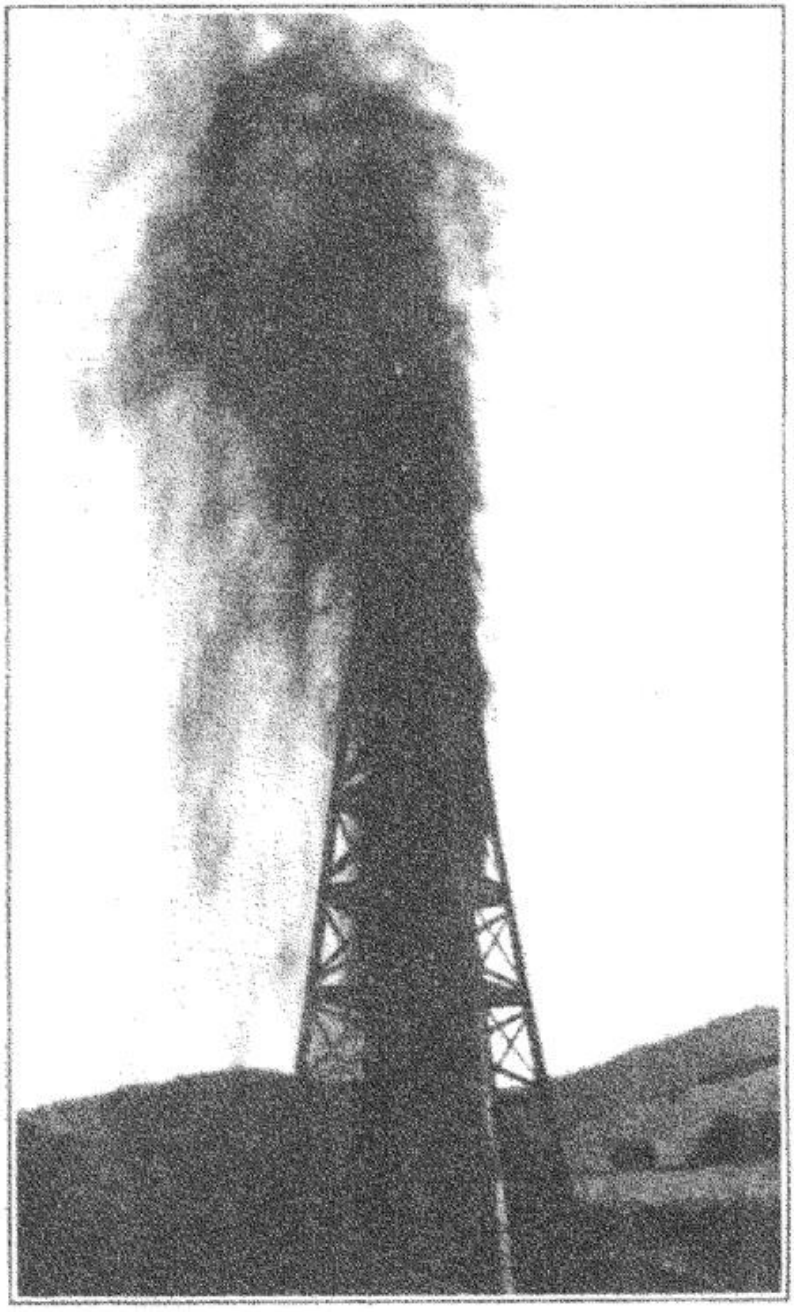
THE CONSERVATION OF NATURAL GAS IN KENTUCKY



A GAS FIELD WASTE

In this Eastern Kentucky well the driller is blowing the "gas head" off. The well produced oil, which the driller wasted as "an experiment."

THE

Conservation of Natural Gas In Kentucky

BY

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Illustrated with Forty-four New Photographs, Maps and Diagrams

FIRST EDITION

JOHN P. MORTON & COMPANY
INCORPORATED
LOUISVILLE, KENTUCKY

1922

To My

FATHER

From whom I learned in youth the value of
Patience and Perseverance
this little book
is
dedicated

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AUTHOR'S PREFACE

CONSERVATION is not a word to be dealt with lightly. Its implications are many, and its value frequently has to be accepted as good while contingent upon a future return. A practical application of conservation always necessitates an industrial readjustment, and this in turn generally brings about financial and business hardships for various individuals and corporations. The interests of a large community or group of communities have never been advanced except at the sacrifice of the few.

In the natural gas problem the necessity for immediate conservation is perhaps more vividly apparent than in any of the other mineral resources. This is particularly true of the gas reserves of Kentucky. The really serious situation which has developed in our sister States of West Virginia, Ohio and Pennsylvania may be delayed in Kentucky if effective preservation measures are introduced at once. The matter is urgent. As in all regional problems of natural resource conservation, the actual co-operation of the individual producer and consumer, as well as that of the conservation-effecting agent, will be required if the best results are to be obtained.

State Geologist of Kentucky.

Old State Capitol,
Frankfort, Kentucky.
January 15, 1922.

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THE CONSERVATION OF NATURAL GAS IN KENTUCKY

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CHAPTER I

THE AGE OF WASTE

At no time in the history of the world has the rate of industrial expansion been as rapid as during the past decade. This is especially true of the United States. The Northeastern and Middle West manufacturing regions of this country have literally been hives of industry. As might naturally be expected, the development of the mineral resources of the world and of the United States in particular has plunged ahead at an unprecedented rate during this period. Mining has been, in fact, a complement of our industrial growth.

New manufacturing industries, as well as new kinds of manufacturing, have created new and increased markets, and an incessant demand for the basic crude minerals of this country. This has been true of coal, petroleum, gas, and the iron, lead, zinc and copper ores. The drain has been particularly severe at the same time on the forest resources of this country, especially the southern Appalachian region; but this latter problem is outside the province of this discussion, though economically closely related to it.

In the feverish haste of the mineral resource producers to supply an ever growing and gluttonous market on all sides, there has crept unheeded and unchallenged into the producing industries such practices as should not only shock our present day somewhat skeptical consciences, but cause us to anxiously contemplate the probable status of our national economic security in the not too far distant future. Certain it is that in the years to come our posterity will be forced to solve many difficult and entirely unnecessary mineral producing problems

because of our present day reckless extravagance. At the same time very greatly reduced supplies of mineral resources and their widespread substitution will become the rule.

NATURAL GAS DEPLETION AT HAND

Indeed the first day of natural resource diminution and hunger is at hand. Figures compiled for the entire United States show that the peak natural gas production of 795,110,376,000 cubic feet was reached in 1917. This great fuel resource, once considered an oil field liability, later an important by-product, and finally a household and industrial necessity, decreased 74,109,417,000 cubic feet or 9 per cent in 1918. Present indications are that the decline has continued on down through 1919, 1920, and 1921, though the exact figures to verify this statement are not available now.

The situation during the last few years has become so acute that many industries using natural gas have been forced to abandon it. Domestic and industrial consumers in outlying sections have been forced to substitute coal, and in those municipalities located close to or within the great gas fields of the Appalachian region rates for purchase have been rapidly increased as the supply has waned. In such cities as Cleveland, Columbus, Cincinnati, Huntington, Charleston, Wheeling, Ashland, Lexington, Louisville, and Pittsburgh there has already been introduced or is now in the process of introduction a sliding upward scale for the purchase of natural gas. Some conservation legislation has also been introduced in the Appalachian district to keep unused supplies of natural gas within the boundaries of the State in which it is produced.

PETROLEUM RESERVES ARE LIMITED

The interpretation of a special report recently completed showing the petroleum reserves of the United States to be 9,150,000,000 barrels, indicates clearly that the pangs of severe mineral resource hunger will in all probability be felt in this industry between 1940 and 1950. The following passages excerpted from this report* allow but a single construction—the imperative need of rigid economy and conservation:

". . . . the oil reserves of the country, as the public has frequently been warned, appear adequate to supply the demand for only a limited number of years. The annual production of the country is now almost half a billion barrels, but the annual consumption, already well beyond the half billion mark, is still growing. For some years we have had to import oil, and with the growth in demand, our dependence on foreign oil has become steadily greater, in spite of our own increase in output. It is, therefore, evident that the people of the United States should be informed as fully as possible as to the reserves now left in this country. . . . .

"The estimated reserves are enough to satisfy the present requirements of the United States for only 20 years, if the oil could be taken out of the ground as fast as it is wanted. Should these estimates fall even so much as two billion barrels short of the actual recovery, that error of 22 per cent would be equivalent to but four years' supply, a relatively short extension of life. . . .

"In the light of these estimates as to the extent of our supplies of natural petroleum, the committee points out the stern obligation of the citizen, the producer, and the Government to give most serious study to the more com-

* Press notice U. S. G. S. 12198, January, 1922.

A PIPE LINE NEARLY ON END

The construction of a natural gas pipe line in Eastern Kentucky is attended with great difficulty, as this view shows.

plete extraction of the oil from the ground, as well as to the avoidance of waste, either through direct losses or through misuse of crude oil or its products."

As the domestic supply of natural petroleum decreases, prices for the many commodity necessities refined from it will increase materially and progressively. Throughout this country those industries and individuals making use of products refined from petroleum will be forced to meet the advancing cost. Such costs for many will be prohibitive. Substitutes both good and bad will flood the market. Inferior makeshifts will no doubt depreciate the arts and many industries. The automobile and the industrial gas engine will in a large measure become relics, unless an adequate substitute for gasoline is produced and sold for a reasonable price. Large users of such necessary by-products as lubricating oils will find themselves confronted by a distinctly serious situation.

COAL PRODUCTION IS WASTEFUL

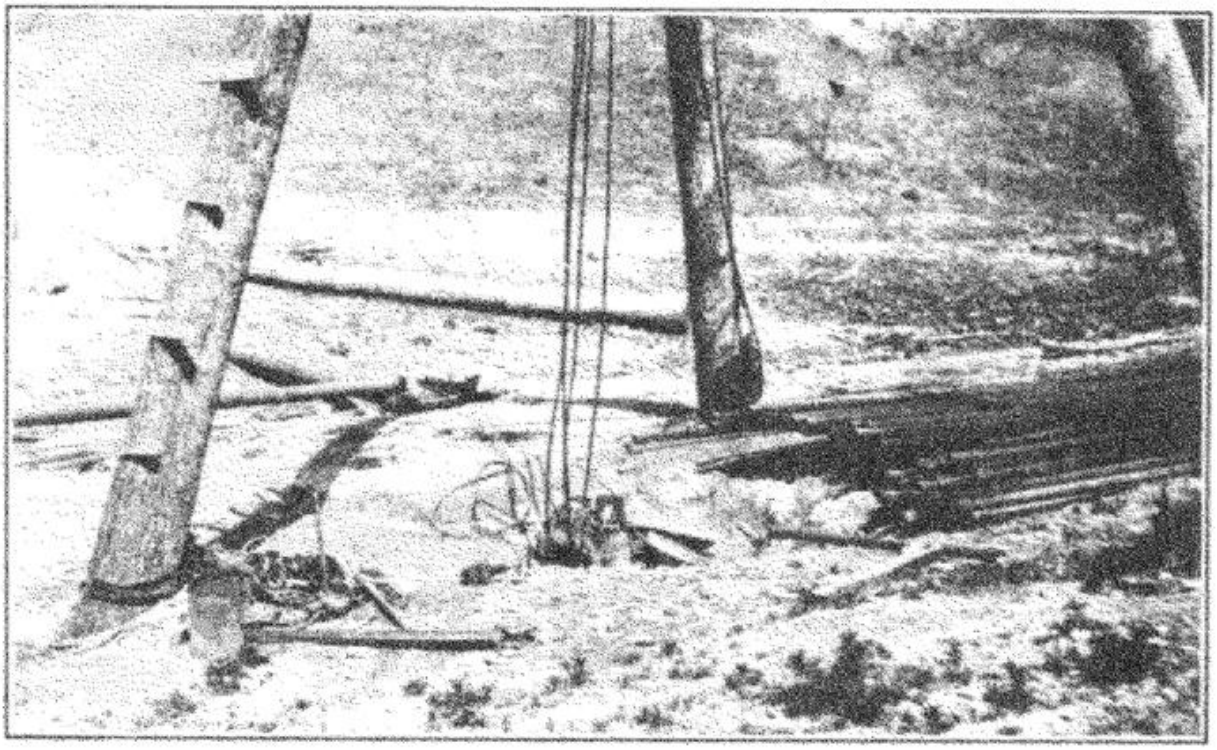
Conditions attending the development of the coal resources of Kentucky are strictly comparable to those found elsewhere in the recently exploited coal fields of the United States, and will serve as an interesting example of our lawless prodigality. In the eastern and western coal fields of Kentucky there is much being done in the way of attempted coal production that honestly invites the most severe criticism. While it is true that most of the larger companies have operated their properties from the start along the lines of the best engineering practice, it is known that hundreds have gone about the production of coal with little or no mining system at all.

In many cases owners of small coal mines are entirely inexperienced in the coal producing business prior to

starting their new mining operations. In response to the unusual demand for the product, properties have been acquired and the new so-called operators have proceeded to produce coal from these new properties. The result has always been a long succession of mistakes and failures, since such operations are largely an experiment at every step. This deplorable condition of affairs has been particularly true of the small "one-horse" mines, and the wagon mines; but many instances of much larger operations could be cited in both the eastern and western coal fields. Fallen-in entries, tumbled-down tipples, and brush covered railroad spurs are the common ear marks of the present day failure of this kind of coal mining.

The ultimate results of such mining methods are obvious upon casual inspection. The experienced operator using systematic methods calls it "ground-hogging" coal; but no term of derision is strong enough to adequately describe the practice. Without method or principle, the would-be operator removes that coal which is most easily obtained. He runs his entries in all directions, and generally has no mine map to show what amount of coal he has moved and what remains to be operated. His rooms are of all sizes, shapes, and descriptions, generally untimbered, with slate and coal "gobbed" at the right or the left, as has suited best his present convenience. Mine water has been given little if any attention, and not infrequently whole rooms are drowned out and abandoned long before they are completely mined. In the end this kind of coal mining leaves not infrequently 50 to 75 per cent of the coal in the ground as pillars, walls, partly cut, drowned out and unmined units.

When he has brought his property into this state of chaos, the untrained operator generally abandons it, and turns to virgin properties for a repetition of the same performance. The coal remaining in such abandoned properties generally is, or will be within a few years, beyond recovery. Due to the softening effects of mine water, roofs will have fallen in, pillars will have collapsed, and other conditions developed which will make the future operation on any such property not only extremely



IGNORANCE RESULTING IN LOSS

This well which is located in Clay County was an excellent gasser. It was left without proper casing and tubing. Salt water softened a shale at some depth and it caved in, ruining the hole and shutting off the gas.

hazardous and expensive, but quite impossible from a commercial standpoint. Instead of mining practically all of his coal as engineering methods allow, he has left a very large percentage in the ground. This portion, whatever it amounts to, has been lost to the world for all time. It has been deliberately wasted!

IGNORANCE PRODUCES OIL LOSSES

In Kentucky's oil fields, the same kind of wasteful operator may be found at every hand. With nothing better to do, he organizes an oil company and starts to drill wells without any idea as to the geological or drilling problems which he must encounter. He is almost certain to drill through the oil sands "by mistake," allowing the oil in many cases to drain away into porous strata below, or the salt water of underlying strata to find its way up into the oil sand.

Any of these practices operate to bring ruin on the property. If continued over a number of adjoining productive leases they will endanger the life and productivity of the field by dissipating the oil in the sand. In the terms of the driller, such practices bring about a "drowning out" of the petroleum. The inexperienced operator, if he strikes gusher oil, is generally not prepared to save it, and in any event will lose much at the casinghead. Not infrequently he will tank it in an open tank for several months or years, while he is making a shift to get a pipe-line connection, and occasionally loses it by fire or other disaster before he can run it into a line.

If the first well is a small producer, he will frequently abandon it, as he thinks temporarily. In the meantime water will take possession of it and ruin its productive qualities. If he has developed gas in small quantities with his oil, he will let the well blow open, thinking that by reducing the rock pressure of his gas he will increase at the same time the flow of the oil. He very seldom obtains the selfish results desired, however, but does generally succeed in disrupting the proper relationship of gas and oil reserves of his own lease. His practices also tend to work havoc with the properties of adjoining

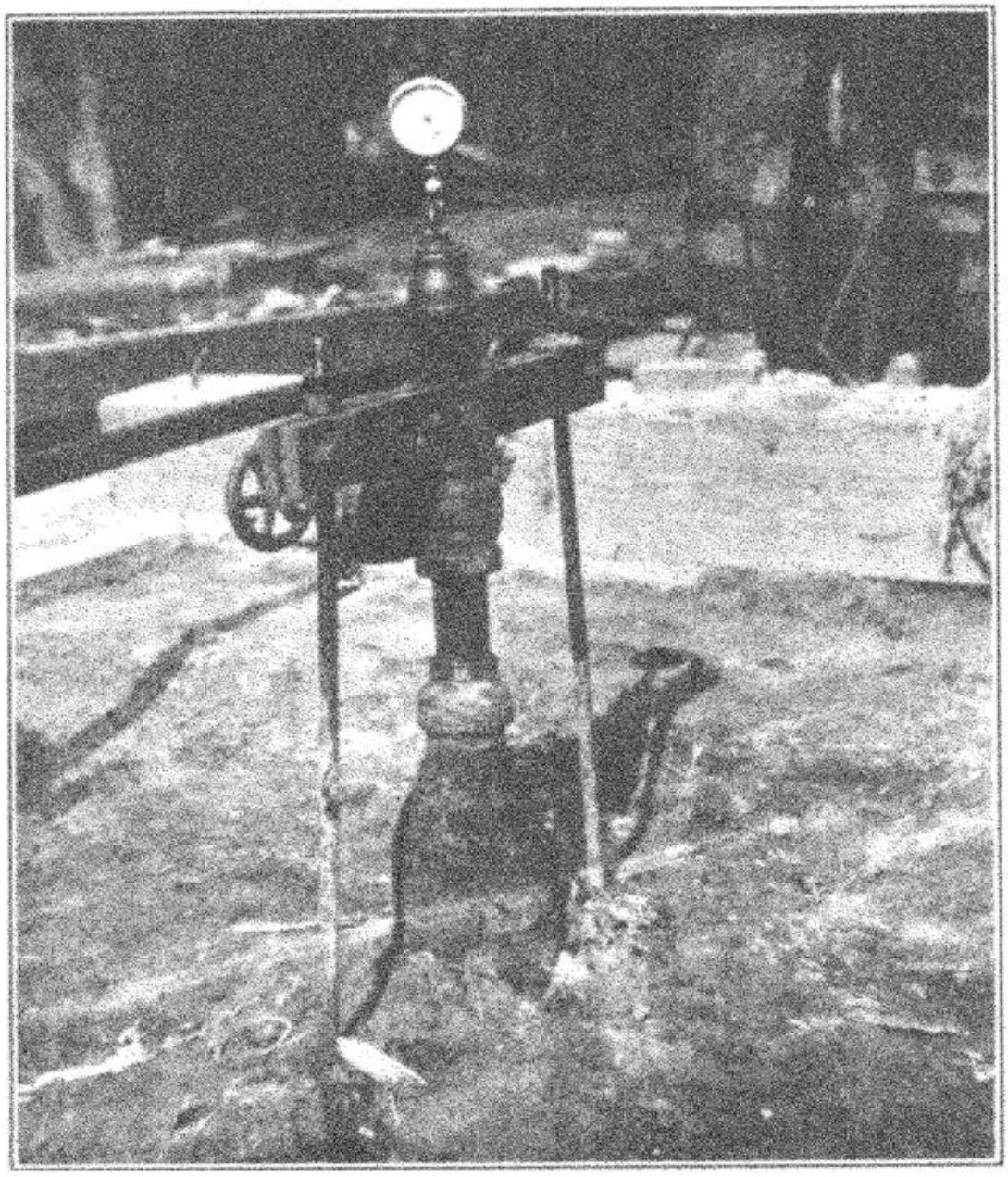
leases, and frequently the entire field. Instead of setting up such forces in the oil "sand" as might result in an increased accumulation of commercial petroleum, he not infrequently develops a greater tendency toward petroleum dissemination. This ultimately results in making the field less commercial and less productive than at the time the well was drilled in. When it is taken into consideration that between 50 per cent and 80 per cent of all the oil originally in the "sand" will remain in the ground after present producing methods have been exhausted, the total loss, including that induced by ignorance and folly, is very great indeed.

Irregularity of pumping any group of wells in an oil field will induce the pasting up of the oil sands with natural waxes to such an extent that wells so attended will naturally fall off gradually in their production. In abandoning his property, if it is not a large producer, many an operator has pulled the casing and failed to plug the water and oil sands. The result of this unlawful practice, as might be cited in some of the Knox County, Kentucky, fields, has been to fill the oil sands with water. The oil which these sands contained is slowly but surely driven out of commercial pools under the water pressure, and widely disseminated through new and unknown regions adjacent. Wherever this oil spoilation has taken place the present generation may be accused of a wanton mineral resource waste, the great value of which it is quite as impossible to estimate as it is to recover.

NATURAL GAS WASTE STATEWIDE

The natural gas fields of Kentucky are well acquainted with the reckless operator. In this State hundreds of excellent gas wells have been drilled in eastern, western

and southern Kentucky, and have been allowed to return unused their priceless treasure to the atmosphere. Notable examples of this practice, which it is true in recent years has been somewhat corrected, occur in the



A GASSER CORRECTLY CLOSED IN

Although the drilling rig is still at this location, the driller has already got his well "closed in" and is saving the gas.

Floyd, Johnson, Barren, Green, Taylor, and Grayson County gas fields. Some eastern Kentucky wells have

been allowed in the recent past to blow open for years, and the guilty parties who have perpetrated an irreparable wrong not only against the field, but against the consuming public, have gone unreprimanded.

The public in general has been slow to realize that natural gas exists, like all other material things, in a perfectly definite though largely an unknown quantity. All natural gas pools contain, could we but figure it, a certain number of cubic feet of gas, and no more. When this amount of gas is used up or otherwise dissipated, it can never be replenished. It is a mistaken conception, but a common one, that natural gas fields will "come back," if they are not drawn upon for a while. Nothing could be more fallacious. Natural gas fields, coal fields, oil fields, and all mineral resources to which we may turn our hand in a time of need, exist in a certain amount, which can never be increased. We may use them carefully, like the thrifty housewife, and extend their period of productivity over a relatively long time; or we may squander them recklessly, priceless as they are, much like the sailor in port. If we do the latter, we will find to our sorrow as a people that what we once thought was an unlimited mineral resource birthright, was in fact a very limited resource, quite susceptible of exhaustion by our modern methods of exploitation.

CHAPTER II

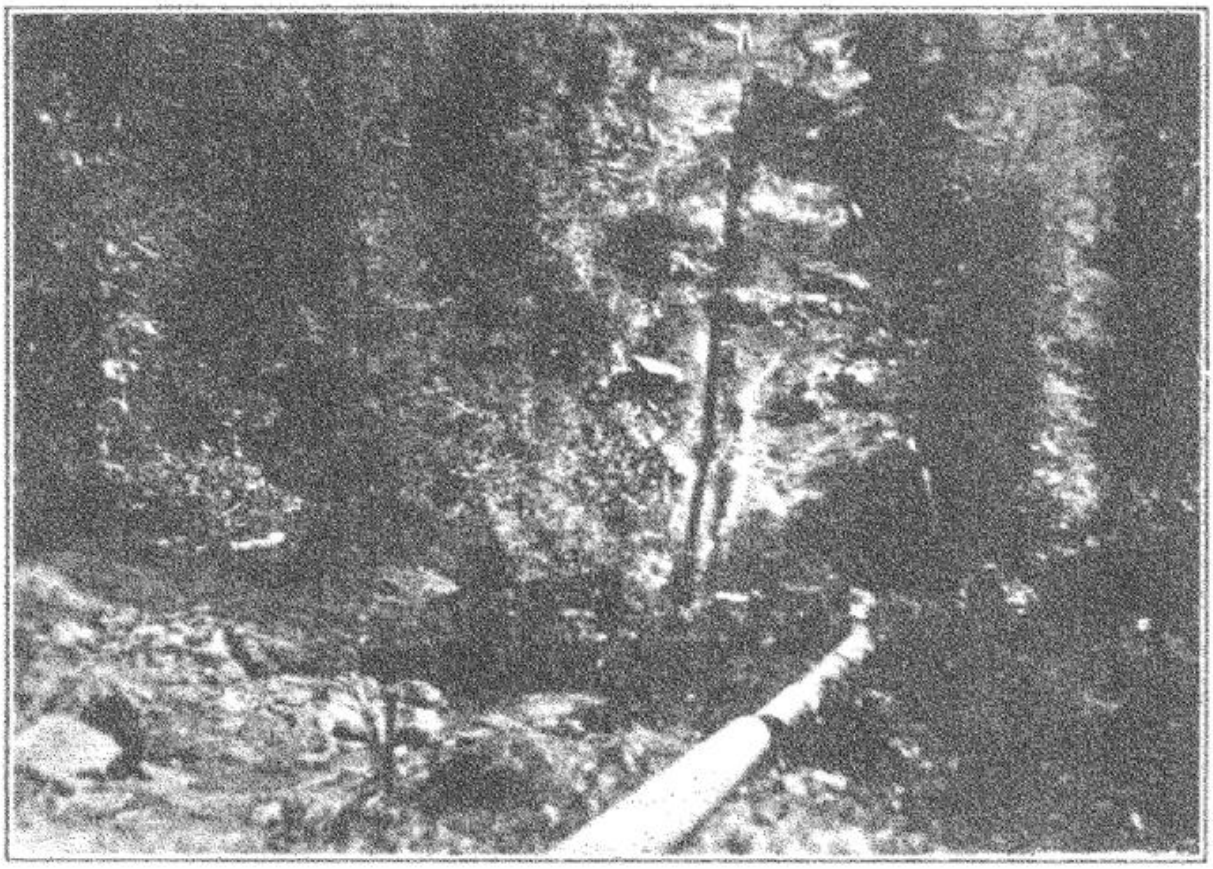
NATURAL GAS RESOURCES OF KENTUCKY

The commercial production of natural gas in the State of Kentucky dates back to the year 1863, when the old Moreman well near Brandenburg in Meade County, Kentucky, was drilled. It was utilized in the manufacture of salt from brines which were found associated with the gas in this and other wells in the Brandenburg district. For a number of years this Ohio River field was the only one of much importance in the State, but with the discovery of natural gas in large amounts in Ohio and West Virginia in the middle 80's, increased activity at once set in, which resulted in the laying of an 8-inch transmission line from the Brandenburg field to Louisville. The metropolis of Kentucky, situated 30 miles to the northeast of this gas field, thus became the first large consumer, and the Kentucky Rock Gas Company, later the Kentucky Heating and Lighting Company, which supplied the natural gas, became the first public utilities corporation giving natural gas service.

