged in person and in my former reports on this subject. It may be urged that these recommendations are coming rather late, as most of the plants have already been laid. This is only partly true, for the reason why, that the above suggestions are on a condensed form of what I have already advocated. And, then again, plants are to be improved, and they must be extended in order to furnish supply to the increasing demand and for extension of lines to remoter fields.

SUBSTITUTES FOR NATURAL GAS.

That the supply of natural gas will last but a very short time longer is conceded by all persons who have given the matter careful and serious consideration. That a gaseous fuel from some source will continue to be extensively used is also generally conceded. Natural gas will have prepared the way for the use of gaseous fuel. The failure of natural gas will, doubtless, bring heavy losses to many individuals, firms and corporations. Still, it will have accomplished much good, in that the knowledge gained by the experience during the years of its existence will greatly benefit the public in general.

The use of a gaseous fuel generated in producer furnaces is now largely used in the operations in metallurgy. The great saving in this method of firing over that of the direct utilization of the combustion of coal is probably due, in a measure, to the utilization of the waste heat in the regenerative chambers. Fuel gas of this character, however—that is, made by the admission of air to the incandescent fuel—can not be conducted long distances except at an expense greater than its value as a heat producer.

In the manufacture of water gas, coke or anthracite coal has to be used. No process has been invented yet whereby soft or raw bituminous coal can be used successfully for this purpose. So long as this is true this gas can not be made cheap enough to come in competition with direct firing with the soft coals of Ohio and Indiana.

It is probable that a mixture of coal gas, water gas and producer gas will be the fuel gas of the future for domestic purposes.

COMPARATIVE VALUE OF GASES.

Without attempting to describe the processes whereby different fuel gases are manufactured, the following tables will show the comparative values of the four gases—natural gas, coal gas, water gas and gases from a producer furnace.

Assuming that producer gas is made from the slack coal that is found

in such vast quantities lying about our coal mines, an approximate analysis of this slack would show it to be composed as follows:

Fixed carbon	55 per cent.
Permanent gas	15 per cent.
Condensable matter, tar and soot	10 per cent.
Water	10 per cent.
Ash	10 per cent.

Deducting the ash, the proportions are, by weight:

Fixed carbon	61.11 per cent.
Volatile combustible matter	16.67 per cent.
Water	11.11 per cent.
Tar	11.11 per cent.

After excluding all of the excesses of deleterious matter, the gas from the producer will then have this composition:

Carbon monoxide	32.69 per cent.
Carbon dioxide	7.93 per cent.
Nitrogen	51.82 per cent.
Illuminating gas (H., CH_4, C_2, etc.)	3.24 per cent.
Watery vapor	2.16 per cent.
Tarry vapor and soot	2.16 per cent.

The value of each of the four gases that are now used being compared will be in heat units per pound of gas:

Natural gas	24.195
Common coal gas	22.968
Water gas	7.069
Siemen's furnace gas	1.957

The above calculation is based upon the following composition of the several gases:

COMPOSITION OF NATURAL GAS.

	Per Cent. By Volume.	*Per Cent. By Weight.*
Hydrogen (H)	2.18	0.268
Marsh gas (CH_4)	92.60	90.383
Carbonic Oxide (CO)	0.50	0.857
Olefiant gas (C_2H_4)	0.31	0.531
Carbonic acid (CO_2)	0.26	0.700
Nitrogen (N)	3.61	6.178
Oxygen (O)	0.34	0.666
Hydrogen sulphite (H_2S)	0.20	0.417
Total	100	100

COMPOSITION OF COAL GAS.

	Per Cent. By Volume.	*Per Cent. By Weight.*
Hydrogen	46.00	8.21
Marsh gas	40.00	57.20
Carbonic oxide	6.00	15.02
Olefiant gas	4.00	10.01
Water	1.50	2.41
Carbonic acid	0.50	1.97
Nitrogen	1.50	3.75
Oxygen	0.50	1.43
Total	100	100

COMPOSITION OF WATER GAS.

	Per Cent. By Volume.	*Per Cent. By Weight.*
Hydrogen	45.00	5.431
Carbonic oxide	45.00	76.041
Marsh gas	2.00	1.931
Water vapor	1.50	1.630
Carbonic acid	4.00	10.622
Nitrogen	2.00	3.380
Oxygen	0.50	0.985
Total	100	100

COMPOSITION OF PRODUCER GAS.

	Per Cent. By Volume.	*Per Cent. By Weight.*
Hydrogen	6.00	0.458
Marsh gas	3.00	1.831
Carbonic oxide	23.50	25.095
Water vapor	1.00	0.686
Carbonic acid	1.50	2.517
Nitrogen	65.00	69.413
Total	100	100

The specific gravity of the several gases is as follows:

Natural gas	.570
Coal gas	.400
Water gas	.570
Producer gas	1.000
Air	1.000

Making a comparison on the basis that natural gas has a temperature of about 40° Fahr., we have the following:

One thousand feet of air at 40° Fahr., will weigh 80 pounds.

Then, 1,000 feet of natural gas, specific gravity,						.570×80=45.6	pounds.
"	"	"	coal	"	"	.400×80=32.0	"
"	"	"	water	"	"	.570×80=45.6	"
"	"	"	producer	"	"	1.000×80=80.0	"

Then,	natural gas,	45.6	pounds	×24,195	heat units	=1,033,292	units.
"	coal "	32.0	"	×22,968	"	= 734,976	"
"	water "	45.6	"	× 7,069	"	= 322,346	"
"	producer "	80.0	"	× 1,957	"	= 156,560	"

Another showing of the comparative value of these four gases is in the evaporating of water.

One thousand feet of natural	gas	will evaporate	893	pounds.		
"	"	coal	"	"	591	"
"	"	water	"	"	262	"
"	"	producer	"	"	115	"

It has been found in practice that coal gas possesses advantages over either of the other gases in a way that does not appear in a theoretical calculation. It will ignite at a lower temperature. This is due to the fact that it possesses more free hydrogen.

A large portion of the black smoke that is seen pouring out of smoke stacks attached to the furnaces of steam boilers is due to the fact that, when the gases generated from the coal comes in contact with the steam boiler, they (the gases) are cooled below their point of ignition, and therefore escape unconsumed.

As this is well known, then the fact becomes apparent that the gas that ignites at a low temperature will produce better results, other things being equal, than a gas that ignites at a higher temperature.

Many people are looking anxiously to some of these fuel gases, or to a combination of them, as their source of fuel when natural gas shall have failed. No doubt, that before that time arrives the manufacture of these gases will have been brought to such a state of perfection as to cheapen them so as to bring them within the reach of all the uses to which this fuel is applied. The vast sums of money invested in conducting mains will not be lost, as the public in many localities will have become so accustomed to a gaseous fuel that will never return to the use of solid fuel. Then it will be that the slack and waste at our coal mines will be converted into fuel gas, and be conveyed through the mains laid for conveying natural gas to manufacturing places and for domestic use.

MEASUREMENTS OF GAS WELLS.

By request, I herewith give a method for measuring the volume of the supply from gas wells. The Pilot tube is now generally used in measuring the velocity flow. This tube may be of any size, as the observed pressure will indicate an absolute independence of size of tube mouth. One-eighth to one-fourth inch are the sizes generally used, and the mouth should be made sharp, or very nearly so.

The tube may be clamped to the tubing of the well in order to hold it in place. Care should be taken to place the mouth of the tube exactly in the center of the stream of flowing gas, and not more than one diameter of the tube mouth above the mouth of the well tubing. The mouth of the well tubing where test is made should be not less than fifteen inches from any collar or valve, or fitting of any kind. This is done for the purpose of having a free flow, as a collar or fitting of any kind would cause an eddying of the gas. From the observed pressure on the gauge, by the use of the tables given below, the volume can be ascertained. I have taken this table from Prof. S. W. Robinson's report to the State Geologist of Ohio on the measurements of gas.