The development of the natural gas resources of Kentucky has been one of gradual rather than rapid increase. At least six rather distinctive periods may be noted in the growth of this industry. These are as follows:

(1) (1750-1872) Period of no commercial development. From the time of early explorations in Kentucky up to and including the drilling in of the Moreman property, natural gas was known, its inflammable quali-

ties were recognized, but it lacked commercialization. (2) (1873-1892) Period of early commercialization of natural gas. Meade and Breckinridge County gas fields chief source of supply. (3) (1893-1905) Period of widespread exploration. Development of large gas production in Martin County. Discovery of the Menifee County field. Initial declines of Meade and Breckinridge Coun-

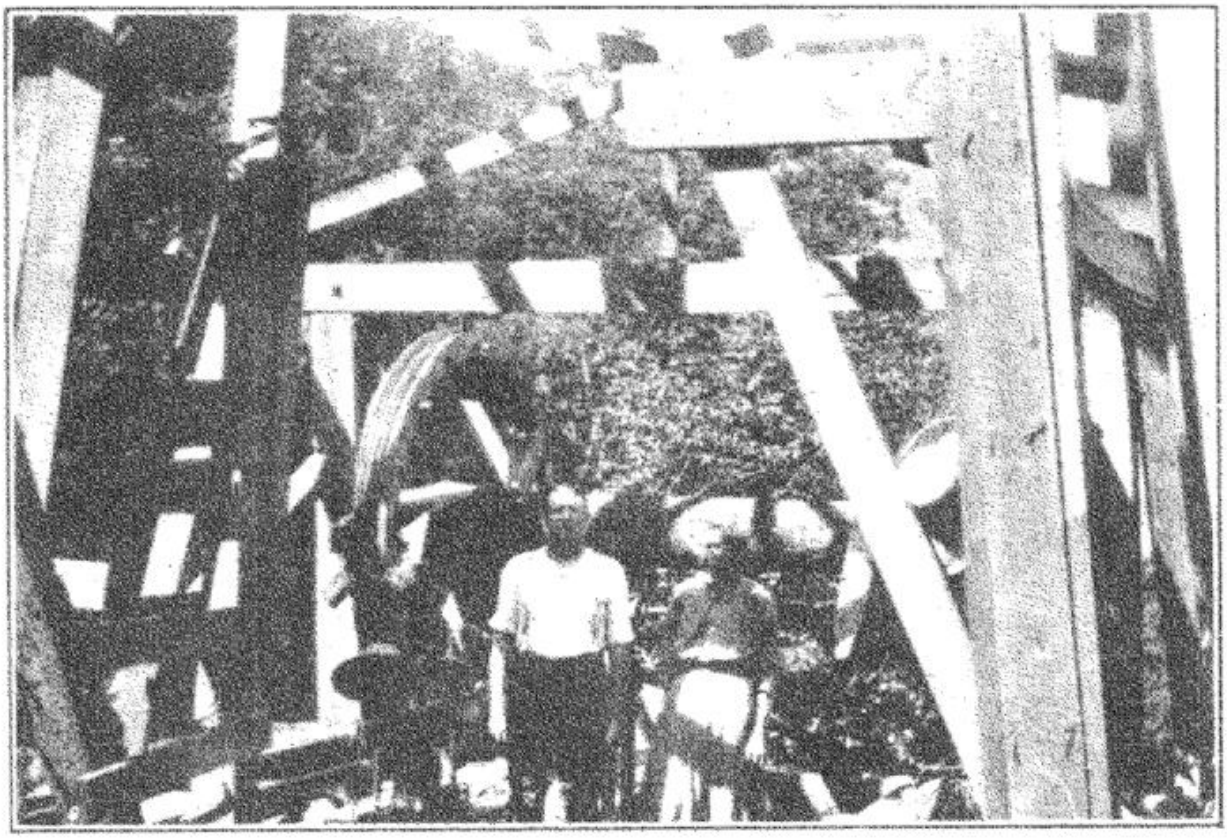


GAS PIPE LINE CONSTRUCTION IN TIMBER

Before gas mains can be laid in the mountain region of Eastern Kentucky, timber-cutting crews must follow the line surveyed and clear away all trees and underbrush.

ties. (4) (1906-1912) Period of eastern Kentucky natural gas exploitation. Drilling up of the Martin County field. Development of the Menifee County field; gradual depletion of Meade and Breckinridge County fields to very small figure. (5) (1913-1917) Period of

importation from West Virginia and Ohio. Martin County becomes the chief developed source of Kentucky natural gas. Meade and Menifee Counties practically abandoned. (6) (1918-1921) Period of intensive development throughout Kentucky. Martin County still a small gas producer. Johnson, Breathitt, Floyd, and other counties become large producers of natural gas in Kentucky.



A STANDARD DRILLING RIG

This gas well is located on the Kentucky side of the Tug Fork of the Big Sandy River in Martin County near Kermit, W. Va. Standard derricks are used in drilling for the deeper gas "sands."

Up to and including the year 1890, Meade County was the only natural gas producing field of much importance in the State, and continued so until the opening of the Martin County field in 1893. The gas production from Martin County was not utilized, however, to any extent

until the laying of the United Fuel Gas Company's main transmission line up the Big Sandy Valley in 1905. Martin County increased its production rapidly until 1915, and from that date has decreased quite as steadily.

A TAYLOR COUNTY GASSER

The Green-Taylor County gas field northwest of Campbellsville is a large field of low rock pressure. The gas "sand" is a limestone.

The Menifee County field was drilled up on an extensive scale in 1904, and was of considerable importance until about 1913, when depletion set in very rapidly. With

the depletion in the Meade, Martin and Menifee County fields a certainty, public utilities corporations in Kentucky were forced to make increasingly large importations of natural gas from West Virginia and Ohio.

It became apparent in 1917 and 1918 that the supplying limit of the Columbia Gas and Electric Company of West Virginia through the Kermit Station had been reached. Following leads established by a large number of indexing gas wells in Eastern Kentucky, an intensive drilling campaign was instituted in Johnson, Magoffin, Floyd, Breathitt and Knott Counties which has resulted in the development during the last four years of several gas fields of recognized importance in Eastern Kentucky. The chief of these from a standpoint of present commercial value is the Beaver Creek field in Floyd County. Close seconds are the Ivyton, Win, Red Bush, Flat Gap, and Frozen Creek gas fields in the eastern part of the State. During this same period, widespread drilling by petroleum "wildcatters" has resulted in the discovery of a large number of more or less isolated gas wells and gas fields in various portions of the State. One of the largest and most important of the several natural gas fields thus found is that which has been outlined in Green and Taylor Counties in central Kentucky.

In the year 1921 commercial production of natural gas in Kentucky amounted to approximately 4,742,000 M cubic feet, valued to the consumer at $1,360,340.00. The consumption of natural gas in the State in the year 1918, the latest for which figures are available, amounted to 12,200,190 M cubic feet, valued to the consumer at $3,093,393.00, and was about 300 per cent greater than the production. The total volume of natural gas consumed in Kentucky in 1921 was without doubt much greater than this amount. With an annual consumption

in Kentucky of such large amounts of natural gas, and a rapidly growing list of domestic consumers, which in 1918 totaled 90,849, an understanding of the natural gas reserves of this State becomes one of very great importance. A detailed consideration of the thirty-one separate gas fields of Kentucky, (1) developed and depleted; (2) partially developed and producing; and (3) indexed by discovery wells, but not commercialized, is given herewith:

KENTUCKY NATURAL GAS POOLS.

I.

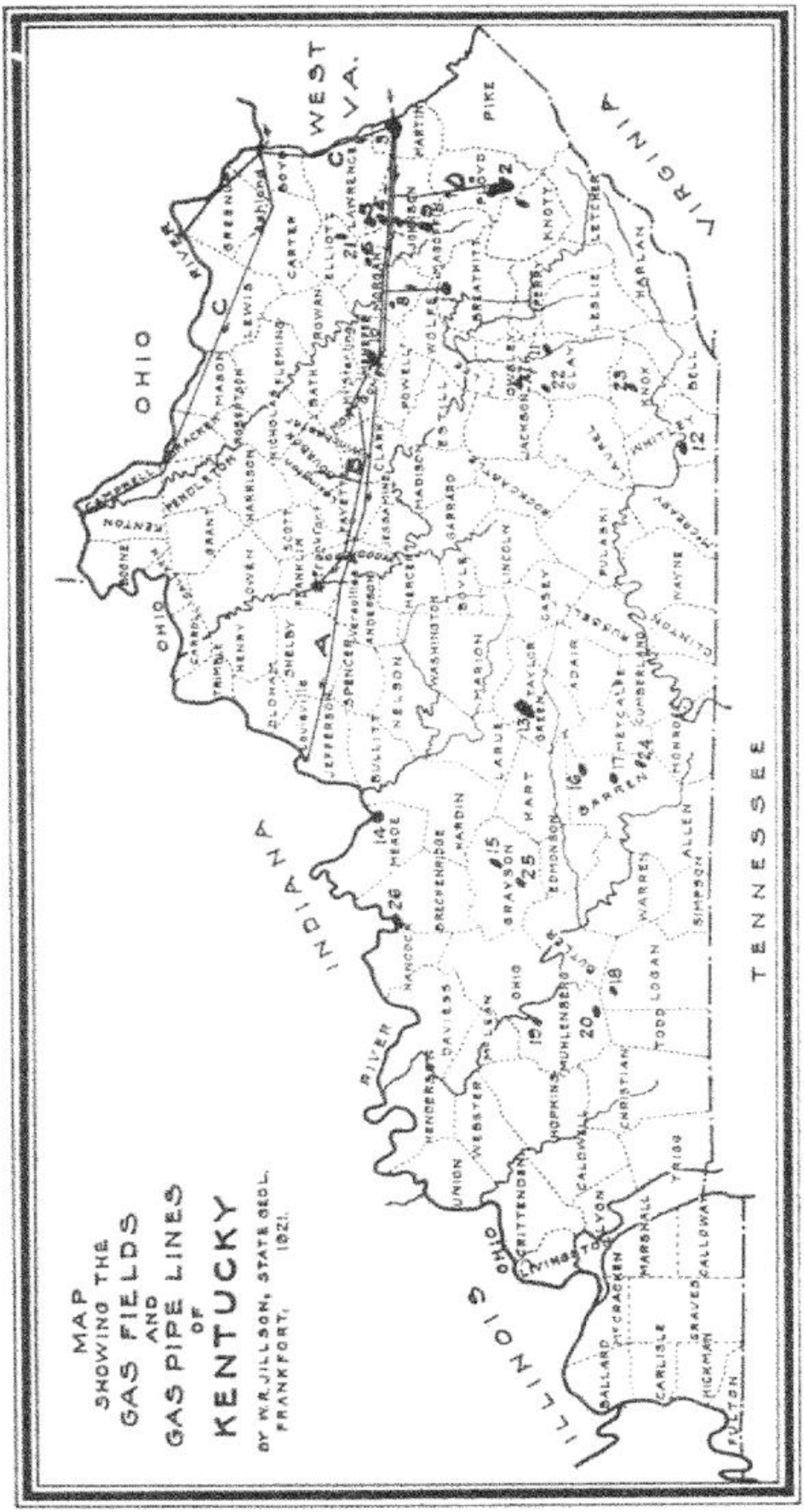
1. Cloverport, Breckinridge Co	Gas pools of yesterday, old or abandoned.
2. Diamond Springs, Logan Co	
3. Martin Co	
4. Meade Co	
5. Menifee Co	
6. Monticello, Wayne Co	

II.

1. Barbourville, Knox Co	Gas pools of to-day, production used in Kentucky towns and cities.
2. Beaver Creek, Floyd Co	
3. Central City, Muhlenberg Co	
4. Elk Fork, Morgan Co	
5. Flat Gap, Johnson Co	
6. Frozen Creek, Breathitt Co	
7. Glasgow, Barren Co	
8. Green River, Green and Taylor Cos	
9. Ivyton, Magoffin Co	
10. Leitchfield, Grayson Co	
11. Prestonsburg, Floyd Co	
12. Redbush, Johnson Co	
13. Williamsburg, Whitley Co	
14. Winn, Johnson Co	

III.

1. Hiseville, Barren Co	Gas pools of tomorrow —probably of commercial importance, but size undetermined. Unconnected by pipe lines.
2. Island Creek, Owsley Co	
3. Meredith, Grayson Co	
4. Mize, Morgan Co	
5. Newcombe Creek, Elliott Co	
6. Oneida, Clay Co	
7. Penrod, Muhlenberg Co	
8. Sparta, Gallatin Co	
9. Rock Fork, Knott Co	
10. Sexton Creek, Clay Co	
11. Temple Hill, Barren Co	



OUTLINE MAP OF KENTUCKY SHOWING NATURAL GAS POOLS AND NATURAL GAS PIPE LINES

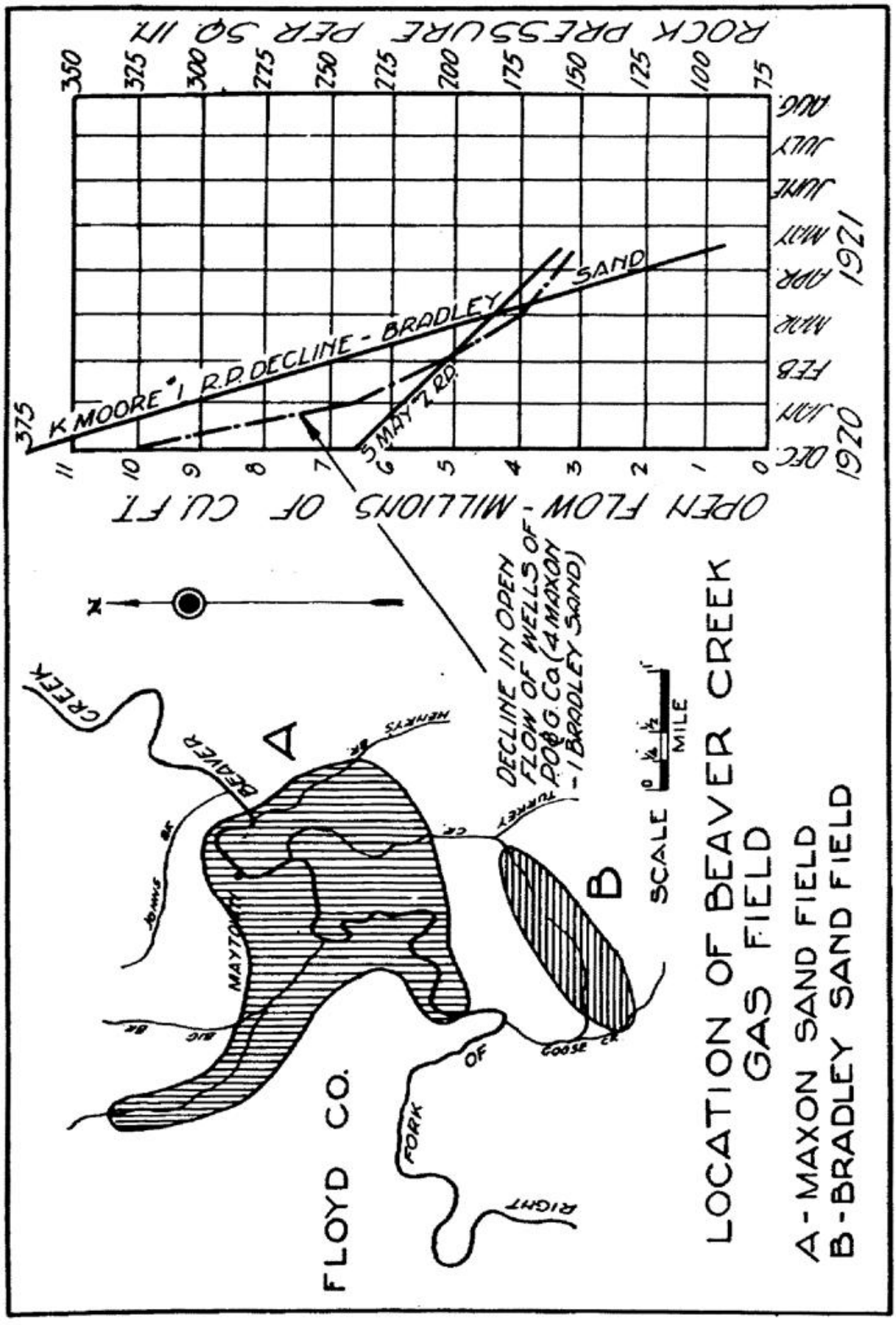
FROZEN CREEK GAS FIELD—(1)

GEOGRAPHY—This field is located in north-central Breathitt, near the Wolfe County line. The nearest town is Taulbee. The wells are drilled along Negro, Sulphur, and Clear Creeks, all branches of Frozen Creek.

GEOLOGY—The natural gas found here occurs in the upper part of a small dome, the axis of which runs about 20 degrees north of east, and with its approximate crest about one mile up Negro Fork of Frozen Creek. Production is secured in the Corniferous (Devonian) limestone at about 1,800 feet. Structural maps of Breathitt County showing this dome have been published by the Kentucky Geological Survey.

HISTORY—The first well was drilled in the field by the Big Six Oil Company in September, 1918. Its open flow was 3,500,000 cubic feet, and its rock pressure 525 pounds. A second well was drilled in November. During the following year two more wells were drilled, and efforts made to market the gas. In June, 1920, a contract was made with the Central Kentucky Natural Gas Company, and preparations to connect with the main line of this company were begun.

By the winter of 1920-1921 a 10-inch line was completed, and deliveries of gas started. By that time ten wells had been drilled, of which five were dry holes. The total open flow developed was 18,000,000 cubic feet, and the average rock pressure about 525 pounds. The largest well came in at 7,875,000 cubic feet, and the smallest at 300,000 cubic feet. The eastern and southern edges of the producing area have been defined. No data on deliveries to date is available.



LOCATION, AND DECLINE CURVES OF BEAVER CREEK GAS FIELD (KENTUCKY)

BEAVER CREEK GAS FIELD—(2)

GEOGRAPHY—The Beaver Creek Gas Field is located in Floyd County. Beaver Creek, a tributary of the Big Sandy River, flows through it and gives it its name. Maytown, on a branch line of the C. & O. R. R., is located in the heart of the pool. The wells are drilled along Right Fork of Beaver Creek from Maytown south to the mouth of Goose Creek, and along Henry's Branch and Wilson, Turkey, and Goose Creeks and their tributaries.

GEOLOGY—The principal structural feature of this region is a rather pronounced anticline. Gas has accumulated on the small terraces and domes forming a part of this structure.

Production has been secured from the Salt (Pennsylvanian), Maxon, Bradley, and Berea (Mississippian), and Corniferous (Devonian) "Sands," which occur at about 600, 900, 1,100, 2,000, and 2,500 feet respectively. The greater part of the gas is secured from the Maxon in the northern and central parts of the field, and from the Bradley in the southern.

All of the gas producing horizons are lenticular. Wells drilled 1,500 feet apart show wide differences in thickness, and porosity of the sands. In fact, one 2,000-foot well drilled only 800 feet from a good well in the Berea sand, showed not a trace of Berea. Drilling results are very erratic, and costs are correspondingly high.

HISTORY—The first well in the Beaver Creek region was drilled at the mouth of Salt Lick Creek in 1891. It produced oil. The first gas well drilled in this field began in 1895, and a half dozen wells were put down in scattered locations in the next decade. In 1918 several companies were formed to develop the field, and drilling began in earnest. By the end of that year a total open flow, old and new, of about 20,000,000 cubic feet had been

developed. During 1919 other wells were drilled, and during 1920 and 1921 an active drilling campaign has been waged.

Most of the wells are in the Maxon Sand. The largest well in this sand of which authentic data is available had an original open flow of 3,600,000 cubic feet. The original rock pressure of this sand was about 250 pounds. Good producers are still being drilled into this sand, but their decline is very rapid, and salt water has appeared in several parts of the field.

A few wells in widely separated parts of the field secured production in the Berea. The size of the wells in this sand range from 250,000 to 3,000,000 cubic feet, and their original rock pressure was 535 pounds.

Recently several large wells have been secured in the southern part of the field in the Bradley Sand, one having an open flow of 12,000,000 cubic feet, and others having more than 5,000,000 cubic feet. This area, however, is comparatively small, being already practically outlined by dry holes.

Production from the Salt sand is not regarded as of commercial importance because of the rapid encroachment of saltwater.

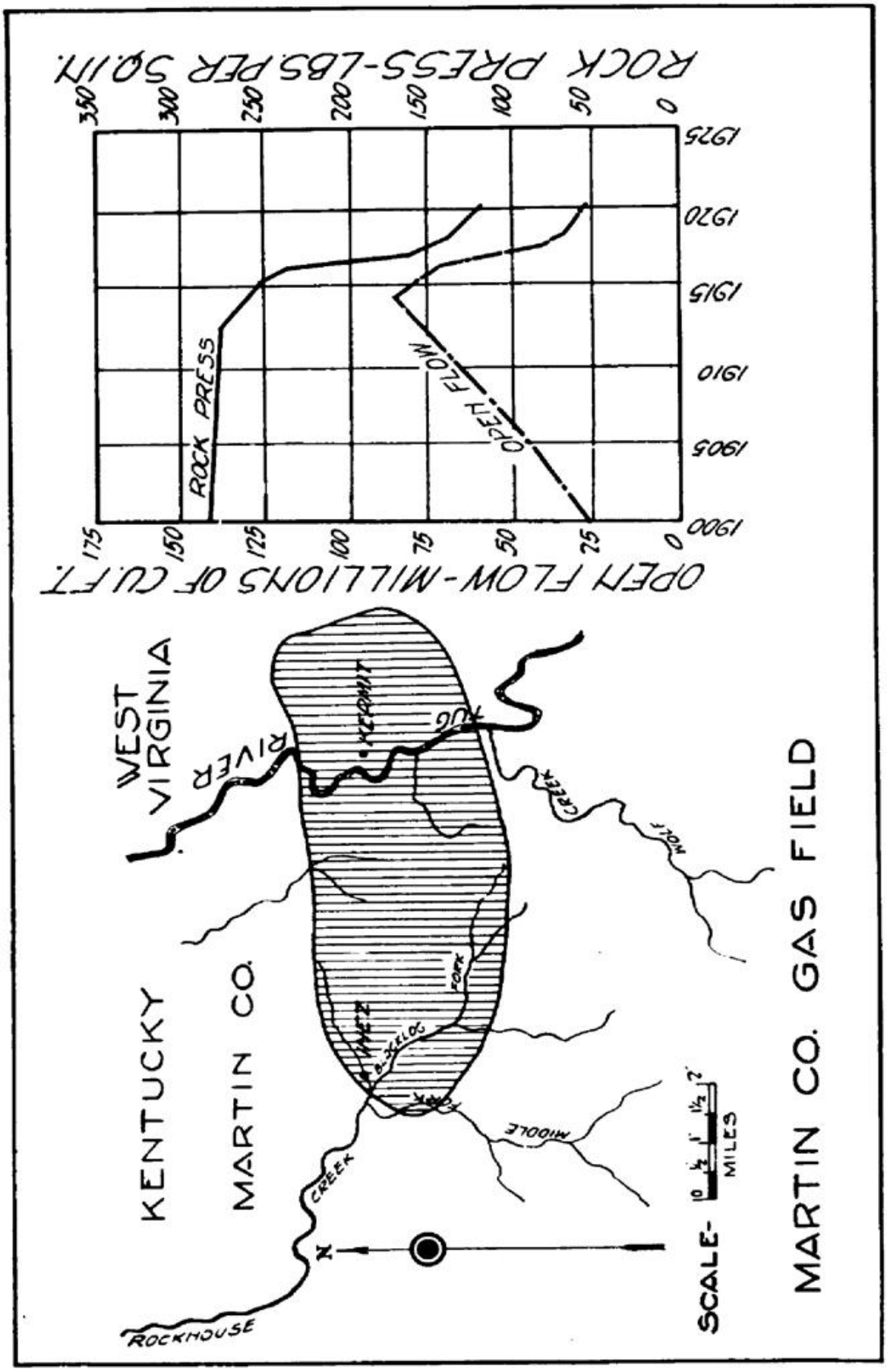
Due to the fact that the natural gas development of this field has been and still is in the hands of several different companies which has allowed only a portion of the available open flow to be drawn on, reliable estimates of the gas reserves of this field have been difficult to make. The results obtained from some of the wells as given hereafter show the field to be spotted, though capable of affording a large supply of natural gas from many wells of medium size and a few wells of rather large capacity.

In 1918 a carbon black plant was erected near Maytown, and began using gas in June. Wells having an

open flow of 7,000,000 cubic feet were connected, and delivered 1,500,000 to 2,500,000 cubic feet per day, but declined in delivery so rapidly that one and two rigs had to be kept drilling continuously. By August, 1920, wells having an original open flow of 10,000,000 cubic feet had been connected, but could only deliver 1,250,000 to 1,750,000 cubic feet per day, while the rock pressure of most of the wells in the Maxon had declined from 250 to 150 pounds, a fall of 40 per cent in rock pressure, and 60 per cent in proportionate deliveries. By the spring of 1921 these wells were furnishing less than 1,000,000 cubic feet per day, with 1 pound at the carbon plant.

In 1920 a compressor station was erected at Maytown by the Pennagrade Oil & Gas Co., and a line built connecting the field with the main line of the Kentucky Pipe Line Company at Sitka. Four wells in the Maxon with an open flow of 7,500,000 cubic feet and an average rock pressure of 240 pounds, and one well in the Bradley with an open flow of 2,375,000 cubic feet and a rock pressure of 372 pounds were connected in December, and deliveries began. Maximum daily deliveries were 1,750,000 cubic feet per day for a few weeks. By April, 1921, deliveries had decreased to 875,000 cubic feet or 50 per cent of the original. The open flow of the Maxon wells had decreased 62 per cent to 2,890,000 cubic feet and their rock pressure 46 per cent to 130 pounds. The Bradley Sand well had fallen off 89 per cent to 260,000 cubic feet, and its rock pressure 76 per cent to 90 pounds. In May, 1921, this well was flooded out by salt water, and after being properly plugged was abandoned.

A second carbon plant was erected in 1920 in the southern part of the field, and placed in operation in November. The plant has a capacity of 3,000,000 cubic



LOCATION, AND DECLINE CURVES OF MARTIN COUNTY GAS FIELD (KENTUCKY)

feet of gas daily. This plant has connected to it most of the wells in its portion of the field, and though not at the present running to full capacity, could rapidly exhaust what appears to be a most promising part of the field.

MARTIN COUNTY GAS FIELD—(3)

GEOGRAPHY—This field is located in east-central Martin County on the Tug Fork of the Big Sandy River. Geologically it stretches over into West Virginia. Warfield, Ky., and Kermit, W. Va., are approximately in the center of the gas-bearing area. The latter town is on the N. & W. R. R.

GEOLOGY—The structure here is anticlinal and the gas is found on a dome about eight miles long and four miles wide. Commercial production is secured from the Salt (Pennsylvanian), Maxon, and Big Lime (Mississippian) "Sands." A few Big Injun and Berea (Mississippian) wells also produced marketable amounts of gas. The Corniferous (Devonian) here is gas bearing, but there is so much hydrogen sulphide in the gas from this strata that it is not used. Drilling depths are from 750 to 1,500 feet. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first well was drilled in 1881. It was allowed to waste into the atmosphere for ten years, after which it was used by a carbon black plant until 1901, when a pipe line was built from the field supplying Ashland, Catlettsburg, Ironton, and Huntington. Wells then making gas were connected up, and an active drilling campaign began.

By 1907, 33 wells had been drilled, and an open flow of 48,250,000 cubic feet had been developed. The size of the wells ranged from 500,000 to 2,500,000, and the original rock pressures were 280, 470 and 565 pounds

respectively for the Salt (Pennsylvanian), Maxon and Big Lime (Mississippian) "Sands."

Active drilling continued. In 1912 a pipe line was laid to supply several towns in Central Kentucky, including those formerly supplied by the Menifee County field. The following year a line was laid to Louisville, and a 2,200 H. P. compressor station was built at Kermit. Deliveries to Louisville began in February, 1914. The year 1914 marked the peak of the production from the Martin County field. By this time 92 wells had been drilled, and the open flow reached 90,000,000 cubic feet. Maximum deliveries were 18,000,000 cubic feet per day.

From this time to the present deliveries have decreased rapidly. The gas producing area was completely defined, and of 46 wells drilled in the next four years by one company, 21 were dry. In spite of the fact that the wells in the upper sands were drilled to the lower producing horizons, the average rock pressure fell steadily. By 1917 it was necessary to rebuild two of the compressors at Kermit, so that they could take the gas at a lower suction.

In 1918 several wells became completely exhausted and had to be abandoned. Although there were then connected 124 wells which had shown original open flow totaling 153,000,000 cubic feet, the combined open flow at that time was only 40,000,000 cubic feet, and the average rock pressure had declined to 150 pounds.

Since depletion set in, pipe lines have been laid to other fields in West Virginia to supply the Kermit Station. The flow and rock pressure of the Martin County field has, however, continued to decline. The field is now regarded as practically exhausted, and is only supplying about 2,000,000 and 3,000,000 cubic feet per day.

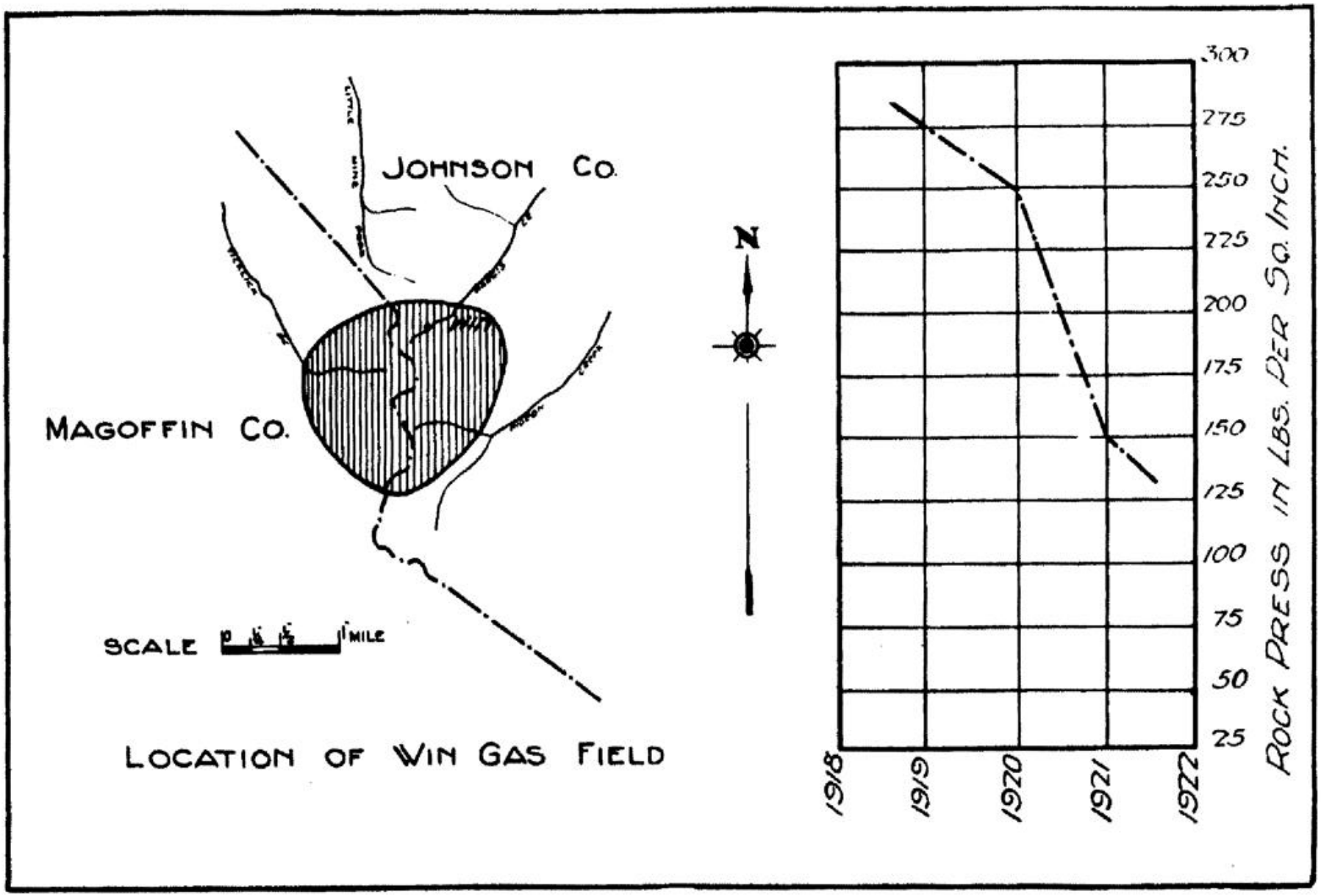
RED BUSH GAS FIELD—(4) AND FLAT GAP GAS FIELD—(5)

GEOGRAPHY—These fields are twins located in the northwestern corner of Johnson County and extending over into Lawrence County. Flat Gap Post Office is on the southeastern edge of the field and Red Bush Post Office on the southwestern flank. The field is crossed by Laurel Creek. The main lines of the Kentucky Pipe Line Co. and the Central Kentucky Natural Gas Co. run about six miles south of the center of the producing area.

GEOLOGY—The structure is a broad dome. Drilling results have been such as to indicate that the contours on the gas sand are not conformable with those on the outcropping strata, and that the gas area may be smaller than was formerly figured. Production is secured from the Weir and the Berea (Mississippian) but principally from the latter "sand." The Weir occurs at 575 feet and the Berea at about 700 feet below the surface. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first well was put down in this field in the fall of 1917. It had an open flow of 500,000 cubic feet, and a rock pressure of 230 pounds. By the summer of 1918 four gas wells had been drilled and a total open flow of 2,250,000 cubic feet developed. The largest well made 900,000 cubic feet, and the smallest 300,000 cubic feet, and the rock pressure averaged 235 pounds.

In July, 1918, a contract was made for the sale of this gas, and a line was laid connecting the field with the main line of the Central Kentucky Natural Gas Co. Deliveries were begun in December, 1918. This field is still putting gas into the main lines. The acreage is in



LOCATION, AND DECLINE CURVES OF WIN GAS FIELD (KENTUCKY)

the hands of several different companies who have been unable to unite their interests. Development of the gas has been slow. Maximum deliveries have never been more than 1,250,000 cubic feet per day. Minimum deliveries much less.

ELK FORK GAS FIELD—(6)

GEOGRAPHY—This field is located in central Morgan County, and extends westward about two miles from the Licking River at West Liberty to Caney Creek.

GEOLOGY—The structure here is anticlinal with the gas apparently gathered about the crest of a small dome. The gas production comes from the Clinton (Silurian) "sand" which is reached at 1,500 feet. The surface rocks are Pottsville (Pennsylvanian), sandstones, shales, and coals.

HISTORY—The wells of this field were originally drilled in search for oil, and the gas production so far developed has been incidental to oil operations. To date about 15 wells have been drilled, five of which made gas in excess of 100,000 cubic feet per day. Two of these made 500,000 cubic feet each. The rock pressure averages 425 pounds.

These wells were connected to West Liberty five years ago. Although the population of this town is only 500, the company owning the wells has difficulty in maintaining the supply during the winter. While the field has not yet been completely drilled, it is evident that it will never be a producer of large commercial importance.

WIN GAS FIELD—(7)

GEOGRAPHY—This field is located on Mine Fork of Paint Creek on the Magoffin and Johnson County lines,

about four and one-half miles from the main pipe lines of the Kentucky Pipe Line, and the Central Kentucky Natural Gas Companies.

GEOLOGY—Production is secured on the top of the Mine Fork (Paint Creek) dome just south of the Paint Creek Fault. The producing area covers about three square miles. The gas sand is the Weir (Mississippian), 900 to 1,100 feet below the surface. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first well was put down in this field in June, 1918, by the Bed Rock Oil Company. In the fall of that year a 250 H. P. compressor station was installed and the field connected with the Central Kentucky Natural Gas Company's pipe line. In the fall of 1919 a 450 H. P. compressor station was built by the Louisville Gas & Electric Co. and a second line built connecting the field with the pipe line to Louisville.

A total of 35 wells, of which 30 were producers, had been drilled in this field up to the end of 1920. The largest well had an open flow of 2,000,000 cubic feet and the smallest 425,000 cubic feet, and the original rock pressure of the wells ran from 285 to 290 pounds. The open flow of the first twenty wells drilled averaged 850,000 cubic feet. The producing area appears to be defined, but there are about 12 to fifteen locations remaining, some of which will be drilled by the end of 1921.

The total open flow of the Win Gas Field reached 18,000,000 cubic feet in January, 1920, at which time the maximum deliveries were 5,000,000 cubic feet per day. This was from 20 wells. Within three months, deliveries showed an appreciable decline and, although additional wells have been drilled and connected up, the total dropped steadily, until the field now averages 1,500,000 cubic feet per day. The present open flow is approxi-

mately 6,500,000 cubic feet, and the rock pressure 135 pounds. A total of about 2,000,000,000 cubic feet has been taken from the field to date.

MIZE GAS FIELD—(8)

GEOGRAPHY—This small field is located near Mize Post Office in the southwestern part of Morgan County, Ky.

GEOLOGY—The gas appears here to be on a small dome, only a few acres in extent. The Corniferous (Devonian) is the gas "sand" and is found from 1,250 to 1,300 feet below the surface. The rocks exposed at the surface are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first well in this field was put down in 1917 as a test for oil. It came in at 800,000 cubic feet, and had a rock pressure of 272 pounds per square inch. By June, 1918, three producers and two dry holes had been drilled. The total open flow developed was 2,800,000 cubic feet, and the average rock pressure 270 pounds. The largest well showed 1,500,000 cubic feet, and the smallest 400,000 cubic feet.

Shortly after its completion the first well was connected to the drilling on the lease, and although only a few thousand feet of gas was used a month, it was drowned out by salt water in two years. Results obtained in drilling this field show it to be so small in extent as to be of only local value.

IVYTON GAS FIELD—(9)

GEOGRAPHY—This field is located in central-eastern Magoffin County, with its eastern edge almost against the county line. Ivyton, on the B. S. & K. R. R., is on the edge of the field. The wells are drilled along Burning Fork and its tributaries.

GEOLOGY—The principal structure here is anticlinal, the gas area being located on a dome, the major axis of which runs about 30 degrees east of north, and the southwestern end of which flattens slightly. Production is secured in the Weir sand (Mississippian). The pay streak averages about 15-25 feet in thickness, and drilling depths are 1,000 to 1,250 feet. One well in the field has been drilled 3,500 feet to the Upper Ordovician, but found no pay sands below the Mississippian series. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first well was drilled in this field in 1919 by the Bed Rock Oil Co., in prospecting for oil. During 1920 five more gas wells were drilled, and at the end of this year an open flow of 11,000,000 cubic feet had been developed. In the early part of 1921 a 6-inch pipe line was laid from the field to Win, connecting with the line of the Kentucky Pipe Line Co., and in March deliveries were begun to Louisville.

By September, 1921, about 25 gas wells had been drilled, and a total open flow of 25,000,000 cubic feet developed. The largest well showed 2,750,000 cubic feet, and the smallest 175,000 cubic feet. The rock pressure averaged 385 pounds. The southern, eastern and western edges of the field have been defined by the drilling of several dry holes. The total productive area appears to be about 2,500 acres. To October 1, 1921, less than 200,000,000 cubic feet have been taken from the field. For this reason, no reliable estimate of its probable life can be made, though it is to be regarded as a commercially important and very valuable natural gas field.

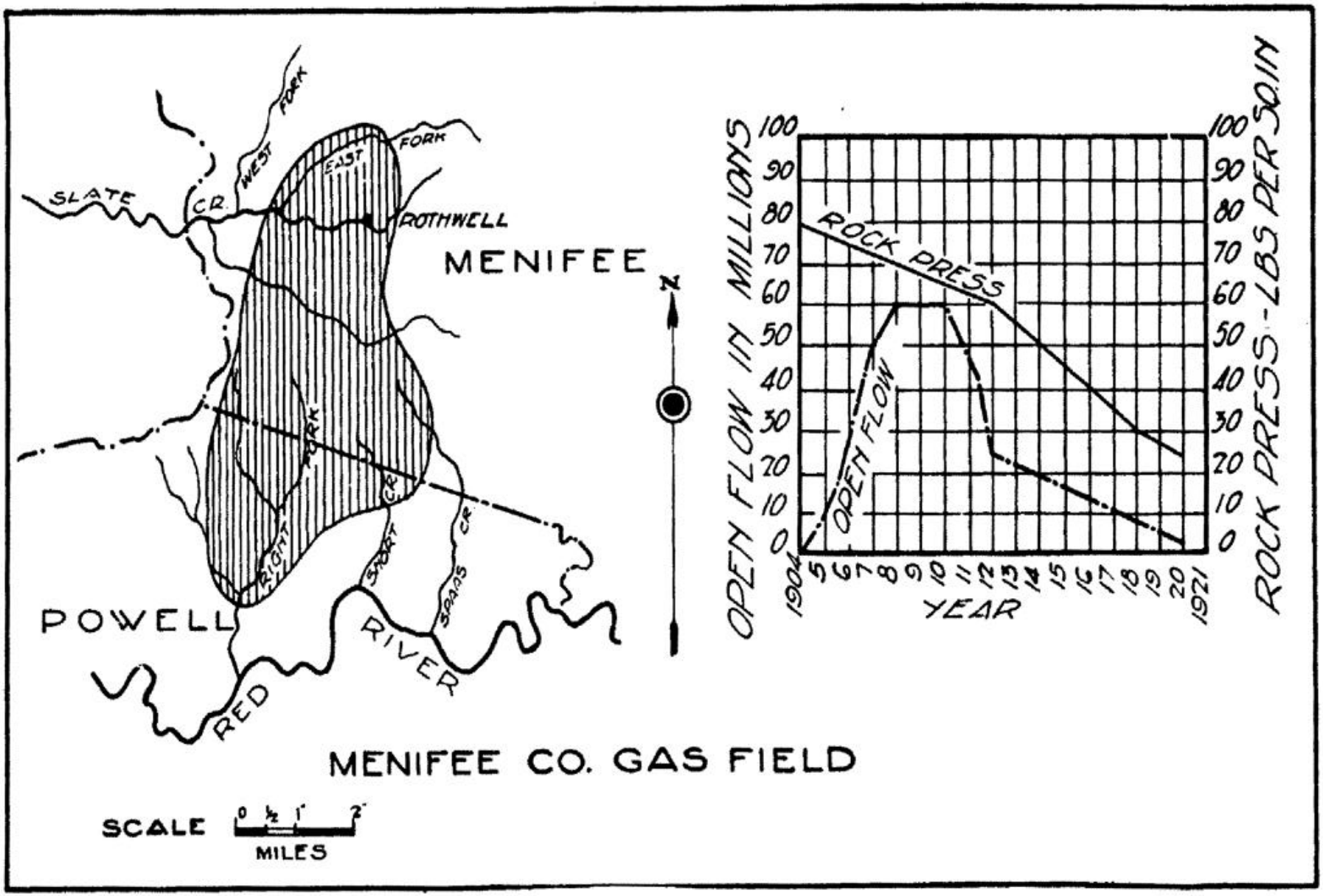
MENIFEE COUNTY GAS FIELD—(10)

GEOGRAPHY—This field is located near Rothwell, in Menifee County, at the end of a branch line of the C. & O. R. R. The field is 8½ miles long and 4½ miles wide, and the total producing area covers 24 square miles.

GEOLOGY—The structure here is monoclinal. The slope rises from the southeast to the northwest at an almost uniform rate of fifty feet to the mile, with only two slight synclinal basins to mar its symmetry. Production is secured from a porous streak 25 feet thick in the Corniferous (Devonian) limestone. Wells are from 400 to 800 feet deep, averaging 500 feet. At the northwest end of the field the porous streak pinches out entirely. The southeastern and southern edges are saturated with salt water. The surface rocks are Pottsville (Pennsylvanian), and Chester (Mississippian) sandstones, shales and limestones.

HISTORY—Gas was discovered in this field in March, 1904, the first well showing 500,000 feet at 452 to 478 feet. The rock pressure was 79 pounds. The following year a company was formed to develop the field, and in February, 1906, a line was laid to Mt. Sterling, Winchester, and Lexington, and a compressor station was built.

By the middle of 1911, 115 wells had been drilled, of which 90 were gassers, and 25 dry holes. The largest well made 1,250,000 cubic feet, and the smallest 250,000 cubic feet. The average original rock pressure was 75 pounds. Maximum deliveries never exceeded 4,500,000 cubic feet. Early in 1912 the producing area was completely defined and drilled up, and with no new wells to be added, the deliveries began to drop rapidly.



LOCATION, AND DECLINE CURVES OF MENIFEE COUNTY GAS FIELD (KENTUCKY)

By June, 1912, the open flow had fallen to 25,000,000 cubic feet, and the rock pressure to 60 pounds. Three wells had been drowned out by salt water, and the deliveries were no longer sufficient to supply the towns connected.

To meet this situation the West Virginia fields were connected, and since 1912 gas has only been taken from the Menifee field as an emergency relief in very cold weather. In 1920 the rock pressure was 25 pounds. Deliveries from the field practically ceased in 1918. In the summer of 1920 a trial was made of using the field as a storage field, but the results of the experiment are not known.

ONEIDA GAS FIELD—(11)

GEOGRAPHY—This field is located in northeastern Clay County near Oneida. The wells are drilled along Red Bird and Bullskin Creeks.

GEOLOGY—The structure here is anticlinal, but not enough data has been gathered as yet to make it possible to determine the exact structural characteristics of the field. A comparison of surface structure and results of drilling to date suggests a lack of accordance between the gas "sand" figure and that seen in the coals above. The gas "sand" is the Corniferous (Devonian), and is found at about 1,600 feet below the surface. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first well was drilled in this field in the spring of 1920 as a test for oil. It made 2,250,000 cubic feet of gas, and three other wells were then put down. By the end of 1920 these had been completed, and the total open flow was 11,000,000 cubic feet. The largest

well had an open flow of 4,000,000 cubic feet, and the smallest 1,500,000. The original rock pressure of all the wells was 350 pounds. As no market for the gas was available, drilling operations were stopped.

In May, 1921, Well No. 1 had an open flow volume of 1,350,000 cubic feet, and a rock pressure of 310 pounds; No. 3 had an open flow of 780,000 cubic feet, and a rock pressure of 270 pounds. Well No. 4 had a volume of 475,000 cubic feet, and a rock pressure of 300 pounds. Well No. 2, originally quite as good as No. 1, caved in, due to inadequate casing, and was ruined. A number of wells have been drilled in the neighboring vicinity, all of which were unproductive. The field is evidently not a large one, though certainly one of value.

WILLIAMSBURG GAS FIELD—(12)

GEOGRAPHY—This field is located at Williamsburg, Ky., in the center of Whitley County, a town of 2,000 inhabitants. It is reached by the main line of the L. & N. R. R. The Cumberland River bisects the town.

GEOLOGY—The structure here is a doming anticline, located nearly in the basin of the Eastern Kentucky Geo-Syncline. Pottsville (Pennsylvanian), Maxon, Big Lime, and Big Injun (Mississippian) "sands" are productive of natural gas. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales, and coals.

HISTORY—The first wells drilled in this section were drilled in 1902, and produced oil and gas from the shallow sand, the producing depths being from 300 to 500 and from 700 to 800 feet. These sands, it would seem, correspond to the upper sands in the Knox County fields, viz: Wages, Jones, and Epperson.

In a recent drilling campaign, the Iroquois Oil & Gas Company tried to make some of these shallow wells into producers. Finding that this was not possible, they decided to drill the Adkins well deeper. It was finished at a depth of 1,381 feet and produced gas from two separate horizons. The top of the first sand was encountered at 1,155 feet and produced gas in this same streak to the depth of 1,180. The next gas was found at 1,365 to 1,370 feet. This well was gauged and found to be making 2,700,000 cubic feet, and had a rock pressure of 220 pounds.