Cubic feet of gas, reckoned at 32° F., discharged by well per day of twenty-four hours of continuous flow, by Pilot tube measurement; the specific gravity of the gas being taken at 0.6 (air = 1), and the temperature of the flowing gas at well mouth being taken at 32° F.:

Pressure by Water Gauge—Inches.	Pressure by Pressure Gauge—Lbs. per Sq. Inch.	Diameter of Orifice, or of Well Mouth.									
		1 Inch.	1½ In.	2 In.	2½ In.	3 In.	3½ In.	4 In.	4½ In.	5 In.	5⅝ In.
.1	.0036	12,390	27,880	49,556	77,440	111,510	151,780	198,220	250,890	309,750	392,000
.2	.0073	17,560	39,510	70,260	109,750	158,040	215,110	281,040	355,590	439,000	555,910
.3	.0109	21,480	48,330	85,940	134,250	193,320	263,130	343,760	434,970	537,000	679,630
.5	.0182	27,720	62,370	110,880	173,250	249,480	339,570	443,520	561,330	693,000	877,080
.7	.0254	32,820	73,840	131,260	205,100	295,380	402,000	525,050	664,610	820,400	1,038,500
1.0	.0364	39,210	88,230	156,830	245,100	352,890	480,400	627,310	794,030	980,400	1,2 0,700
1.5	.0545	48,030	108,070	192,120	300,200	432,270	588,400	768,480	972,600	1,200,800	1,517,900
2.0	.0727	55,340	124,520	221,360	345,900	498,060	677,960	885,440	1,120,600	1, 83,600	1,751,000
3.0	.109	67,910	152,800	271,630	424,500	611,190	832,020	1,086,510	1,375,200	1,698,000	2,148,800
4.0	.145	78,410	176,420	313,660	490,100	705,690	960,600	1,254,620	1,587,800	1,960,400	2 480,900
5.0	.182	87,670	197,260	350,670	518,400	789,030	1,074,860	1,402,670	1,775,310	2,193,600	2,733,900
7.0	.254	103,500	232,880	414,000	646,900	931,500	1,267,900	1,656,000	2,096,900	2,587,600	3,274,800
10.0	.3636	123,000	276,750	492.000	768,800	1,107,000	1,506,750	1,968.000	2,490,800	3,075,000	3,890,900
13.75	.50	146,220	328,990	484,880	913,880	1,316.000	1,791,200	2,339,500	2,76 ,900	3,655,500	4,626,500
20.62	.75	175,350	394,540	701,400	1,096,000	1,578,150	2,148,160	2,805,600	3,550,900	4,384,000	5,548,200
27.5	1	201,800	454,010	807,200	1,261,200	1,816,050	2,471,800	3,218,500	4,066,100	5,044,600	6,384,600
. . . . .	1.5	247,840	557,650	991,370	1,549,000	2,231,000	3,036,000	3,965,000	5,019,000	6,196,000	7,842 000
. . . . .	2	285,130	641,540	1,140,500	1,782,000	2,566,200	3,493,000	4,562,000	5,774,000	7,128,000	8,921,000
. . . . .	2.5	316,500	712,130	1,266.000	1,978,000	2,848,500	3,887,000	5,064,000	6,409,000	7,913,000	10,014,000
. . . . .	3	344,350	774,780	1,377.400	2,152,000	3,099,100	4,218,000	5,510,0 0	6,973,000	8,609,000	10,895,000
. . . . .	3.5	370,000	832,500	1,480,000	2,313,000	3,330,000	4,582,500	5,920,000	7,493,000	9,250,000	11,707,000
. . . . .	4	393,000	884,250	1,572,000	2,156,000	3,537,000	4,814,200	6,288.000	7,958,000	9,825,000	12,435,000
. . . . .	4.5	415,270	934.350	1,661,100	2,595,000	3,737,400	5,087,000	6,644,000	8,409,000	10,382,000	13,139,000
. . . . .	5	436,200	981,450	1,744,800	2,726,000	3,925,800	5,343,000	6,973,000	8,833,000	10,905,000	13,802,000
. . . . .	5.5	456,200	1,026,500	1,824,800	2,851,300	4,105,900	5,589,000	7,299,000	9,238,000	11,405,000	14,435,000
. . . . .	6	473,750	1,065,900	1.895.000	2,961,000	4,264,000	5,803,000	7,580,000	9,593,000	11.844,000	14,990,000
. . . . .	6.5	489,840	1,102,100	1,959,400	3,062,000	4,409,000	6 001,000	7,837,000	9,919,000	12,246,000	15,499,000
. . . . .	7	506,920	1,138,30)	2,023,700	3,162,000	4,553,300	6,198,000	8,095,000	10,245,000	12,648,000	16,008,000
. . . . .	7.5	522,010	1,174,500	2,088.000	3,263,000	4,698,000	6,395,000	8,353,000	10,571,000	13,050,000	16,517,000
. . . . .	8	538,500	1,211,600	2,154,000	3,366,000	4,846,000	6,597,000	8,616,000	10,905,000	13,462,000	17,038,000
. . . . .	9	565,570	1,273,200	2,263,000	3,537,000	5,093,000	6,93 ,0 0	9,054,000	11,459.000	14,147,000	17,905,000
. . . . .	10	589,270	1,325,900	2,357.100	3,683,000	5,303,000	7,219,000	9,428,000	11,933,000	14,372,000	18,645,000
. . . . .	12	633,340	1,425,000	2,533,300	3,958,000	5,700,000	7,758,000	10,133,000	12,825.000	15,833,000	20,040,000
. . . . .	14	675,000	1,518,0 0	2,700.000	4,219,000	6,075,000	8,269,000	10,8 0,000	13,669,000	16,875,00)	21,357,000
. . . . .	16	713,556	1,605,500	2,854.2 0	4,459,700	6,422,000	8,741,000	11.415,000	14,449,000	. . . . .	. . . . .
. . . . .	18	748,650	1,684,500	2,994,600	4,679,000	6,738,000	9,151,000	11,978,000	15,160,000	. . . . .	. . . . .
. . . . .	20	779,350	1,753,500	3,117,400	4,871,000	7,014,000	9,548,000	12,470,000	15,762,000	. . . . .	. . . . .