The pay "sands" correspond somewhat to the "sands" of Floyd County. The Big Lime is not encountered until after the bit has passed through these upper gas pays. The Big Lime is found to be from 350 to 380 feet thick in this section. Gas production in one well at a depth of 1,515 feet is possibly from Big Injun sand.

PRODUCTION.

Map No.	Name	Open Flow	Rock Pressure
1	Adkins No. 1	2,700,000	220 lbs.
2	J. Rose No. 1	2,800,000	220 lbs.
3	E. G. Moss No. 1	1,900,000	180 lbs.
4	E. G. Moss No. 2	400,000	----------
5	Electric Light Plant	2,900,000	180 lbs.
6	C. W. Rains	500,000	----------

This gas at the present is being piped to Williamsburg for domestic purposes.

GREEN RIVER GAS FIELD—(13)

GEOGRAPHY—This field is located partly in Green and partly in Taylor County. The producing area extends from Greensburg northeastward almost to Campbellsville, and from Salome south to Ebenezer. The Green River passes through the field, and the Campbellsville branch of the L. & N. R. R. crosses it in a northeasterly and southwesterly direction.

GEOLOGY—A long anticlinal ridge comes into the field at the northeast and runs southwest until it flattens out in the big Kentucky geo-syncline which passes through the southern part of Green and Taylor Counties. Three smaller folds cross the main ridge almost at right angles. Most of the gas is found on the three domes formed by the intrusion of these cross folds. Gas is also found in the area along the main anticline between the domes, but in a smaller quantity. The gas "sands" are the Corniferous (Devonian) and the Saluda (Ordovician) limestones, here taken together about 40 feet thick, with 25 feet of pay sand. Drilling depths are from 400 to 600 feet. The surface rocks are limestones (St. Louis age) of the middle and lower Mississippian system.

HISTORY—The first gas wells in the field were drilled some years ago, when an effort was being made to extend the limits of a small oil pool found near Greensburg. Drilling was desultory until 1919, when the Green River Gas Company purchased most of the wells, and laid plans to market it. The following year connections were made to the towns of Greensburg and Campbellsville, three wells being used for this purpose.

To date about 25 wells have been drilled, and an open flow of about 28,000,000 cubic feet developed. The size of the wells ranges from 225,000 cubic feet to 3,500,000

cubic feet. The rock pressure averages 39 pounds. Not enough gas has been taken from the field to make it possible to estimate its depletion curve.

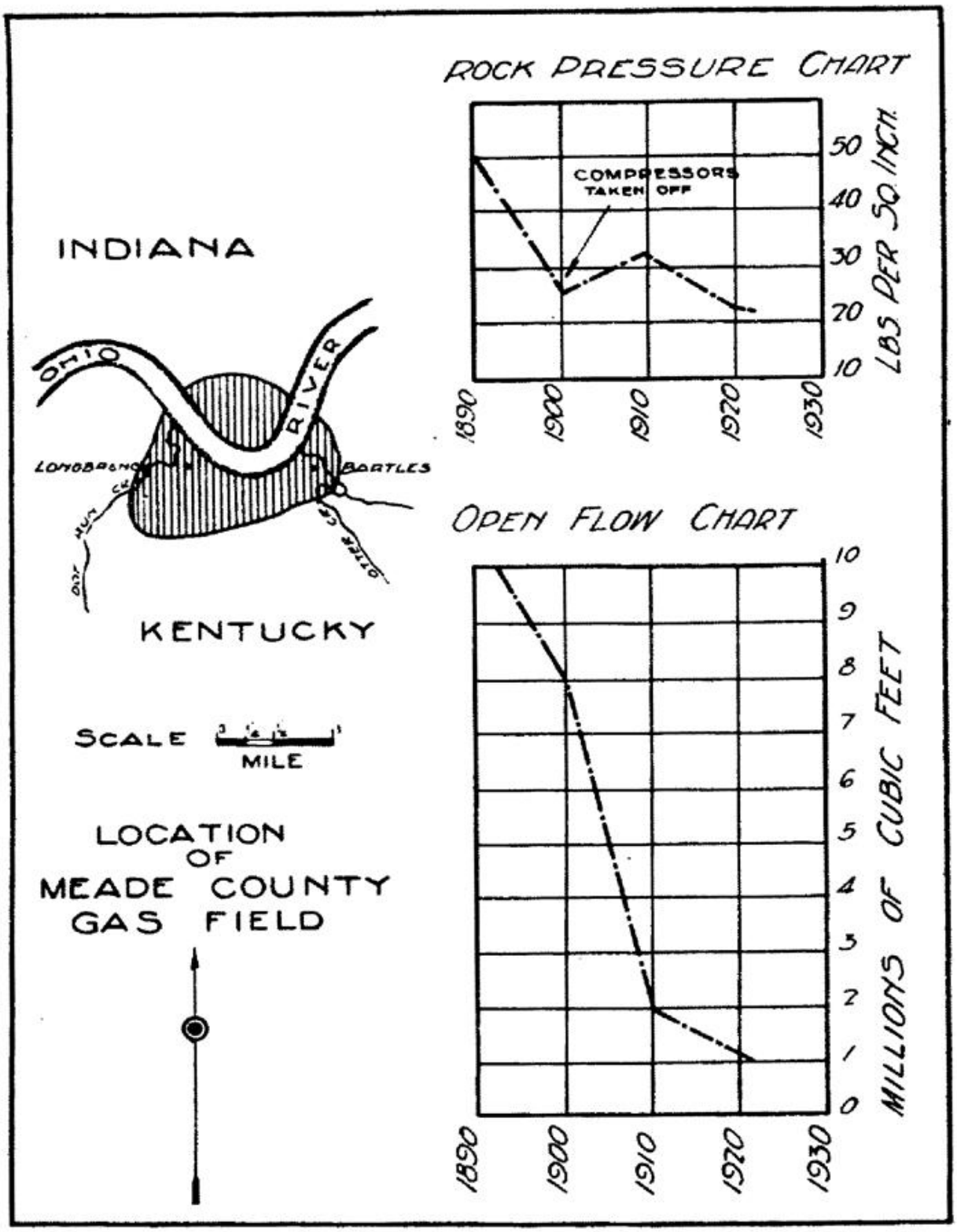
MEADE COUNTY GAS FIELD—(14)

GEOGRAPHY—This field is located in the extreme northeastern corner of Meade County, along the L. H. & St. L. Railroad from Bartles to Long Branch, 35 miles southwest of Louisville. The best gas area at Long Branch is along the bank of the Ohio River and at Bartles is immediately adjacent to the town.

GEOLOGY—Production comes from two small domes on two roughly parallel cross folds running northeast from the Dry Ridge anticline which crosses the northern part of the county. The crests of these domes are near Long Branch and Bartles respectively. The gas "sand" is a 15-foot lens in the black Chattanooga shale (Devonian), and is about seven feet below the top of the shale. The black shale lies at 300 to 400 feet under the surface. A peculiarity of this field is that salt water appeared in all the wells, either at the time of drilling or very shortly thereafter. Some have been pumped for 35 years to keep them from sealing. The surface rocks are limestone of the middle and lower Mississippian system.

HISTORY—The first well in this field was drilled in 1858, and from that time to 1888 several wells were put down, and were used in making salt from the brine found in them. Commercial development began in 1888, at which time a company was formed to pipe the gas to Louisville. A line was completed in 1890.

The largest well in the Meade County field came in at 2,000,000 cubic feet, with a rock pressure of 51 pounds. The highest initial rock pressure recorded was 64 pounds



LOCATION, AND DECLINE CURVES OF MEADE COUNTY GAS FIELD (KENTUCKY-INDIANA)

for a well near Bartles, and the lowest 22 pounds for one in the same portion of the field. The average rock pressure was 50 pounds, and the average open flow about 500,000 cubic feet. Altogether about 100 wells were drilled by 1890. The producing area at Long Branch was completely outlined by non-productive wells, and that at Bartles fairly well drilled up. In 1890 the 30 best wells were connected to the pipe line. These wells when tested individually gave a total open flow of 10,000,000 cubic feet, and when all were flowing into the line the maximum deliveries were less than 2,000,000 cubic feet.

Natural gas deliveries fell off rapidly, causing two 150 H. P. compressors to be installed in 1891. New wells were then drilled and old ones cleaned out and connected to the line, and deliveries increased until in 1904 they averaged 1,000,000 cubic feet per day. This marked the peak production. From this time on the rock pressure declined rapidly, and the use of compressors was finally discontinued.

LEITCHFIELD GAS FIELD*—(15)

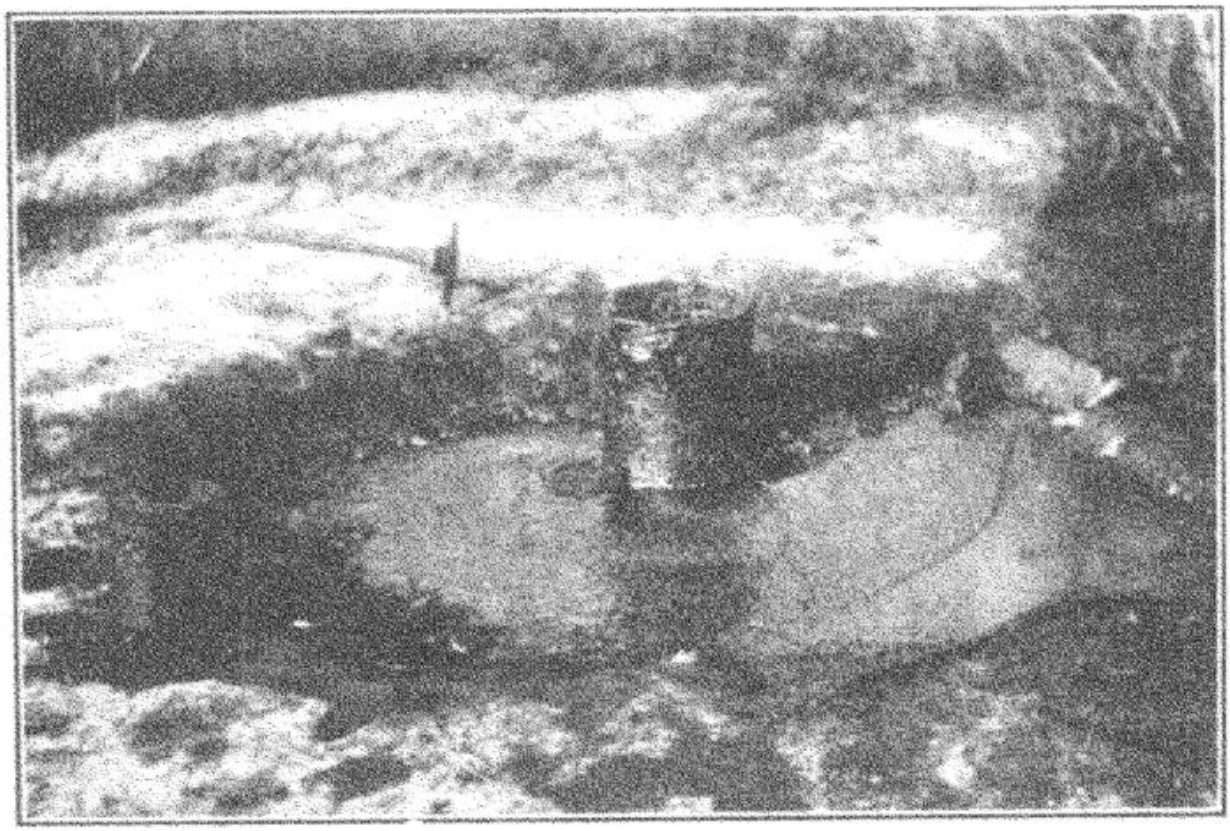
GEOGRAPHY—The Leitchfield gas field is located in the central portion of Grayson County in the immediate vicinity of the town of Leitchfield. The extent of the field has never been determined, but it is probably not a large field. The structural geology of the section indicates that it may be extended somewhat further to the east and to the west.

GEOLOGY—The gas is secured in porous strata of St. Louis (Mississippian) limestone at a depth of from 700 to 1,200 feet. The structure is a doming nipple on a great anticline, the major axis of which extends nearly

* Geology of Oil and Gas in Grayson County, W. R. Jillson, Kentucky Geological Survey, Series VI, Vol. II, p. 183, 1921.

east and west. The surface rocks are of the Chester Series (Upper Mississippian).

HISTORY—The first producing gasser in this field, now known as the "Old Leitchfield Well," was drilled about 1890, near the town. It produced between 5,000 and 10,000 cubic feet, and was subsequently abandoned. Several gas and artesian water wells have been drilled near Leitchfield. The best gasser of these is the Xerxes Hunter, No. 1, located on the northwest limits of the



AN OIL FIELD WASTE

This is an old oil well in Western Kentucky. It was abandoned and never plugged. It has been producing (wasting) oil for ten or fifteen years.

town. About 100,000 cubic feet of gas from this well is being used daily in Leitchfield. It is reported to have had an original open flow of between 3,000,000 and 4,000,000 cubic feet. The W. S. Proctor is a commercial gasser, but its size is not known.

HISEVILLE GAS FIELD—(16)

GEOGRAPHY—This field is located in the northeastern portion of Barren County in the vicinity of Hiseville Post Office. The extent of the field is not definitely known, but it is not considered to be a large gas field. It is defined by several gas wells. The nearest main line railroad station is Cave City, which is located about 10 miles west.

GEOLOGY—The natural gas is secured beneath the black Chattanooga shale (Devonian) in the underlying limestone, probably of Devonian and Ordovician age. Individual wells are reported to be producing an initial maximum of 1,000,000 cubic feet open flow. No surficial indications of important gas structure are recognized in this field, and for this reason the gas accumulation is regarded as a pocket or crevice source. The rock pressure is about 75 pounds. The St. Louis (Middle Mississippian) limestones are found at the surface.

HISTORY—The first well in this field was drilled in the 90's in prospecting for oil. When gas was found, the territory was abandoned. About six wells showing gas have been drilled and plugged. The limits and capacity of the field are not known.

GLASGOW GAS FIELD—(17)

GEOGRAPHY—This gas field is located in and surrounding the town of Glasgow, Kentucky, in Barren County. The extent of this field is not definitely known, but it is regarded as a relatively small field.

GEOLOGY—The natural gas of the Glasgow field is secured at depths ranging from 415 to 500 feet in an Ordovician limestone "sand," 105 feet beneath the Devonian shale. No large structure exists at Glasgow, and gas for this reason is regarded to be a pocket deposit. The surface rocks are the Warsaw limestones (Lower Mississippian). There are now fourteen wells drilled

producing gas and no dry holes. The largest well is the Powell gasser with an open flow of 500,000 cubic feet and a rock pressure of 150 pounds. The Sampson gasses has the highest rock pressure with 270 pounds, but its open flow is only 200,000 cubic feet. The total gas production of the Glasgow field now is 3,500,000 cubic feet open flow.

HISTORY—The Glasgow gas field was opened during the year 1921 by "wildcatters" prospecting for oil.

DIAMOND SPRINGS GAS FIELD—(18)

GEOGRAPHY—This field is located in northwestern Logan County on the L. & N. Railroad in the vicinity of Diamond Springs Post Office. The extent of the field, which is small, has been well defined by a number of old wells.

GEOLOGY—The natural gas of this field is found in the limestone beneath the Devonian black shale, which occurs on a sharp monoclinal dip to the northwest. The wells are approximately 700 feet deep. The surface rocks are Pottsville (Pennsylvanian) sandstones and shales, and Chester (Mississippian) limestones and sandstones.

HISTORY—Practically all of the wells in the Diamond Springs gas field are old wells, having been drilled in about 1910.

CENTRAL CITY GAS FIELD—(19)

GEOGRAPHY—This field is located closely surrounding Central City and Junction Point on the L. & N. and the I. C. Railroads. The wells are located close to the town and used for local consumption. The production is not large.

GEOLOGY—The gas of the Central City gas field is found in the Coal Measures in association with No. 8 coal. The structure has not been defined. The surface rocks are Pottsville (Pennsylvanian).

HISTORY—The first productive gas well was drilled in the Central City region about 1910.

PENROD GAS FIELD—(20)

GEOGRAPHY—This field is located in the southeastern part of Muhlenberg County on Rocky Creek, between Rosewood, Penrod and Dunmore.

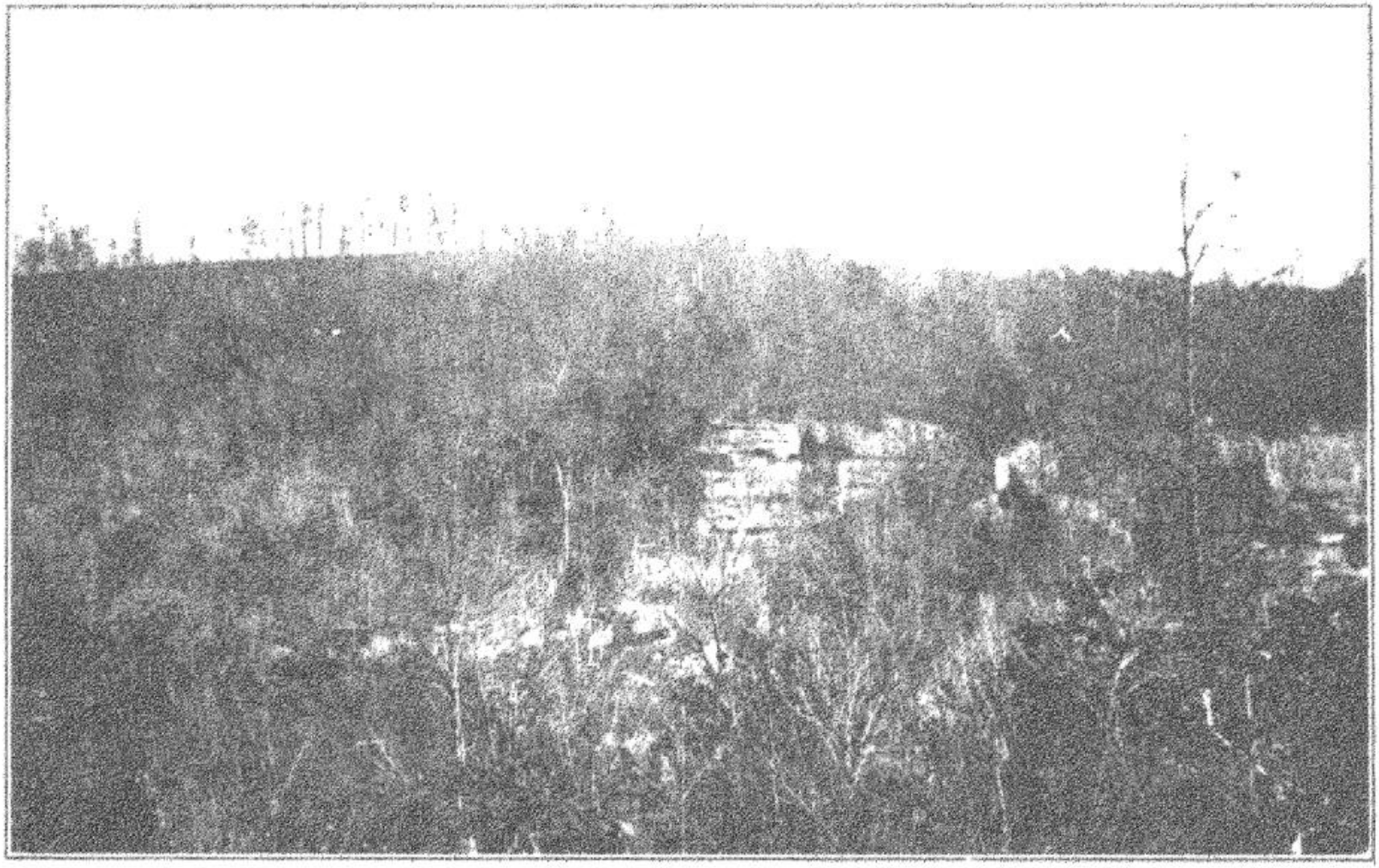
GEOLOGY—The surface rocks are Pottsville (Pennsylvanian) sandstones, shales and coals. This gas field lies about two miles south of the Twin Tunnels fault, and is on the upthrow side of the fault, which is normal. The displacement of the break is unknown. Its direction is S. 86 E. The normal regional dip is almost due north. Gas pay sands are reported to be Pottsville (Pennsylvanian), and are found at a depth of about 700 feet.

HISTORY—The field is new and to date only four wells have been drilled. The first of these produced a small amount of gas and oil. The second showed about 300,000 cubic feet of gas and some oil. The last two wells produced both oil and gas. Further testing is contemplated for the near future.

NEWCOMBE CREEK GAS FIELD—(21)

The Newcombe Creek field is located in the southern-central portion of Elliott County, Kentucky. The nearest railroad station is Redwine on the North Fork Railroad, and is ten miles distant. The field is about four miles long and frcm one-half to three-quarters miles wide.

GEOLOGY—The gas of this field is found in the Wier and Berea sands (Mississippian) at a depth of about 800 feet. The structure is an elongated dome, the major axis of which is nearly north and south. A contour map of this structure has been published by the Kentucky Geological Survey as a part of Series V, Bull. I, Oil & Gas Resources of Kentucky. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales and coals.



A NATURAL GAS STRUCTURE

Natural gas occurs most frequently trapped in a closed anticline or dome. The Sandy Hook anticline shown above "in section" is located in Elliott County, in which the Newcombe Creek Gas Field (21) is found.

HISTORY—Gas was first secured in the Elliott County field in 1917, and sporadic drilling has continued to date, with the result that there are at present four or five gas wells in this field which produced when drilled in between 250,000 and 1,000,000 cubic feet open flow per day. The gas is not commercialized.

SEXTON CREEK GAS FIELD—(22)

GEOGRAPHY—This field is located in northwestern Clay County on Sexton Creek, a northeasternly flowing tributary to the South Fork of the Kentucky River.

GEOLOGY—The structure is an anticline which has been recognized by a study of the surficial coals. Production is secured from the Corniferous (Devonian) limestone. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales and coals.

HISTORY—The discovery well of this field was drilled in about 1918 by Charles Dulin and associates, and the amount of production is not known. The nearest railroad station is Manchester, which is located ten miles to the southeast.

BARBOURVILLE GAS FIELD—(23)

GEOGRAPHY—These gas fields are located in the immediate vicinity of Barbourville and Little Richland Creek.

GEOLOGY—The gas found here is secured in the Big Injun (Mississippian), Epperson, Jones and Wages (Pennsylvanian) sands. No large structure is known to exist at this point, and gas is regarded as a pocket deposit. The depths of the wells vary from 400 to 1,400 feet. The surface rocks are Pottsville (Pennsylvanian).

HISTORY—The first gas well of commercial importance in the Knox County gas field was drilled in about 1900 by oil prospectors. In 1906 the Cumberland Gas Co. installed its transmission line, and in 1907 began supplying gas to domestic consumers in Barbourville.

TEMPLE HILL GAS FIELD—(24)

GEOGRAPHY—This gas field is located in southeastern Barren County on the head of Skaggs Creek at Temple Hill Post Office. The field is ten miles distant from the nearest railroad station, which is Glasgow.

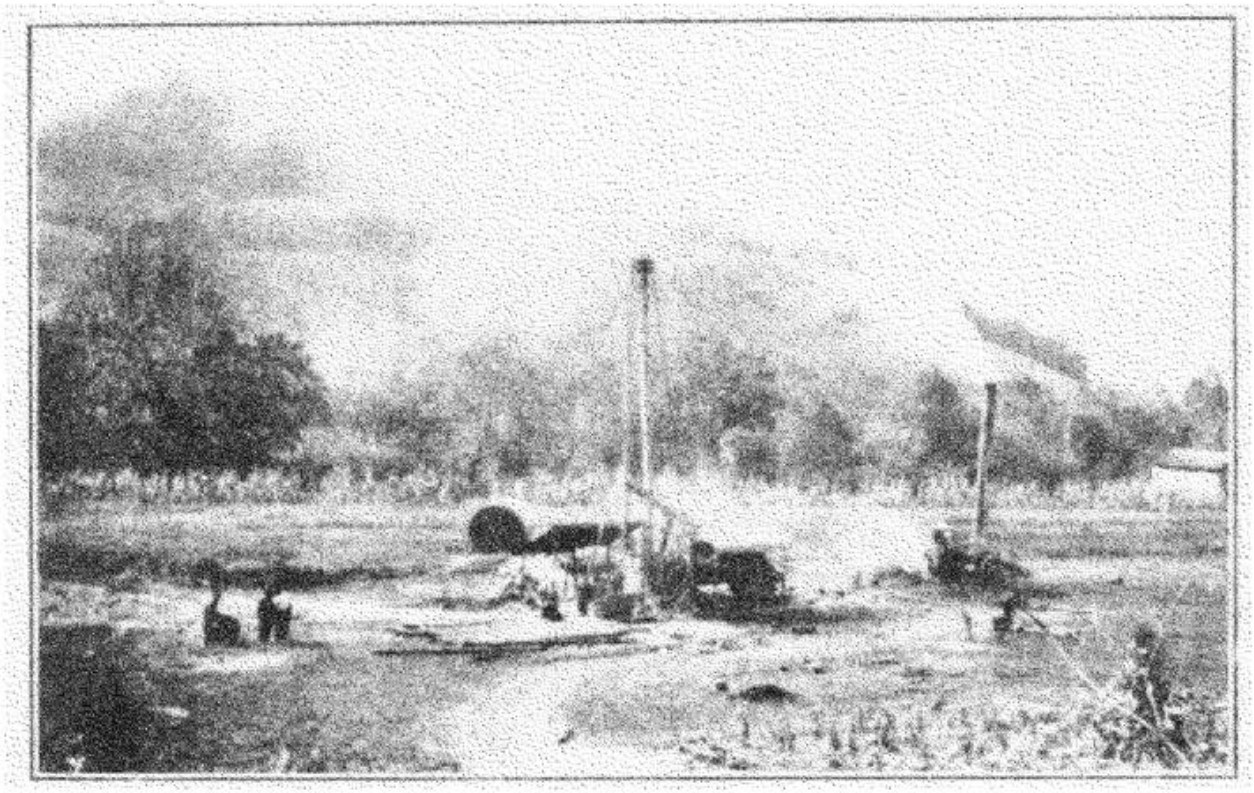
GEOLOGY—Gas produced in the Temple Hill gas field is secured in the porous strata of the Ordovician limestone at a depth of from 800 to 1,200 feet. A pronounced anticlinal structure with a northeast-southwest axis is responsible for the gas accumulation, which occurs in pockets. The field is not more than a mile long and one-half mile wide. The surface rocks are Warsaw and Fort Payne (Lower Mississippian) limestones.

HISTORY—The first producing well drilled in the Temple Hill gas field was drilled by Merry Bros. of Glasgow, Ky., in 1919. The well produced originally 1,000,000 cubic feet of gas, after which it rapidly declined. Since then three other gas wells have been drilled in this section, one of which is regarded to have had an original production considerably over 5,000,000 cubic feet. This volume rapidly blew off, however, and the well declined to a very nominal pressure and volume. This gas field is not regarded as one of large commercial importance, due to the short life of the wells.

MEREDITH GAS FIELD—(25)

GEOGRAPHY—This field is recognized by a single well located 1½ miles southeast of Meredith Post Office in Grayson County on the C. Hazelwood farm. The field is about ten miles southeast of Leitchfield.

GEOLOGY—The index gasser of this field is located on the top of the Meredith dome. Production was secured



DRILLING FOR GAS WITH A PORTABLE RIG

Throughout Eastern Kentucky wherever the gas sands are shallow enough the "portable rig" is used in preference to the "standard derrick."

in the Mississippian System, in what is called the Major "Sand" at a depth of 1160 feet. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales and coals.

HISTORY—This well was drilled in 1917 by the Kentucky Oil & Refining Company. When gauged by the writer in November, 1921, it was found to be making 400,000 cubic feet, with a rock pressure of 335 pounds.

A well drilled approximately 2½ miles south was unproductive. There is no commercial outlet for the gas of this field at the present time.

CLOVERPORT GAS FIELD—(26)

GEOGRAPHY—This gas field is located in northwestern Breckinridge County on the L. & N. Railroad surrounding Cloverport and joining the Ohio River.

GEOLOGY AND HISTORY—The gas found here is produced from a "sand" within the black Chattanooga shale (Devonian). Wells are small, and have been drilled in for a long time. Production from this field reached its peak a number of years ago, since which time it has been declining. It is now practically abandoned, and of no commercial importance. The surface rocks are limestones and shales of the Chester Series (Upper Mississippian).

ISLAND CREEK GAS FIELD—(27)

GEOGRAPHY—This Owsley County gas field is located in the southwestern portion of Owsley County towards the head of Island Creek, a tributary of the South Fork of the Kentucky River. The nearest railroad station is Cressmont in southern Lee County, which is ten miles distant in an air line to the northwest. The nearest post office is Travelers Rest. The extent of the gas field, which is recognized by three index gas wells, is unknown.

GEOLOGY—Structure of this field is reported to be anticlinal, with regional dip to the southeast. The

field is located close to the bottom of the Eastern Kentucky geo-syncline. The surficial rocks are Pottsville (Pennsylvanian) sandstones, shales and coals. Gas production is secured from Corniferous (Devonian) limestone. The wells are about 1,200 feet deep.

HISTORY—Gas was discovered in the field by the Owsley Oil and Gas Company in the Harve Price No. 1 in 1918. This well gauged originally 1,250,000 cubic feet open flow. Later, the Rufus Barker No. 1 was drilled, with initial production of 1,100,000 cubic feet. The Petroleum Exploration Co. drilled in the third gasser, the Aleck Bond No. 1, which had an original open flow of 1,050,000 cubic feet of natural gas. Further developments are now under way in this region.

ROCK FORK GAS FIELD—(28)

GEOGRAPHY—This Knott County gas field is located toward the head of Rock Fork of Right Beaver Creek, close to the Floyd County line. It is known by one well only, which is drilled on the W. R. Bolin farm.

GEOLOGY—The structure of this field is anticlinal, the fold pitching to the north. The gas "sand" is a porous strata within the Big Lime. The field lies close to the Beaver Creek field, and like the latter field is located on the southeastern flank of the Eastern Kentucky geo-syncline. The surface rocks are Pottsville (Pennsylvanian) sandstones, shales and coals. The Kentucky Geological Survey has prepared a structural map of Knott County.

HISTORY—This well was drilled in by the Pennagrade Oil and Gas Co. in 1917 while prospecting for oil. It gauged 4,680,000 cubic feet, had a rock pressure of 540 pounds, and was shut in. The size of the field is unknown,

as no other wells have been drilled in this immediate vicinity. The Big Lime sand, while a big flush producer of gas, is not regarded as long-lived.

PRESTONSBURG GAS FIELD—(29)

GEOGRAPHY—This field is located on Middle Creek and Bull Creek in central Floyd County, Ky.

GEOLOGY—Surface rocks are Pottsville (Pennsylvanian) sandstones, shales and coals. Gas production is secured from the Wier (Mississippian) and Corniferous (Devonian) "sands" at depths ranging from 1,450 to 2,400 feet. The structure is distinctly anticlinal, though located close to the Eastern Kentucky geo-syncline, which passes just to the north of this pool.

HISTORY—This small gas field is known by three wells, two on Middle Creek and one on Bull Creek. The first one was drilled in on the John Gray farm on Bull Creek in 1917 by the Eastern Gulf Oil Company in prospecting for oil. The Middle Creek wells were drilled in 1918 and 1919 by A. Fleming and associates on the Middle Creek Coal Co. tracts, and the Eastern Kentucky Development Co. on the W. H. Fitzpatrick lease. Gas from all three of these wells is now piped at Prestonsburg, where it is used by domestic consumers. The volume and rock pressure of these wells is not known, but they were not large. The Bull Creek well is the best gasser of the three.

MONTICELLO GAS FIELD—(30)

AND

SPARTA GAS FIELD—(31)

These fields are of no commercial importance at present, though each gave promise of commercialization for a time. The Monticello field was located close to the Wayne County town of the same name, and produced from two "sands," the Berea and a shallow "sand" above it. Natural gas was piped into Monticello in 1918, where it was used for a few months. The gas reserves of Wayne County were rapidly exhausted, however, and new ones could not be developed.

The Sparta field is located in southeastern Gallatin County. It produced a considerable amount of gas in two or three wells drilled during the years 1920 and 1921 from Ordovician, possibly Trenton, sands. The production was flashy and soon exhausted. It was never commercialized except for drilling purposes.

CHAPTER III

OUR NATURAL GAS INDUSTRIES

It is not difficult to establish the fact that natural gas is a luxury which is rapidly decreasing in quantity in many places, and especially in the Eastern United States. The fact has been well established in Pennsylvania, Ohio, and West Virginia. It is now being established in Kentucky by a general recognition of actual conditions of depletion in the fields throughout the State.

At a time when the public is beginning to give its attention to the certain exhaustion in the near future of this valuable mineral resource, it is pertinent that some consideration be given to those industries which depend upon it for their continuance. The two users of large quantities of natural gas in Kentucky, are: The public utilities corporations, which supply by the use of extensive pipe lines the domestic consumers in our cities and the carbon black corporations, which produce and use natural gas in the field for the manufacture of carbon black. Since the gas field interests of these two principal consumers of Kentucky's natural gas are in direct conflict, it is expedient that each of them be presented separately, in order that an adequate understanding and contrast of their economic value to society may be secured. The public service corporations supplying natural gas will be discussed first, and the carbon black manufacturers later.

Public Utilities Corporations Supplying Natural Gas

In the State of Kentucky there are three large gas public utilities corporations. One of these, the Central Kentucky Natural Gas Company, serves through its

subsidiaries 14,898 consumers in the towns of Paintsville, Mt. Sterling, Winchester, Paris, Lexington, Versailles, Midway and Frankfort. Another, the Kentucky Pipe Line Company, which is a subsidiary of the Louisville Gas and Electric Company, serves 49,710 consumers in the City of Louisville, its suburbs, and the field including Ivyton, Magoffin County. Each of these companies owns and operates a 6, 8 and 12-inch main transmission line extending from the Martin County gas field in Eastern Kentucky through to their respective western termini, Frankfort and Louisville. The Kentucky Pipe Line Company's main, 222 miles in length, was constructed during 1913 and 1914, and was completed March 15, 1914. The Central Kentucky Gas Company's main line was completed in 1912. This latter line has several short connections to Eastern Kentucky fields, principally in Johnson and Menifee Counties. The Kentucky Pipe Line Company is interested as a small stockholder in the natural gas transmission line of the Pennagrade Oil and Gas Company from the Beaver Creek gas fields in Floyd County to its main line in Johnson County. The Kentucky Pipe Line Company also owns and operates a gas line from the Ivyton gas field in Magoffin County which connects with its main line in Johnson County.

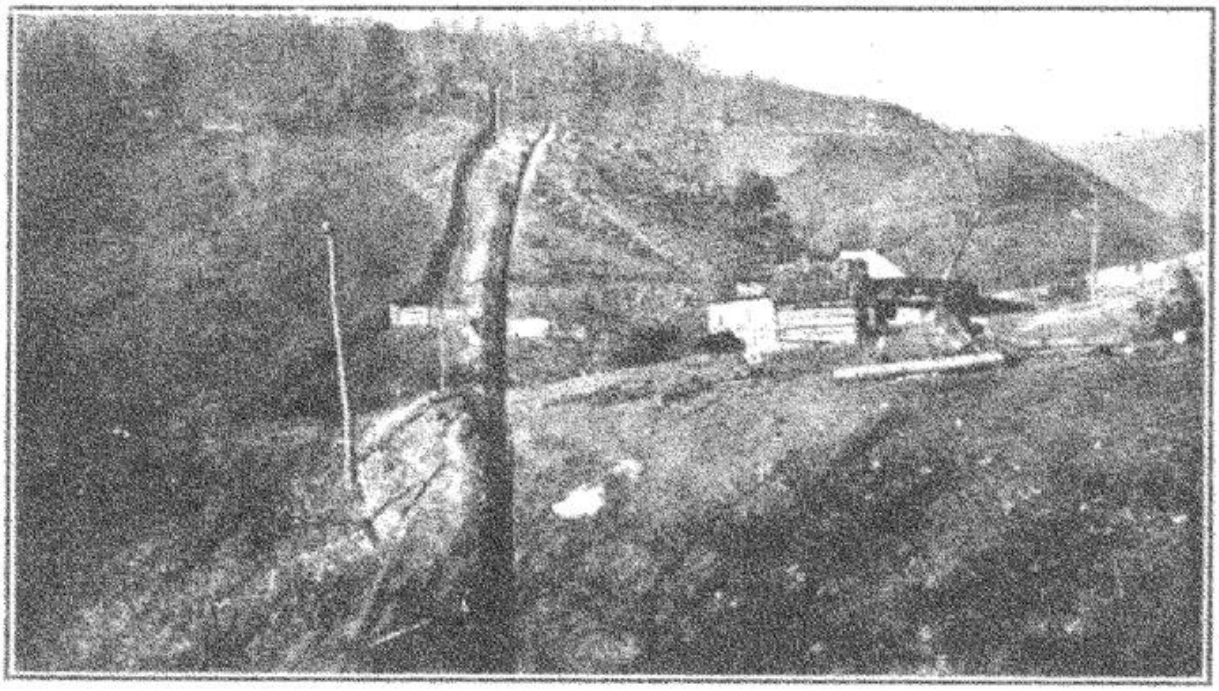
Both of these companies have made much use of the Martin County, Kentucky, gas fields and the West Virginia gas fields in the past, through the United Fuel Gas Company's (Columbia Gas and Electric Co.), service from Inez in Martin County. Each of them still secures a considerable portion of their natural gas from this source of supply, though the volume which this large West Virginia service corporation has been able to give to the Kentucky service corporations has steadily decreased during the last several years, due to the depreciation of

PRELIMINARY WORK ON GAS PIPE LINE

On many of the steep hillsides of Eastern Kentucky "breakers" have to be built into the gas pipe line ditch to prevent washing. This view is in Morgan County.

the source of natural gas supply in Martin County, Kentucky, and elsewhere in West Virginia.

The following table shows the volumes and values of the recent annual runs of some of the larger natural gas public utilities corporations of Kentucky. The first serves the central cities and the second Louisville, principally.



UP HILL, DOWN HILL, AND ON

Big gas pipe lines in Eastern Kentucky avoid neither the hills nor the valleys in their efforts to follow the shortest course—a straight line.

Runs and values Central Kentucky Natural Gas Co. (1919-21).

Yrs.	Consumption, 1000 Cu. ft.	Field Value	Delivery Value
1919	1,548,579	$154,857.00	$619,431.60
1920	2,005,989	200,599.00	802,395.60
1921	1,936,109	193,611.00	774,443.60
	Runs and Values Kentucky Pipe Line Co. (1918-20).		
1918	1,685,000	$186,529.00	$589,750.00
1919	1,965,000	194,535.00	687,750.00
1920	2,760,000	276,864.00	966,000.00

Larger than either the Kentucky Pipe Line Co. or the Central Kentucky Gas Co. in point of capitalization, but much inferior to these corporations in point of direct

service to Kentucky municipal consumers, is the United Fuel Gas Co.'s pipe lines, which extend northward from Inez in the Martin County fields through Louisa to Catlettsburg and Ashland, Huntington, Ironton, Portsmouth, Cincinnati and other points. The principal towns and cities in Kentucky served by this line are Inez, Louisa, Buchanan, Catlettsburg, Ashland, Maysville, Greenup, Covington and Newport, which towns taken altogether consume a relatively large amount of natural gas.

Comparison of Natural Gas Volumes Produced in Kentucky and the Volumes Imported from W. Va., and Ohio.*

Year	Volume Produced in Kentucky.	Kentucky Percentage of Consumption.	Volume Imported from W. Va. and Ohio.	Imported Percent- of Consumption.	Total Volume Consumed in Kentucky
1910	1,356,771	28%	3,423,719	72%	4,780,490
1911	1,358,963	29%	3,375,617	71%	4,734,580
1912	1,659,696	32%	3,443,245	68%	5,102,941
1913	1,821,526	37%	3,089,516	63%	4,911,042
1914	1,421,818	19%	5,803,808	81%	7,225,626
1915	1,667,423	21%	6,078,930	79%	7,746,353
1916	2,106,542	21%	7,781,414	79%	9,887,956
1917	2,802,079	23%	9,251,366	77%	12,053,445
1918	3,022,439	25%	9,177,751	75%	12,200,190

* All volumes are figured in M cubic foot units; U. S. G. S. Min. Res. adapted.

Much smaller in size than the three utilities corporations discussed above is the Green River Gas Company, which owns a large portion of the recently outlined Green River gas field in Green and Taylor Counties, Kentucky. This company operates a short line out of this field to Greensburg and Campbellsville, and is proposing the construction of a pipe line from Campbellsville on to Lebanon, and other small towns. This latter line has not yet been constructed.

Volumes and Values of Natural Gas Consumed in Kentucky.* (1910-1918.)

(All volumes in M cubic feet.)

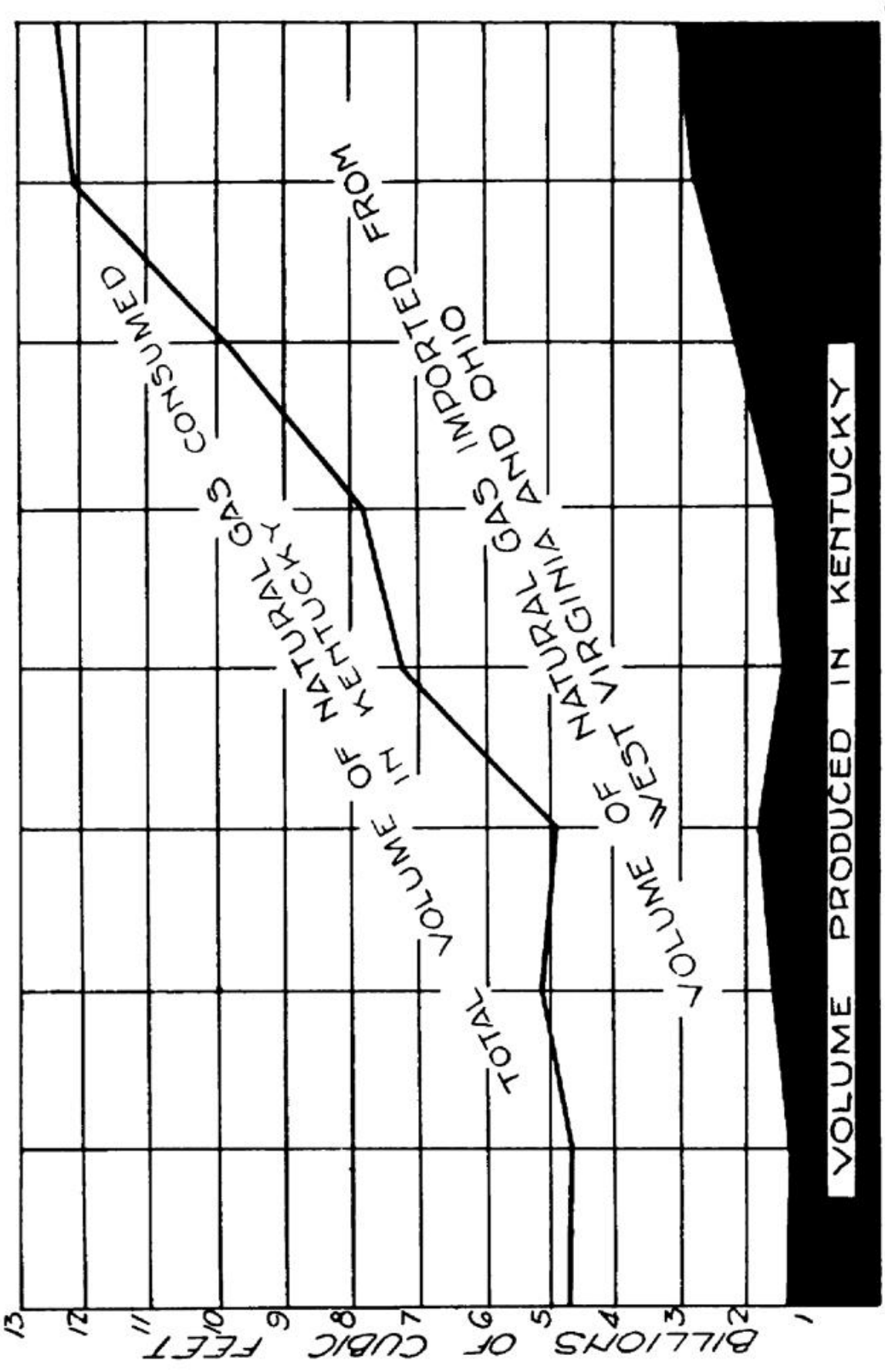
Year	Total Volume Consumed.	Value of Consumption.	Average Price in Cents Per M cu. ft.	Percentage of Increase over Previous Year.	Volume Imported from W. Va. and Ohio.
1910	4,780,490	$908,293	19.00	---------	3,423,719
1911	4,734,580	901,759	19.05	1%†	3,375,617
1912	5,102,941	1,070,664	20.98	7.56%	3,443,245
1913	5,911,042	1,225,116	20.72	15.83%	3,089,516
1914	7,225,626	1,787,308	24.73	22%	5,803,808
1915	7,746,353	1,942,423	25.08	7%	6,078,930
1916	9,887,956	2,331,687	23.59	28%	7,781,414
1917	12,165,489	3,114,402	25.84	22%	9,251,366
1918	12,200,190	3,093,393	25.35	.0028%	9,177,751
Total	69,754,667	16,375,045	Gen. Av. 22.7	---------	51,425,366

* The major totals include all of the Kentucky produced natural gas, plus that which is imported from West Virginia and Ohio; U. S. G. S. Min. Res. adapted.

† Decrease of 1911 compared to 1910.

The amount of natural gas furnished by the public utilities corporations of this State and consumed by the householders of our Kentucky cities is very large, totaling according to the best figures available 2,760,000 M cubic feet in 1920. The following table shows the distribution and production of natural gas in the cities service industries.

The average individual has but little conception of the large number of domestic consumers who are served by the public utilities corporations of this State, and of the real and widespread dependence placed upon this fuel source for domestic heating and lighting. The following table shows the distribution of domestic and industrial consumers from 1906 to 1918.



GRAPH SHOWING VOLUMES OF KENTUCKY PRODUCED AND IMPORTED NATURAL GAS

LOCATION, PRODUCTION AND VALUE OF PRINCIPAL KENTUCKY NATURAL GAS FIELDS

(Years 1918 to 1920, inclusive.)

FIELD	1918		1919		1920	
	Amount Produced	Price	Amount Produced	Price	Amount Produced	Price
1 Martin County	1,200,000	13c	900,000	13½c	600,000	14c
2 Meade County	120,000	10c	120,000	10c	120,000	10c
3 West Liberty	15,000	10c	15,000	10c	15,000	10c
4 Beaver Creek	300,000	4c	600,000	4c	750,000	5c
5 Win			120,000	11c	1,000,000	11c
6 Central City	50,000	10c	50,000	10c	50,000	10c
7 Flat Gap			150,000	11c	150,000	11c
8 Leitchfield			10,000	10c	15,000	10c
9 Green County					60,000	20c
Total and averages	1,685,000	11.07c	1,965,000	9.90c	2,760,000	10.14c

NOTE—The gas from these fields was purchased as follows: From fields 1, 2, and 5 by Louisville Gas & Electric Co.; from fields 1, 5, and 7 by Central Kentucky Natural Gas Co.; from fields 3, 6, 8, and 9 by towns adjoining fields; from field 4 by Carbon Black Plants. Volumes in M cubic feet.

Consumers and Producers of Natural Gas in Kentucky.*
(1906-1918.)

Year	Domestic.	Industrial.	Total Consumers.	Number of Producers.
1906	17,216	18	17,234	45
1907	19,279	239	19,518	38
1908	21,778	42	21,820	38
1909	25,639	137	25,776	38
1910	27,961	112	28,073	47
1911	41,201	70	41,271	74
1912	45,603	103	45,706	88
1913	54,446	146	54,592	93
1914	78,505	128	78,633	101
1915	84,666	117	84,783	86
1916	85,583	125	85,708	107
1917	90,041	124	90,165	118
1918	90,849	100	90,949	122

The widespread use of natural gas for fuel and light in Kentucky is indicated by the fact that sixty-two towns and cities, and nearly 100,000 consumers, are now dependent upon it.