Pressure by Water Gauge—Inches.	Pressure by Pressure Gauge—Lbs. per Sq. Inch.	Diameter of Orifice, or of Well Mouth.									
		1 Inch.	1½ In.	2 In.	2½ In.	3 In.	3½ In.	4 In.	4½ In.	5 In.	5½ In.
. . . . .	25	845,150	1,901,600	3,381,000	5,282,000	7,606,000	10,353,000	13,522,000	. . . . .	. . . . .	. . . . .
. . . . .	30	902,180	2,148 300	3,609,000	5,639,000	8,120,000	11,054 0 0	14,435,000	. . . . .	. . . . .	. . . . .
. . . . .	35	954,870	2,148,300	3,819,000	5,968,000	8,593,000	11,697,000	. . . . .	. . . . .	. . . . .	. . . . .
. . . . .	40	996,660	2,247,000	3,995,000	6,242,000	8,988,000	12,231,000	. . . . .	. . . . .	. . . . .	. . . . .
. . . . .	45	1,036,700	2,332,600	4,147,000	6,479,000	9,330,000	12,700,000	. . . . .	. . . . .	. . . . .	. . . . .
. . . . .	50	1,072,000	2,412,000	4,288,000	6,700,000	9,648,000	13,132 000	. . . . .	. . . . .	. . . . .	. . . . .
. . . . .	55	1,106,880	2,495,000	4,428,000	6 918,000	9,962,000	13,539 000	. . . . .	. . . . .	. . . . .	. . . . .
. . . . .	60	1,137,600	1,137,600	4,550,000	7,110,000	10,238,000	13,935,000	. . . . .	. . . . .	. . . . .	. . . . .

INSPECTION OF PLANTS.

There has been but very little complaint during the year of plants furnishing gas to consumers. I have found in my inspection that the gas machinery is being kept in a much better condition than formerly. This is the result of the managers having acquired more experience and of their having a greater appreciation of the dangerous agent which they are required to handle. This condition is largely due to the fact that plants are subject to inspection. In making my inspections I have tried at all times to impress upon the minds of those in charge of plants and gas machinery the extremely dangerous character of this fuel, and the great necessity of careful attention, also that none but the best regulators, pipes, fittings and other machinery should be used, and that this should at all times receive their best attention and be kept in the best possible condition. I condemned but one regulator during the year. This one belonged to the Fountainton Gas Company and was located at New Palestine in Hancock County.

I have found owners and managers of plants, as a general thing, very ready to accept my suggestions as to changes and repairs that may be necessary in order to give good and safe service. By so doing plants have been kept in good condition and the necessity for condemnation has been avoided.