Recent Natural Gas Deliveries to Louisville, Ky.
(Volumes in M Cubic Feet)

Month	Deliveries 1919	Deliveries 1920	Deliveries 1921
January	291,000	365,000	392,000
February	272,000	343,000	356,000
March	282,000	314,000	303,000
April	245,000	306,000	270,000
May	218,000	237,000	228,000
June	145,000	169,000	155,000
July	144,000	164,000	165,000
August	155,000	168,000	188,000
September	164,000	183,000	190,000
October	205,000	254,000	308,000
November	289,000	357,000	346,000
December	357,000	412,000	440,000
Total	2,766,000	3,272,000	3,340,000

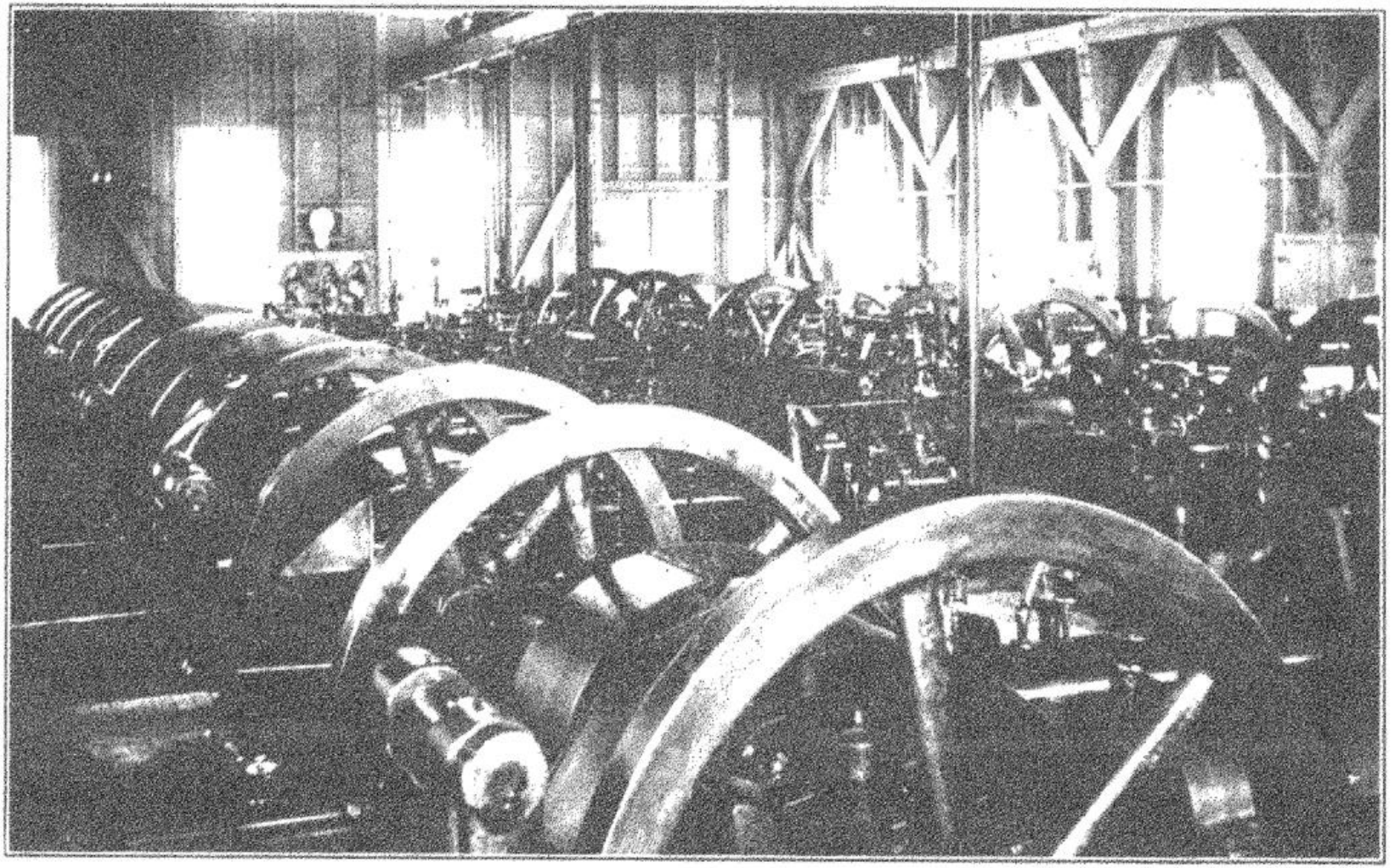
* U. S. G. S. Min. Res. adapted.

Kentucky Towns and Cities Using Natural Gas–1921:

1 Ashland.
2 Barbourville.
3 Bellevue.
4 Brooksville.
5 Buchanan.
6 Burning Springs.
7 Campbellsville—475*.
8 Caney.
9 Cannel City.
10 Catlettsburg.
11 Central City—250.
12 Chinnville.
13 Clifton.
14 Clintonville.
15 Cloverport—200.
16 Cold Spring.
17 Covington—28,567.
18 Dayton.
19 Diamond Springs.
20 Dover.
21 Estill.
22 Foster.
23 Frankfort—2,638.
24 Garrett.
25 Glasgow—30.
26 Greensburg—125.
27 Greenup.
28 Hazel Green.
29 Inez.
30 Ivyton—25.
31 Kavanaugh.
32 Kenner.
33 Langley.
34 Leitchfield—100.
35 Lexington—7,315.
36 Louisa.
37 Louisville—49,685.
38 Ludlow.
39 Maysville—1,544.
40 Maytown.
41 Midway.
42 Monticello.
43 Mt. Sterling—1,134.
44 Newport.
45 North Middletown.
46 Paintsville—369.
47 Paris—1,300.
48 Pollard.
49 Prestonsburg—250.
50 Rothwell.
51 Russell.
52 Salyersville—100.
53 Versailles—116.
54 Warfield.
55 Wayland.
56 West Covington.
57 West Liberty.
58 West Point.
59 Wheelwright.
60 Williamsburg—300.
61 Winchester—2,026.
62 Worthington.

In summation, the public utilities natural gas service corporations of the State of Kentucky have at present invested capital in the sum of approximately $25,000,000 in their endeavors to serve municipal domestic consumers with fuel and light. At the present time there is invested by the natural gas consuming public not less than $9,500,000. In the year 1918, 90,849 individual consumers in the towns and cities of Kentucky used 12,200,190 cubic feet of natural gas, which was worth $1,220,019 in the field, and $3,093,393 to the purchasing public. Data for 1921, were it available, would undoubtedly show a considerable increase in both the total volume and value of the natural gas consumed in Kentucky.

* The number of consumers is given where known.



CENTRAL KENTUCKY NATURAL GAS COMPANY'S PRESSURE PLANT

Much of the large investment of capital required by gas utilities corporations goes into "booster" stations, pipe lines and gas field purchase or "wild catting." The continuous operation of these stations is also a considerable item of normal expense.

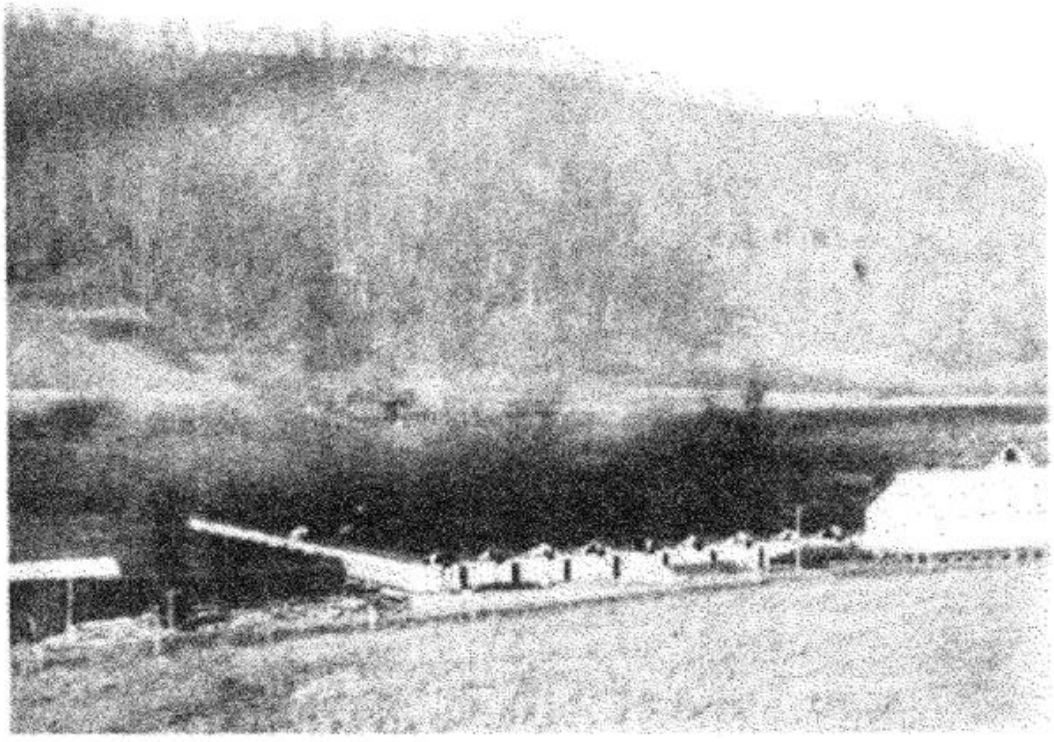
Volumes and Values of Natural Gas Produced in Kentucky and Consumed in Kentucky.

Year	Volume Natural Gas Produced in Kentucky M cu. ft. Unit.	Value of Production in the Field at 10 Cents Per M cu. ft.	Value of Kentucky Produced Natural Gas Consumed in Kentucky.	Average Rate Per M cu. ft.
1890	100,000	$10,000	$30,000	.30
1891	129,973	12,997	38,993	.30
1892	143,916	14,392	43,175	.30
1893	228,333	22,833	68,500	.30
1894	277,333	27,733	89,200	.30
1895	329,000	32,900	98,700	.30
1896	330,000	33,000	99,000	.30
1897	300,000	30,000	90,000	.30
1898	343,766	34,377	103,133	.30
1899	419,150	41,915	125,745	.30
1900	646,773	64,677	194,032	.30
1901	625,533	62,553	187,660	.30
1902	852,603	85,260	255,781	.30
1903	935,753	93,575	280,726	.30
1904	895,213	89,521	268,564	.30
1905	848,535	84,854	237,590	.28
1906	1,026,790	102,679	287,501	.28
1907	1,357,777	135,778	380,176	.28
1908	1,515,254	151,525	424,271	.28
1909	2,097,471	209,747	485,192	.23+
1910	1,356,771	135,677	456,293	.34–
1911	1,358,963	135,590	407,689	.30
1912	1,659,696	165,970	497,909	.30
1913	1,821,526	182,153	509,846	.28
1914	1,421,818	142,182	490,875	.35
1915	1,667,423	166,742	614,998	.368
1916	2,106,542	210,654	752,635	.34
1917	2,802,079	280,208	872,706	.34
1918	3,022,439	302,243	1,027,629	.34
1919	3,942,000	394,200	1,103,760	.28*
1920	3,497,000	349,700	1,014,130	.29*
1921	4,742,000	474,200	1,360,340	.27*
Total.....	42,801,430	$4,279,835	$12,896,749	Gen.Av..311

* Volumes and values of 1919, 1920, and 1921 estimated. Average price per M decline is due to increasingly large amounts of natural gas consumed by carbon black manufacturers in Eastern Kentucky at low figure of 10 cents per M cubic feet.

CARBON BLACK DEFINED

There is a popular confusion among laymen in the use of the terms lamp black and carbon black. This should not be, for they are two entirely distinct commodities. Although their appearance is somewhat similar, their method of manufacture is entirely different, lamp black being a by-product of oil, and carbon black a by-product



EASTERN CARBON PLANT IN OPERATION

This plant is located in the Beaver Creek Gas Field in Floyd County, Ky. Dence soot or carbon fumes make detailed photographs impossible.

of natural gas. Both of these commodities are a soot, and throughout the United States they are commonly classed together in the literature under the title "lamp black." Each product is formed by a smudge or partial combustion process in which oil, coal tar, resin or some other solid or liquid carbonaceous substance is burned in an insufficient quantity of oxygen or air.

Carbon black taken separately refers to the product resulting from the incomplete combustion of gas, and is deposited by actual contact of the flame upon some metallic substance. A large number of carbonaceous materials, such as gas retort coke, oil coke, graphite, carbon black, lamp black, fine black, wood pulp black, willow charcoal refuse blacks, and leather blacks, are prepared and on the market. Each of these possess different flocculent and qualitative characteristics. None of them show the same color, chemical composition, or physical structure. Each kind of "black" has its own specific adaptation or adaptations, and is not readily substituted for another. In some cases substitutes are impossible.

The term carbon black is synonymous with a number of trade names developed, and, in some instances, copyrighted, by carbon black manufacturers. Some of these commercial titles are *Gas Black, Natural Gas Black, Ebony Black, Jet Black, Hydro-Carbon Black, Satin Gloss Black, Silicate of Carbon Black.*

All of these carbon blacks are made in one of the four following methods: (1) formation by direct contact of the natural gas flame upon a depositing surface; (2) produced by combustion of the oil, tar, etc., in an inadequate supply of air where soot is allowed to settle slowly on the floors and walls of the collecting chambers; (3) carbonization of solids after their reduction to a very finely divided condition; (4) produced by heating carbonaceous vapors or gases to the temperature of decomposition. The heat is applied externally with or without air in the forming chambers. This is called the cracking or thermal decomposition method. Carbon blacks so produced are essentially a mixture of hydro-carbon and other organic substances, and may in certain cases contain a considerable percentage of mineral matter.

HISTORY OF THE CARBON BLACK INDUSTRY.

Carbon black as an industry was born in the year 1872, when two gentlemen, Messrs. Halworth and Lamb, of Massachusetts, erected at New Cumberland, West Virginia, the first factory in the product which was successfully made on a commercial scale. At this early time no regulatory appliances for natural gas were known, and a very great waste of natural gas resulted. The indiscriminate blowing of natural gas was not, however, recognized as an economic waste at this early time. Since 1826, when natural gas was first used for lighting purposes in the United States, at Fredonia, New York, no regulating appliances had been perfected. The total consumption of natural gas in this way was small. Natural gas itself was very cheap, and the waste in proportion to the amount used was very large. At this time natural gas was considered a dangerous nuisance, to be "blown off" in an oil field whenever found if possible, or to be disposed of in any other practical or safe way.

For a short time the manufacturers of carbon black at New Cumberland, West Virginia, though employing very crude methods involving slabs of soap-stone as depositing surfaces for the carbon black, had things their own way and sold their product to the trade at a maximum of $2.50 per pound. Their product, however, was in many ways not as excellent as that which has recently sold for five and six cents per pound. The demand for carbon black increased rapidly, and in 1883 A. R. Blood devised the revolving disc method of manufacturing carbon black. This process is still in use, and is now known as the "Blood or Rotating Disc" method.

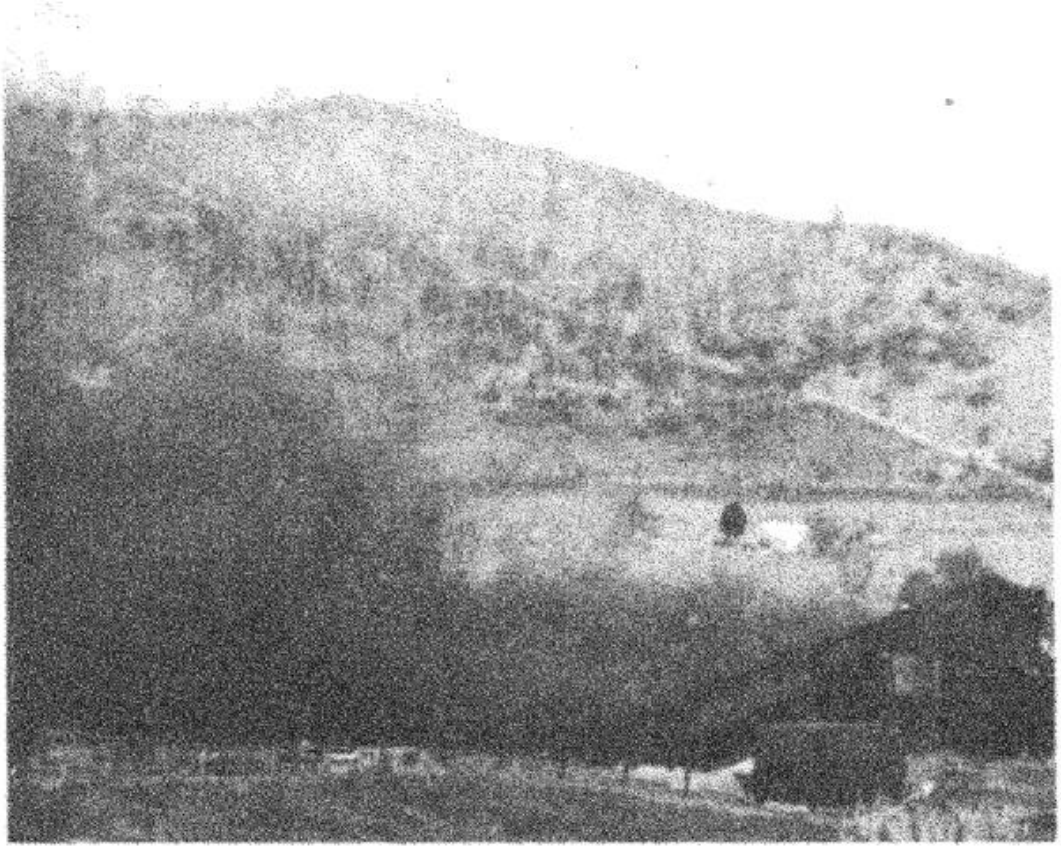
The new process improved the methods of production and brought the price down to 31 cents per pound.

Mr. Blood, working to perfect a better process of carbon black manufacture, evolved the roller process about the same time, which, though it gave a much smaller yield of carbon black, produced a much finer grade. Carbon black thus produced sells today for a higher price than other grades. About ten years later, in 1892, L. J. McNutt patented his channel process, which was an improvement over all the other methods from a mechanical standpoint. It was at this time that petroleum was first introduced in the attempted manufacture of carbon black. The trial was unsuccessful. Since the time McNutt's patent was registered, a number of improved methods have been completed, most of which are not practical. In 1916 a patent was issued covering a new process for the production of carbon black from the mulsified or cut crude oil, now a great oil field waste. But this method has not succeeded from a commercial standpoint.

PRODUCTION OF CARBON BLACK

Up until the recent discovery of the large natural gas fields near Monroe and Shreveport, in Louisiana, about seventy-five per cent of the world's supply of carbon black was produced in West Virginia, which had been producing and selling natural gas for about 3 cents and 4 cents per 1,000 cubic feet. Recent advances in the price of West Virginia natural gas to 7 cents and 8 cents per 1,000 cubic feet forced many of the carbon black manufacturers of this State to move to other sections where gas could be secured at a lower figure. In Louisiana the average price is 2 cents and in Oklahoma 5 cents to 6½ cents per 1,000 cubic feet. In the State of West Virginia in 1918 there was produced 289,123,513,000 cubic feet of gas, of which 24,830,697,000 cubic feet of gas was consumed in carbon black manufacture. This represented a reduction of the immense volume of natural gas used for carbon

black purposes amounting to 1,232,009,000 cubic feet for the entire State of West Virginia as compared with the production figures of 1917. But because of the decrease in the total production of natural gas for the entire state, the percentage of natural gas used by carbon black really jumped ahead from 8.5 per cent in 1917 to 8.7 per cent in 1918. Statistics covering the recent production of carbon black in the United States follow:



NORTH VIEW OF LIBERTY CARBON PLANT

This carbon manufacturing plant is located in the Beaver Creek Gas Field. The escaping fumes of carbon or soot indicate a portion of the lost fuel.

TABLE I.

Production of Carbon Black from Natural Gas in the United States in 1918.

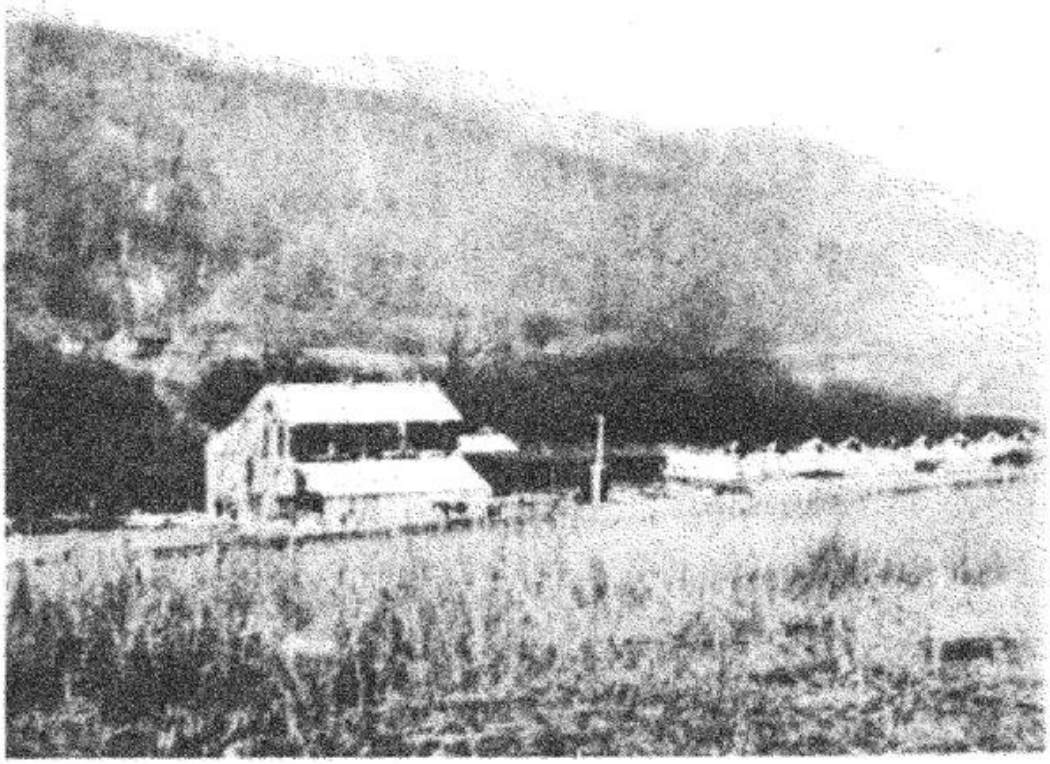
West Virginia	30,000,000 lbs.
Louisiana	8,000,000 lbs.
Wyoming	3,000,000 lbs.
Oklahoma	1,500,000 lbs.
Other States, including Kentucky	1,000,000 lbs.
Total	43,500,000 lbs.

Production of Carbon Black from Natural Gas in the United States in 1919–1920.

STATE	Number of Plants.	Carbon black produced.				Gas used.
		Quantity (pounds).	Value.	Average price per pound (cents).	Average yield of carbon black per M cubic feet (pounds).	Quantity (M cubic feet).
1919						
West Virginia	23	29,925,614	$2,358,119	7.9	1.3	23,117,332
Louisiana	7	14,024,606	933,334	6.7	.7	20,291,021
Wyoming, Montana	2	4,868,947	231,747	4.8	1.1	4,306,153
Oklahoma, Kentucky	2	2,922,274	244,726	8.4	1.5	1,954,029
Pennsylvania	2	315,500	48,114	15.3	1.4	227,700
	36	52,056,941	3,816,040	7.3	1.04	49,896,235
1920						
West Virginia	19	26,659,469	2,221,674	8.3	1.43	18,628,780
Louisiana	15	18,565,498	1,455,764	7.8	1.0	18,099,800
Wyoming, Montana, Kentucky	1, 1, 2	5,850,313	326,424	5.6	1.6	3,673,108
Pennsylvania	2	246,612	28,424	11.5	1.2	197,290
	40	51,321,892	4,032,286	7.9	1.26	40,598,978

USES OF CARBON BLACK

The industries making large use of carbon black are many. The product enters as a necessary constituent into the manufacture of printing inks, automobile rubber tires, paints, stove and shoe polishes, phonograph records, black leathers, bookbinders' boards, buttons, typewriter ribbons, carbon papers, celluloids, electric insulators,



NORTHEASTERN VIEW OF EASTERN CARBON PLANT

The methods used by this plant are as good as any now known and in general and commercial use. The fuel loss percentage is nevertheless high.

carriage cloths, colors and pigments, drawing and marking inks, artificial stones, tarpaulins and black tiles. Carbon black superseded the use of lamp black as a pigment in printers' ink in 1864, when it was found that a blacker and more rapid imprint could be obtained from inks using carbon black as a pigment. Modern newspaper

printing and other forms of rapid printing where rotary presses require a rapid drying ink, find carbon black inks indispensable. The finely divided nature of carbon black is well illustrated when it is pointed out that a single pound when mixed with eight pounds of oil and other chemicals will make ink sufficient in quantity to print over 2,000 copies of the ordinary sixteen-page city newspaper.

About 35 per cent of the total output of carbon black is used in the printers' ink industry. The rubber tire manufacturing business of this country is the other large individual consumer of carbon black. It is used in tire manufacture as a strengthening agent, giving the rubber a greater mileage and increasing its tensile strength and elasticity considerably. About 40 per cent of the carbon black manufactured in this country is used in the rubber tire business, and the large number of black tread tires seen on the market is illustrative of the importance and value of this use of carbon black.

The amount of carbon black exported to foreign countries during the war and shortly thereafter was small, chiefly because of the closing of the German and Austrian ports. Prior to 1914 about one-third of the carbon black manufactured in this country went to these countries. England, France, China and Japan also imported American carbon black. Recently the export of this mineral resource by-product has increased considerably, due to the stimulation of world trade. The renewal of relations with Germany and Austria may also be expected to increase the annual export very considerably.

CHEMICAL COMPOSITION AND RECOVERY PERCENTAGE.

Analyses of natural gases are extremely variable. The following ranges of methane in natural gas have been demonstrated:

Louisiana	94.12
West Virginia	70.75
West Virginia	65.23
Wyoming	46.45

The ethane fraction is quite as variable, and is as follows:

Louisiana	3.44
West Virginia	24.14
West Virginia	30.07
Wyoming	43.10

The nitrogens also vary as follows:

Louisiana	1.94
West Virginia	4.83
West Virginia	3.14
Wyoming	9.49

The carbons per one thousand feet also show an inequality which is as follows:

Louisiana	33.8 lbs.
West Virginia	39.9 lbs.
West Virginia	42.3 lbs.
Wyoming	44.3 lbs.

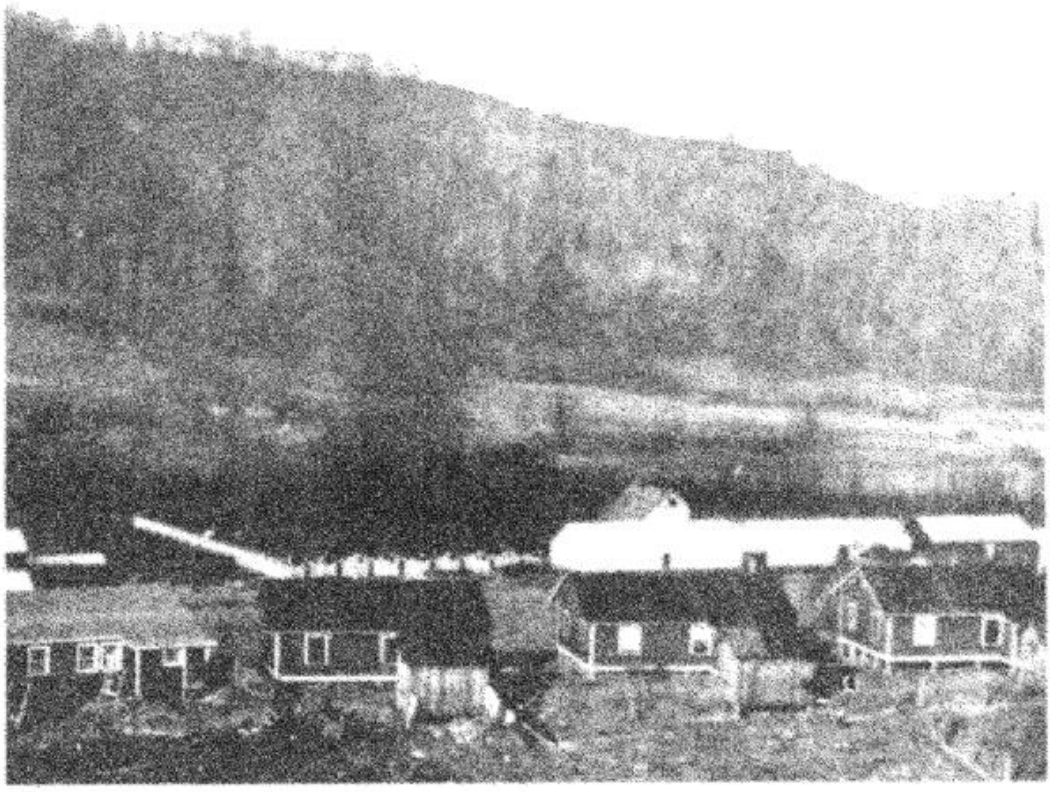
That the percentage of carbon recovery in the carbon black industries is relatively small is soon seen by a comparison of recovery volumes with the above figures. The great waste of carbon is, however, only a fraction of the total loss. To it must be added all of the hydrogen which, of course, could not be deposited, and is lost as unused heat. The carbon recovery for the States discussed above is as follows:

Louisiana	2.4
West Virginia	2.5
West Virginia	2.6
Wyoming	3.1

COMPARISON OF METHODS.

The four commercial processes perfected and used in manufacturing carbon black have many merits and demerits, but are generally evaluated in the following order:

(1) Channel system. This system produces the largest quantity and the best commercial grade. (2)



MAKING NATURAL GAS CARBON BLACK

This view shows both the factory and dwellings used by employees of The Eastern Carbon Company on Beaver Creek, Floyd County, Kentucky.

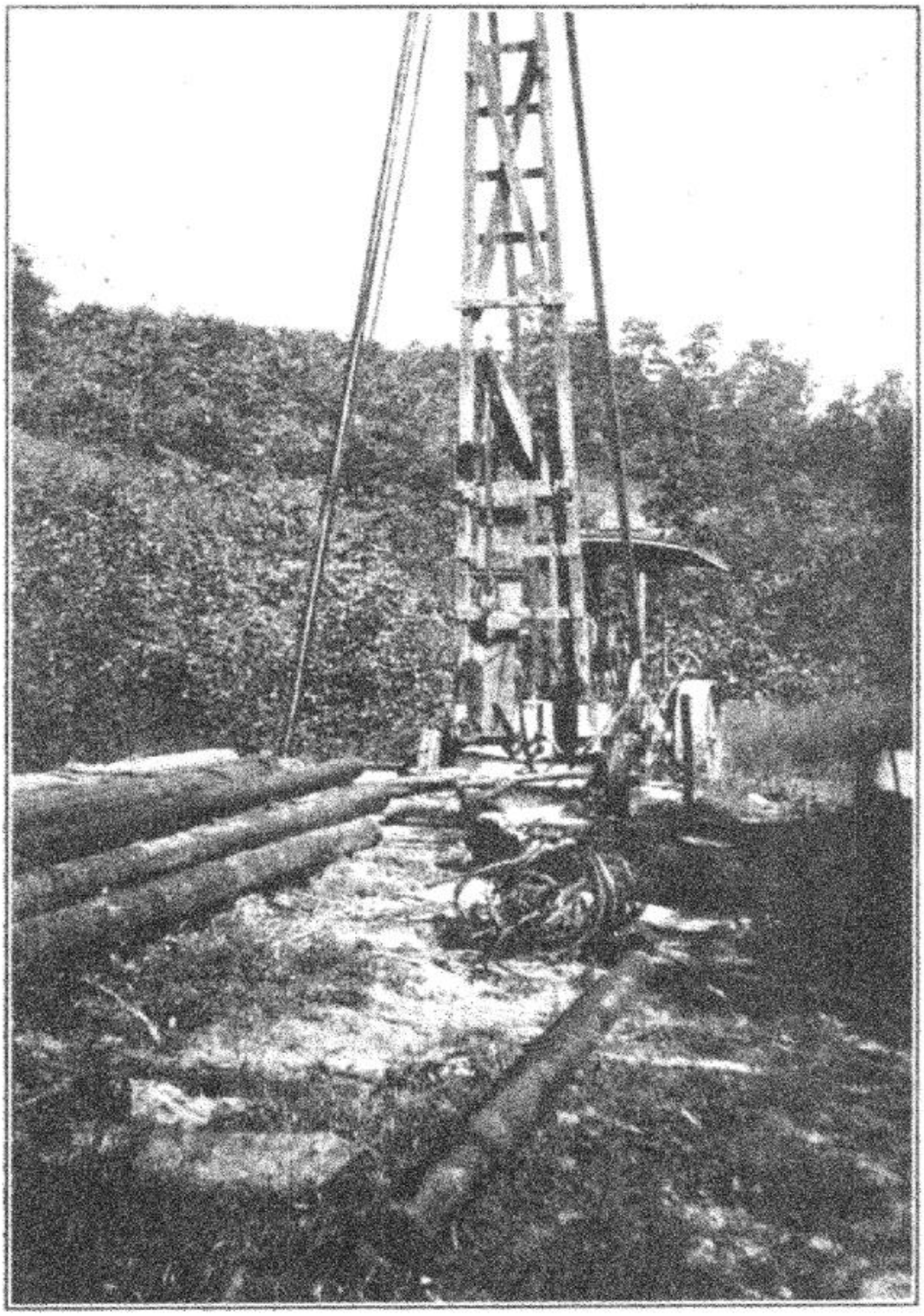
Small rotating disc. This method is inferior in some respects to the channel system, but is widely used. (3) The rotating cylinder. This process produces the best grade of carbon black, but a much smaller quantity. (4) The large plate. This method produces a larger quantity than the rotating cylinder, but is inferior to it in grade. It does not produce as large an amount as

the rotating disc or the channel system. There is very little carbon black produced by the so-called "cracking process."

The factors affecting the yield of carbon black are: (1) Design of the plant. (2) Weather conditions. (3) Pressure of natural gas. (4) Absence of salt water or oil or other mineral substance in the natural gas. Some of these factors are within the control of the carbon black manufacturer. It is seldom, however, that all of them are found operating favorably in any individual plant.

Carbon black has been made from artificial gas, but the product is much more costly than the natural gas carbon blacks. The artificial gases produce glossy, intense carbon blacks, which in turn result in rather high price printing inks. Although there is a considerable difference in the quality of the blacks made from artificial gas and natural gas, the one could undoubtedly supersede the other, if it were absolutely necessary. Carbon black could also be made from illuminating, black, furnace, producer, or coke oven gas, were it not for the prohibitive cost of the manufacture of these several gases.

Experiments looking toward the production of carbon black by the explosion of mixtures of acetylene gas and air under a known pressure have not been a commercial success. The grade of carbon black thus produced has also been inferior. As compared to this method of production, the straight burning of acetylene gas gives a much larger recovery figure, one ranging about 17%, and the black thus secured is a superior product. For some industrial purposes, such as phonograph records, medical hard rubber, stove and shoe polish, some grades of printer's ink, and black paint and other pigment, it may be possible to substitute lamp black or other kinds



A PORTABLE DRILLING RIG

In the shallow gas fields well drilling is done by "churn" drills, generally of the type shown above.

of carbon blacks for natural gas carbon black, but up to the present time it has not been demonstrated that other adequate substitutes exist for the carbon black used in the newspaper and book printing ink and the rubber tire industries.

Various attempts to find certain mixtures of fuel and gas oil from which a gas could be produced for the manufacture of carbon black have not been commercially successful. Other methods of production have also been tried and resulted in commercial failure. Chlorine has been added to the burning natural gas in an effort to secure a greater deposition of carbon, but this has also failed. It is difficult to increase the production of carbon black, for such processes as do increase the deposit of black also increase the amount of black carried away in flue gases. It is possible, however, to increase the deposit of carbon somewhat by improving the design of plants whereby they may be operated more or less independently of wind and weather conditions. The process of thermal decomposition, now only partially understood, may, following further investigation, offer a method of increased productivity and conservation in the manufacture of carbon black.

THEORY OF FORMATION OF CARBON BLACK

When natural gas burns in an incomplete supply of air or oxygen, the carbon contained is liberated in the heat of the flame as a direct decomposition product of the unburned gas. The cool metallic depositing surface functions to chill the liberated carbon in the flame sufficiently to prevent its further combustion. A metallic surface that is cold may prevent the maximum separation of carbon, and on the other hand, if it is too hot, it may allow too much carbon to be burned. In this event, the

properties of the carbon that remain unconsumed will be altered to some degree. The temperature of the channels in the process of similar name, is about 300 degrees. Careful air regulation has much to do with the amount of carbon black which will be produced, since too much air may readily allow a larger combustion of the carbon already affixed to the plate.

LIBERTY CARBON PLANT IN OPERATION

The dense sooty fumes are principally composed of carbon black which the process is unable to retain. This lost carbon is only a part of the waste which is beyond control.

Some newly developed processes using a retort and refractory material at about 1,200 degrees centigrade or above, give a theoretical yield of about 40 per cent, but the carbon black thus produced is not of a salable grade. The process is in reality only an experiment which demonstrates the separation of carbon and hydrogen by this method. It suggests, however, the possibility of an

increased production of carbon black. Under the microscope, lamp black, which is recognized in the industries as a somewhat less intense black than carbon black, frequently appears blacker and more opaque.

KENTUCKY CARBON BLACK INDUSTRY

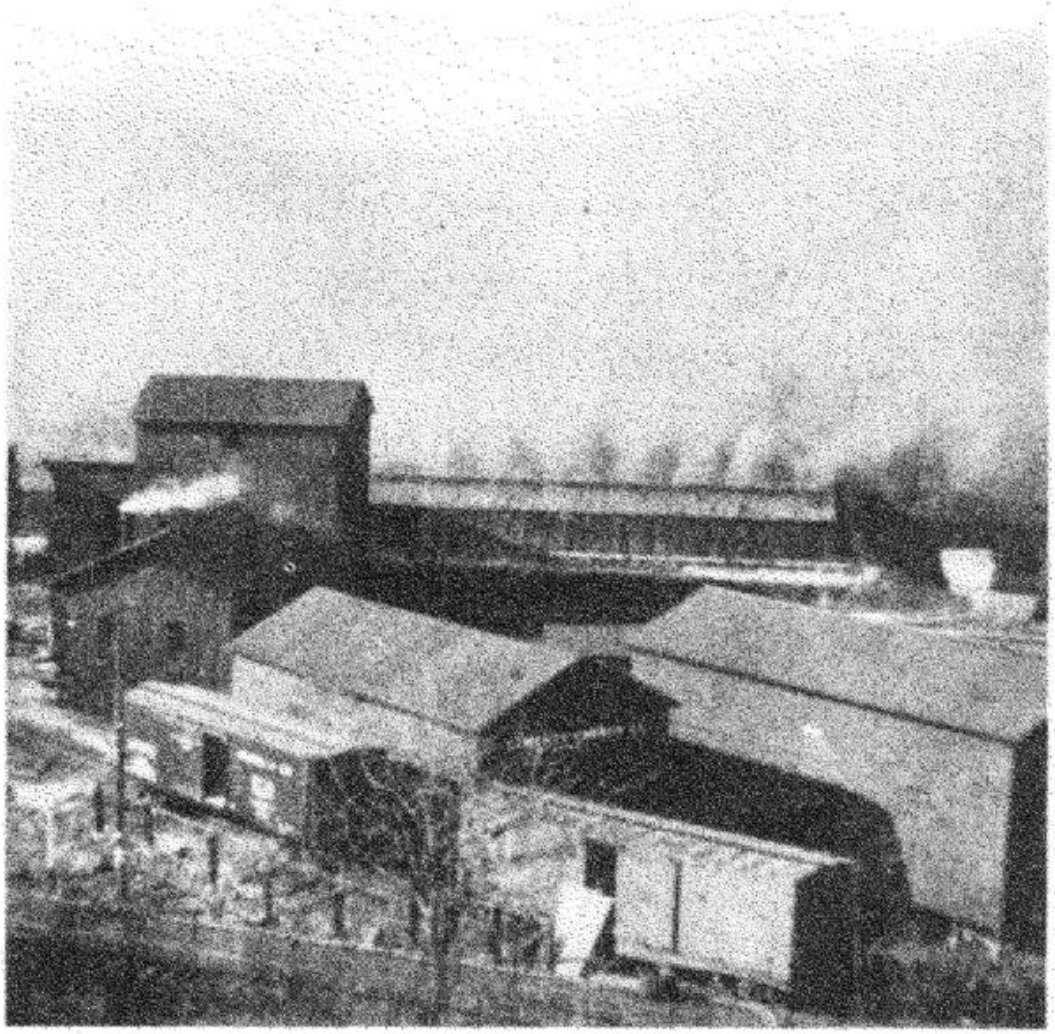
At the present time there are but two carbon black plants in operation in the State of Kentucky. These are the Liberty Carbon Company's plant at Langley, Ky., the juncture of Wilson's Creek and Right Beaver Creek in Floyd County, and the Eastern Carbon Company's plant at Osborne on Right Beaver Creek, also in Floyd County, Ky. Both of these operations are located in the heart of the Beaver Creek gas pool. Each of them will be discussed separately.

OPERATION OF THE LIBERTY CARBON COMPANY

Oldest in point of establishment, the Liberty Carbon Company's plant at Langley, Kentucky, was first put in operation in June, 1918. The so-called channel process of manufacturing carbon black is used. Its operation has been practically continuous to date, fourteen separate units being operated, with a total daily capacity of natural gas consumption of 2,750,000 cubic feet. At the time the plant was opened it was supplied with the natural gas by the Keystone Gas Company, four wells being used which has an open flow at the casinghead of approximately 7,000,000 cubic feet of gas per day, and an average rock pressure of about 235 pounds.

By the spring of 1919 these wells had become so reduced that the J. Akres well, which is reported to have had an open flow of 2,500,000 cubic feet of gas per day and

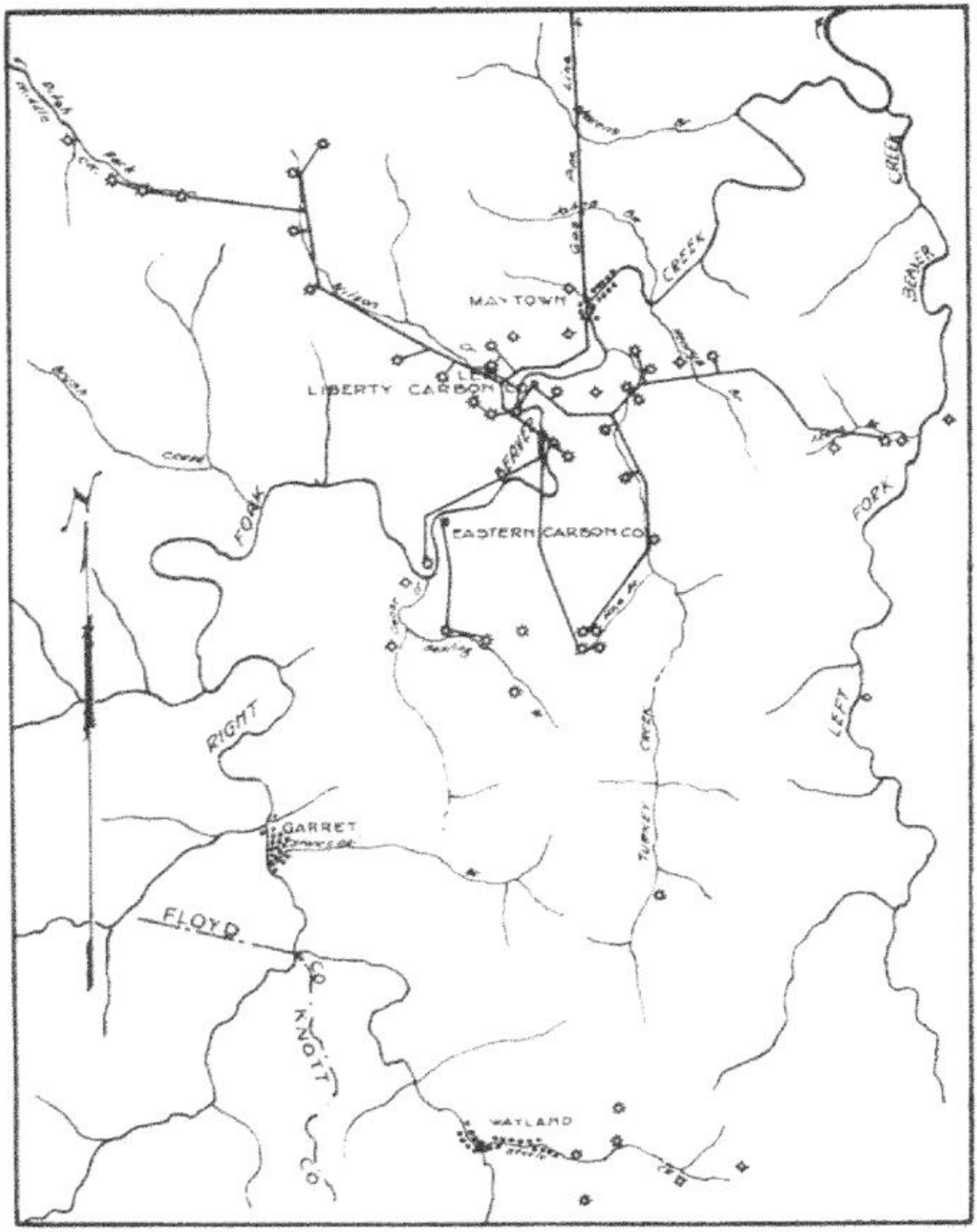
rock pressure of 500 pounds, was connected. At this same time it is reported that some of the original wells had been invaded by salt water, with a resulting loss of gas production. During the first several months of operation this carbon plant operated at full capacity. In May, 1920, the best estimates available indicate that this plant was



RAILROAD YARD—LIBERTY CARBON COMPANY, FLOYD COUNTY, KENTUCKY

using 1,500,000 cubic feet of gas from all wells available which had an original open flow of about 10,000,000 cubic feet. The rock pressure during these two years of operation had fallen to approximately 115 pounds.

During the summer of 1920, with very light pressure at the plant end of the line, gas depletion began to make



A PORTION OF THE BEAVER CREEK GAS FIELD

This sketch map shows the location of the principal natural gas producing area, the carbon black plants, and the main pipe lines. Only the recent or commercially important producing gas wells are shown. A number of wells in the old oil and gas pools at Bosco and Garrett are not indicated.

itself noticeable, and two emergency test wells were put down on Turkey Creek to the Berea sand. Each of these showed less than 500,000 cubic feet of gas per day, but decreased prices and demand made it possible for these wells to carry the desired operation of the plant. In August 1921, an additional test well was put down on Hays Branch of Turkey Creek to the Bradley sand, and this well is reported to have gauged about 6,000,000 cubic feet of gas open flow, although it was only about 1,500 feet from a well that was practically dry in the Bradley sand. The present weak carbon black market has made it possible to hold this splendid well in reserve for a time.

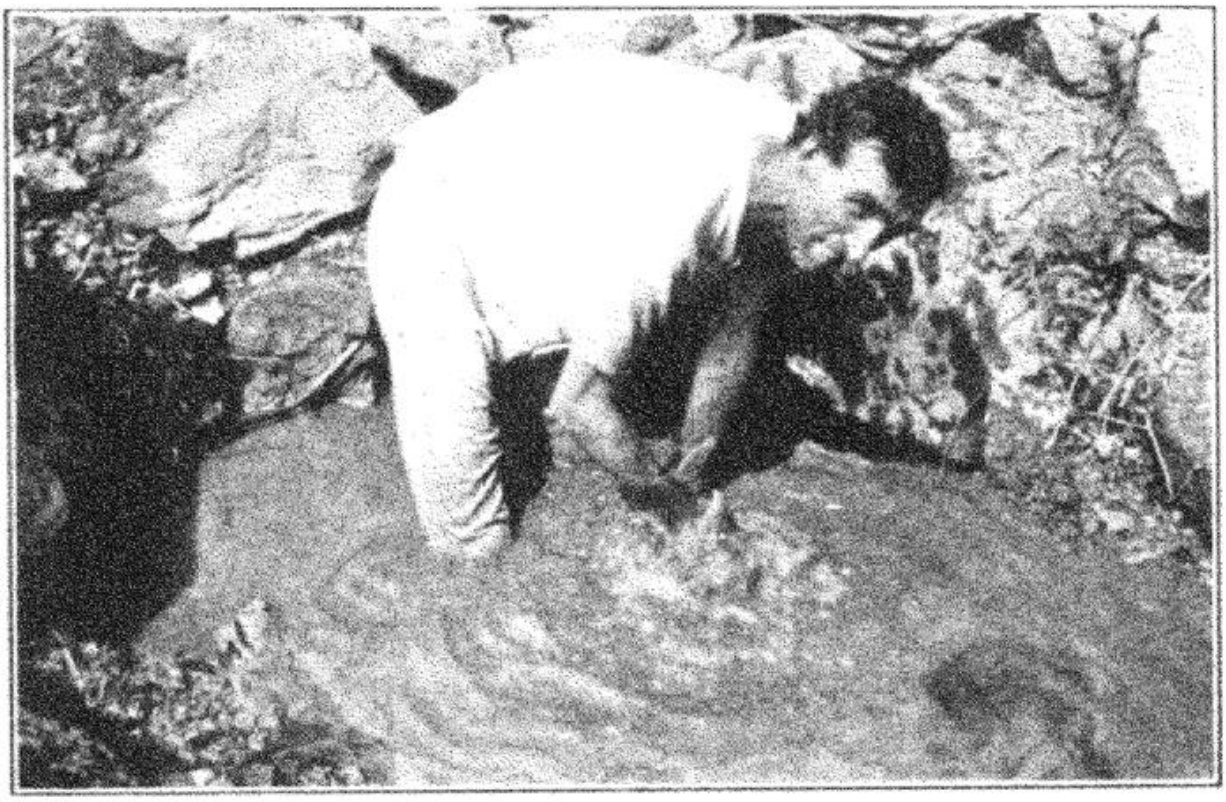
The Liberty Carbon Company has approximately $160,000 invested in this plant, including 4½ miles of gathering pipe line, with which it maintains connections with its wells in the field. The company uses twelve gas wells which are located on leases owned by the Keystone Gas Company. All of these wells are not used at the same time, but are drawn upon alternately, generally in groups of fours, while the remaining eight are allowed to recuperate.

At the present time the Liberty Carbon Company is using an open flow of approximately 2,250,000 cubic feet of gas per day, making approximately 4,500 pounds of carbon black per day. This production amounts to little less than 2 pounds per one thousand cubic feet of gas. About 50 per cent of the production of the carbon black of this plant is now being shipped to Akron, Ohio, where it is used in the manufacture of automobile rubber tires. A much smaller fraction is exported to Germany, France, England, China and Japan. The present selling price is 8 cents per pound.*

* Data secured from W. H. Davis, Charleston, West Virginia.

OPERATION OF THE EASTERN CARBON COMPANY

This carbon black company is located approximately two miles above the Liberty Carbon Company's plant, just below the mouth of Goose Creek on Right Beaver Creek in Floyd County, Kentucky. It is owned and operated by Davis Bros. of Charleston, West Virginia, and was put in operation in November, 1920. It makes carbon black by what is known as the Revolving Disc



NOT BATHING—REPAIRING A LEAK

When a gas main breaks, the blow-out frequently causes a depression which soon fills back with water. It makes a disagreeable job for the repair man, especially in winter.

Process. The Eastern Carbon Company owns two wells in the Goose Creek region which have a total open flow capacity of 15,000,000 cubic feet of natural gas. The capacity of the plant itself is about 3,000,000 cubic feet. At the present time it is only drawing on one well. The average present consumption is 1,500,000 cubic feet of

gas per day, from which about 3,500 pounds of carbon black are produced. This is slightly over 2 pounds of carbon black per one thousand cubic feet of gas.

The original expense of constructing this plant and securing its gas reserve amounted to approximately $350,000. The present cost of operation is $120 per day. This company owns gas fields of its own, and also contracts for gas. The plant is being operated on a 50 per cent basis at present. The principal part of the Eastern Carbon Company's product is used in the manufacture of printer's ink.*

VOLUME OF KENTUCKY CARBON BLACK

Of the two plants in Floyd County, Kentucky, the Eastern Carbon Company is probably more efficient, as may be noted by a comparison of the production reports of the two, and also a study of carbon black escape fumes as seen in the field. The fumes produced by the Eastern Carbon Company are not nearly as dense or as large as those of the Liberty Carbon Company plant at Langley, Ky., though in justice it should be pointed out that the capacity and tonnage of the latter plant is much larger than the former. The manufacture of carbon black in the Kentucky Beaver Creek field, based on the normal capacity of the plants in operation, requires approximately 1,250,000 thousand cubic feet of gas per year. This amount of gas, according to the methods employed, will produce about 2,500,000 pounds of carbon black, which at 8 cents per pound would be worth about $200,000.00. During an extended period of dull carbon black market, such as the present, the full amount of gas herein estimated might not be entirely consumed, and the figures of production in such an event should be correspond-

* Data supplied by Mr. Patterson, Superintendent.

ingly lessened. If this amount of gas were used, it would represent the same amount as would normally be sufficient to supply about 30,000 domestic natural gas consumers for an entire year in a city four times the size of Lexington, or one three-fourths the size of Louisville.

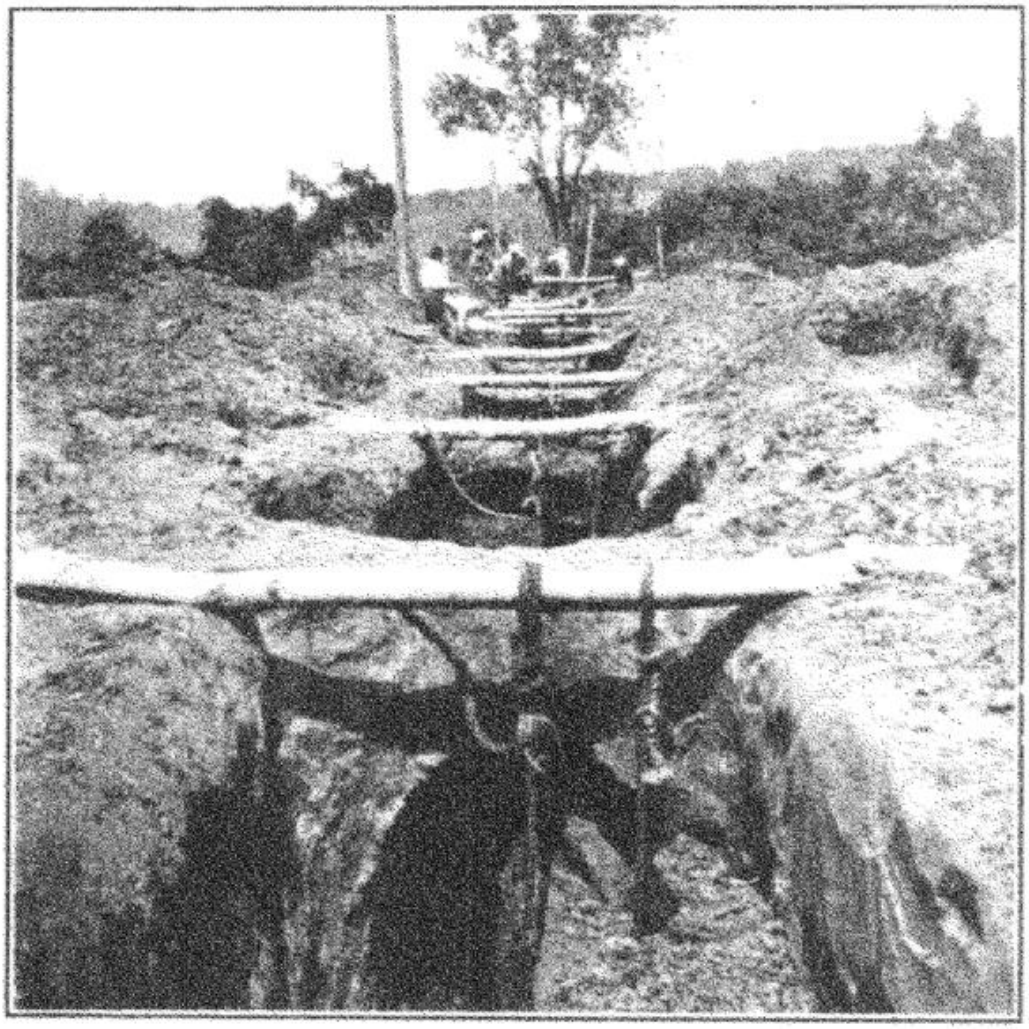
CARBON BLACK VS. PUBLIC UTILITIES

It is generally conceded that there should not be any question from an economic standpoint as to who should take the natural gas supply of any field that is tapped by a public utilities pipe line. It has been clearly pointed out that when public service corporations can afford to pay as high as 10 cents per thousand cubic feet on a contractural period basis for natural gas, and carbon black cannot be sold for more than 7 or 8 cents per pound, that it is better business for the owner of natural gas, though he be a carbon black manufacturer, to contract this gas to the public utility corporation than to consume it himself in the production of carbon black. While this would seem to be a self-concluding statement based on well known economic laws, there are, as a matter of fact, many special factors which operate to alter the practical operation of the principle.

The elimination of long transmission lines, their expensive construction, and continual maintenance, which is one of the large items of cost to any public utilities corporation supplying natural gas to a municipality, gives an initial advantage to the carbon black industry. Manufacturers of carbon black are forced to expend but relatively small amounts of money for their gathering lines, which are always short in length, small in size, and inexpensive in construction. It is not infrequently the case that carbon black plants are erected on the leases themselves which produce the natural gas

used, though generally after a short initial period it is found necessary to secure additional supplies of natural gas.

Carbon black plants do not find it necessary to install expensive compressor stations. These "booster" plants, as well as the main transmission line and the intricate



LOWERING A TWELVE-INCH LINE

In this instance a gas pipe line was lowered nearly twenty feet in a Jefferson County bottom to avoid artificial drainage.

system of distribution in a municipality, are heavy burdens for any public utilities corporation. These items find no counterpart in the carbon black industry. The carbon black plant uses the normal rock pressure of the well or group of wells under its control, and finds these

pressures adequate, whereas such pressures are of relatively little importance when matched against the counterbalancing friction encountered in a long public utilities transmission line.

The total expenditure of capital required for the installation of a carbon black plant is a relatively small amount of money as compared to that which is necessary for the proper establishment of such an extended public utility as a natural gas service corporation. The history of the carbon black industry is one of repeated migration. Economic stress or the failure of the natural gas supply of the locality are the usual causes of these industrial movements. A review of the history of public utilities corporations reveals quite the opposite. Operating under long term franchises or municipal contracts with large capital invested, these companies must remain stationary within their selected localities. Natural gas service corporations must provide adequate supplies of natural gas for the present to fulfill their franchise requirements, and must also secure sufficient reserve for the future to insure the fulfillment of their municipal contracts, as a growing depletion of natural gas is recorded in their operating fields. These principles of operation are applicable to every carbon black plant and every natural gas public service corporation in not only the State of Kentucky, but the entire Eastern United States.

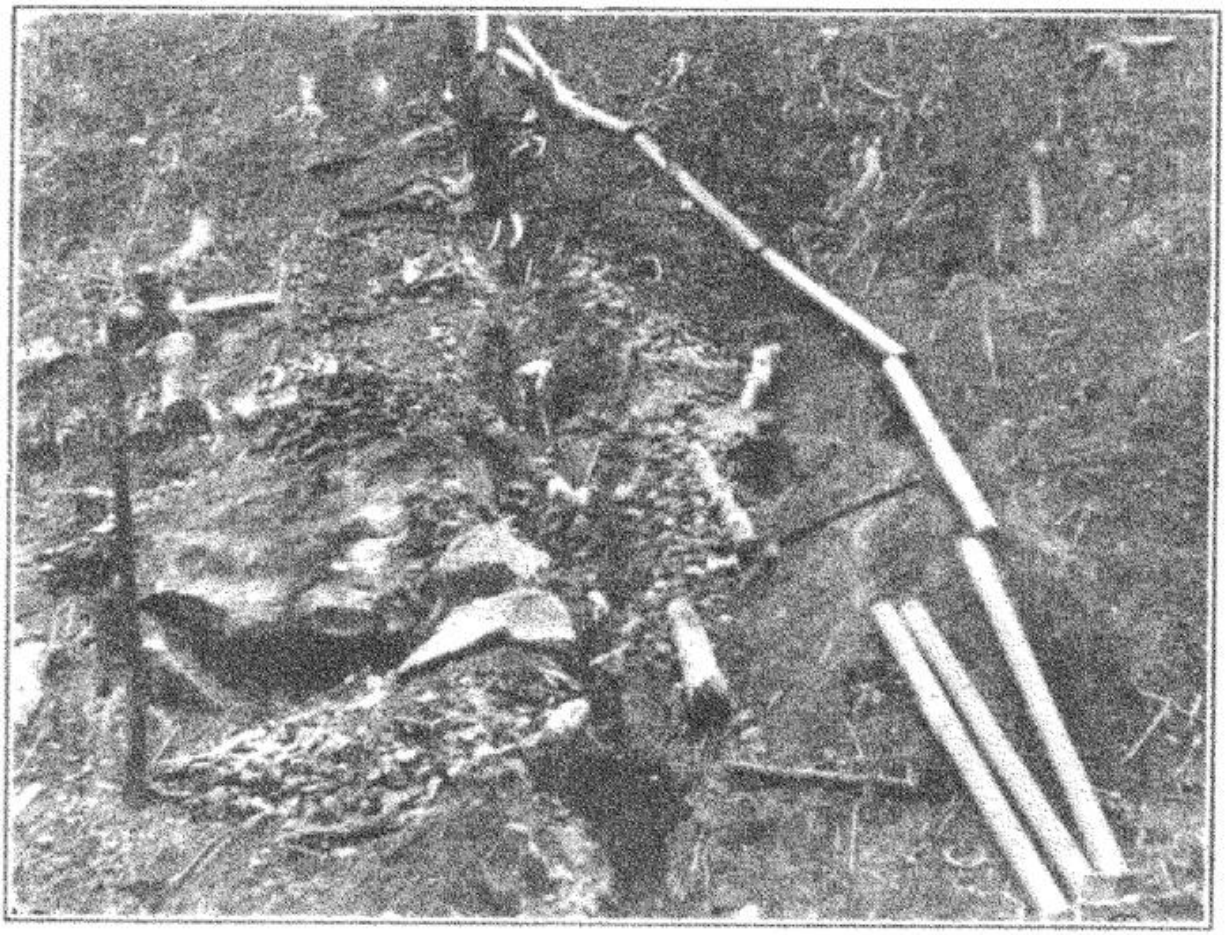
CHAPTER IV

TREND OF CRITICAL COMMENT

The degree of success attained in the practical application of any theory is the proper measure of its value. The American public of today is amply justified in regarding with suspicion all theories which do not find a sound and practical substantiation. In recognition of the economic importance of the natural gas conservancy problem, and with the thought in mind of presenting the depletion situation concretely, there has been selected from a large correspondence of the writer a number of excerpted statements relative to the matter in hand. A perusal of these statements will assist greatly in demontrating the magnitude, intricacy, and acuteness of this problem which now faces a very large part of our country, including the State of Kentucky.

Technical opinions concerning natural gas conservation are herewith advanced, and while somewhat at variance as to ways and means, it will be noted that the use of industrial gas, especially that for the manufacture of carbon black, is generally deplored. The statements of carbon black manufacturers and natural gas utility corporations are, however, included, so that both sides of the case may be seen in their typical presentation. Letters from the mayors of cities both large and small facing the natural gas shortage problem, all tell the same story of inability of public utilities corporations to carry peak loads. The gradual introduction of higher rates will also

be noted, and with it the general and pressing need of effective natural gas conservation measures. The excerpted correspondence follows:



GAS LINE CONSTRUCTION IN JOHNSON COUNTY

One has but a vague idea of the many difficulties which attend the construction of a natural gas pipe line until he goes "on the job." This is a pipe line scene in Johnson County in the limestone ledge region.

Philip S. Smith, Acting Director, Department of the Interior, United States Geological Survey:

"No rule that will cover all cases seems possible. Rather the utilization of the gas from each district, or even from each pool, must be considered separately if a fair conclusion is to be reached. However, there are certain facts that apply everywhere which should be constantly borne in mind.

"Either the public utilities or the carbon black interests can use, unaided, more than the total available gas. There is not enough for both to operate unrestricted, nor for either to operate for an indefinite period.

"Neither industry is indispensable. Artificial gas, coal and electricity can take the place of gas for light and heat; lamp black can substitute for carbon black in pigments; zinc oxide or other filler can replace it more or less satisfactorily in the tire industry; and there are substitutes for all its minor applications. Humanity will endure if either or both industries are abolished. Relative indispensability is a matter of argument.

"Where the two industries are in conflict, the public utilities commonly can invoke the argument of priority, which undoubtedly merits some consideration. Curtailment of the supply of the public utilities unquestionably causes more actual suffering than does the restriction of the carbon black industry.

"Where the two industries are established, the public utilities represent greater investments, and damage to them is therefore a greater financial loss than is damage to the carbon black industry. The monetary value of the gas taken from the ground is greater when it is used through public utilities than when it is burned to make carbon black.

"All of the above quite strongly favors the public utilities, and to this must be added the action of States that have legislated against the carbon black industry. On the other hand, there are fields capable of yielding much gas for which there is no market through the public utilities. Drilling activities may prohibit storing the gas in the ground, and in such occurrences the carbon black plants save great waste and provide a much needed commodity. There are fields capable of yielding much gas which are so located that there is small likelihood of their serving the public through public utilities companies for a decade or more, but where the obstacles to the production of carbon black may be easily overcome. . . . . "

H. Foster Bain, Director, Department of the Interior, Bureau of Mines:

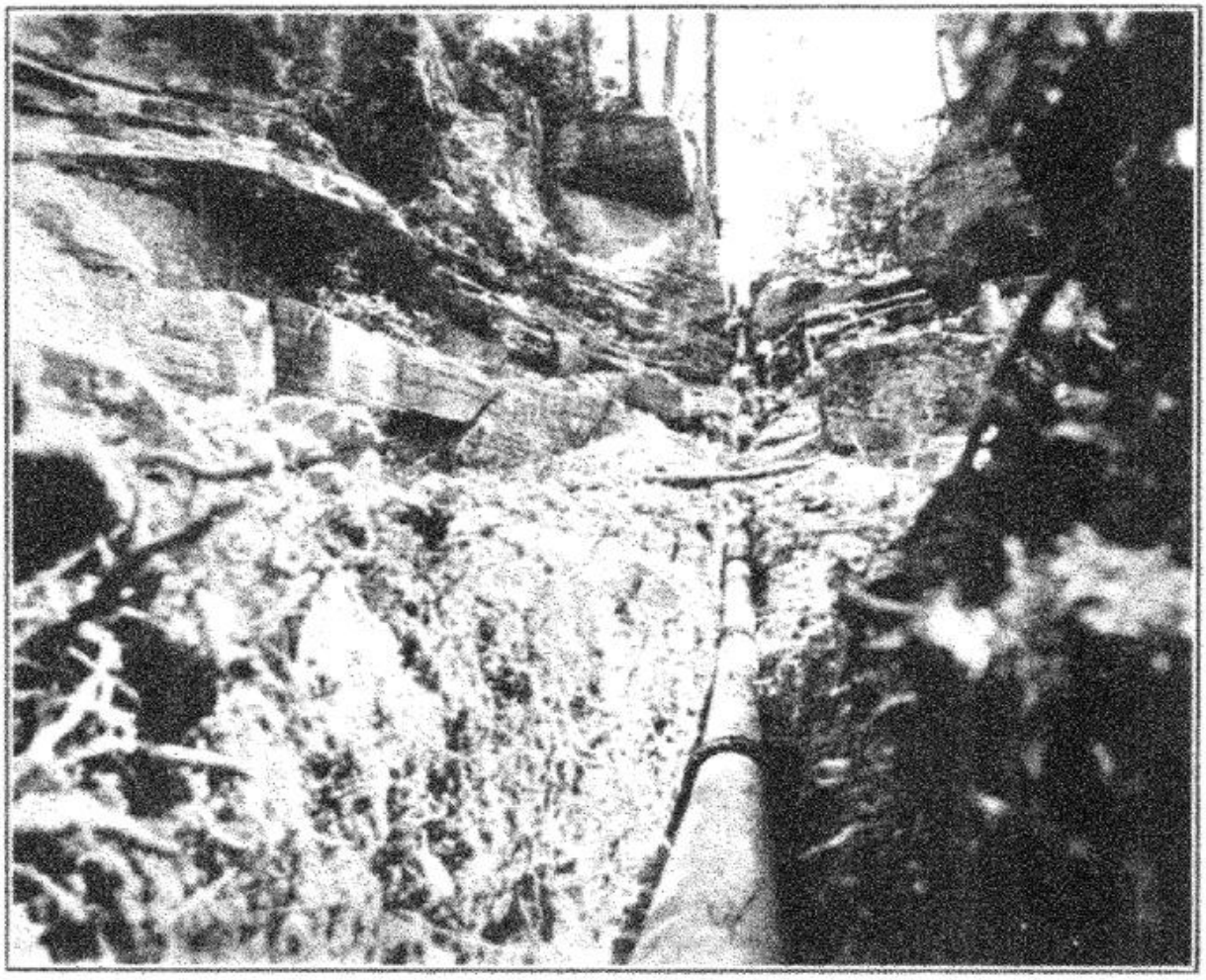
"The National Committee on Natural Gas Conservation in Washington, D. C., June 11, 1920, passed a resolution which reads as follows:

> '*Resolved*, that carbon black be made when gas is produced in isolated sections with no present or reasonably prospective market for gas being produced, when gasoline has been extracted and when practical and modern and improved methods are used.'

"The question of the utilization of natural gas for the manufacture of carbon black is necessarily a local one and can only be decided after the various economic conditions in the district under consideration are carefully considered. . . . ."

J. W. Hassell, Chief Supervisor, Oil and Gas Division, Railroad Commission of Texas:

"The use of natural gas for the making of carbon black is prohibited in this state except as permitted by Sections 2, 3, 4 and 5 of Rule 41 appearing on page 21 of our Oil and Gas Circular Number 12 enclosed herewith. Our Statute, being Article 1 of an Act of the 36th Legislature of this State, and appearing on



NOT A QUARRY—A PIPE LINE

The reason for excessive cost in gas pipe line construction is made plain by this view on the head of Raccoon Creek.

page 1 of the circular, and Rule 1, appearing on page 8 prohibiting the wasteful use of gas. Rule 41 with reference to carbon black was adopted after a general hearing, at which hearing the Railroad Commission found as a fact that the burning of natural gas in the manufacture of carbon black was a wasteful use of the same. Since the Statute prevents absolutely the wasteful use of gas and since the Railroad Commission has determined as a fact after hearing that the burning of same in the manufacture of carbon black is a wasteful use of gas, the writer has uniformly

held that it is not within the power of the Railroad Commission to grant a permit except as provided in the three sections mentioned and indicated by the blue pencil mark on the margin of the circular.

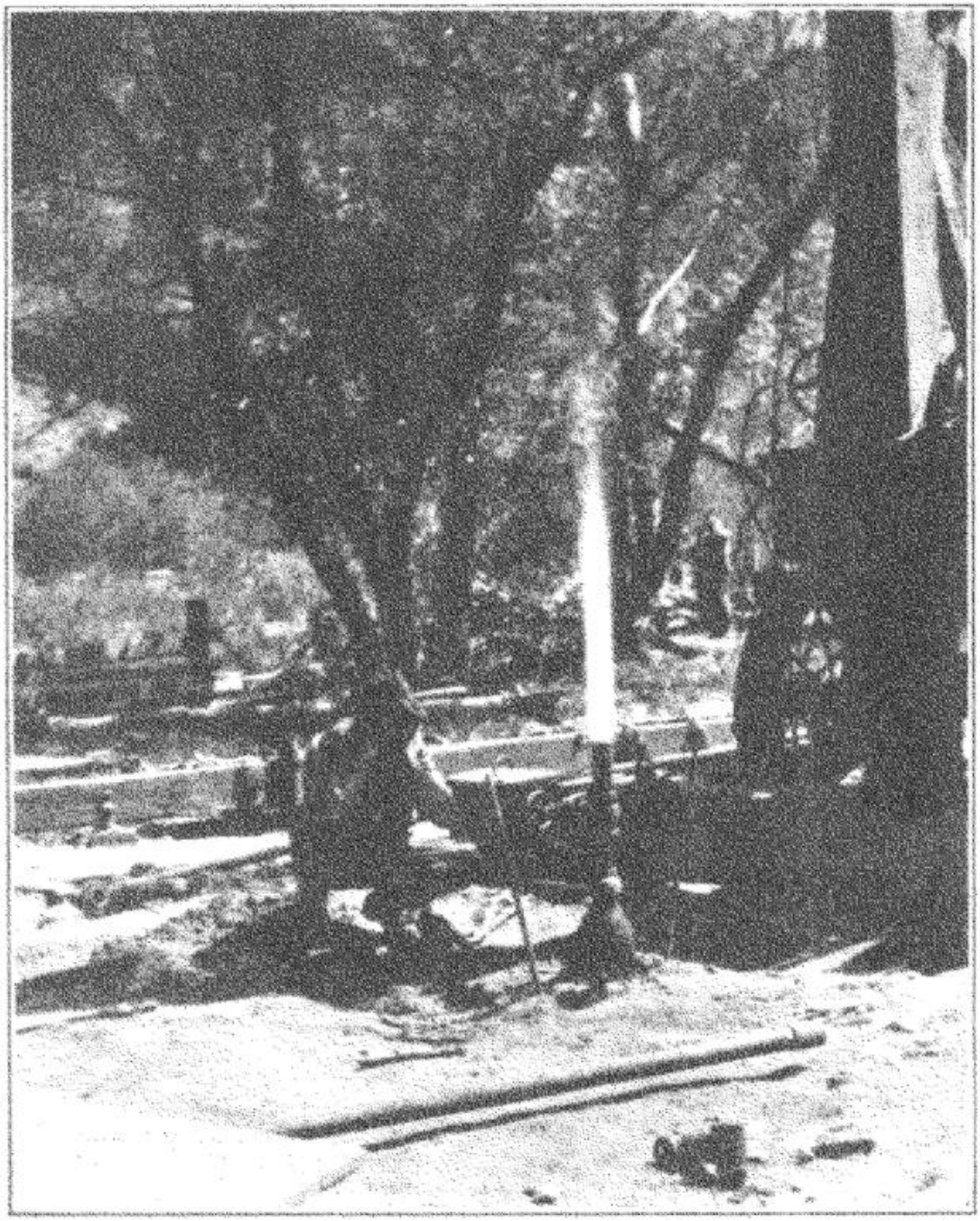
"It is my opinion, as it was that of my predecessors, Dr. George C. Butts and Judge S. P. Sadler, that the use of natural gas for the manufacture of carbon black should not be permitted where it is practicable to apply the gas to industrial enterprise and domestic use. Where a field is so isolated or so small that it is not feasible to carry the gas to industrial centers, or where no market can be had for the same or expected for many years, it might be permissible to allow its use for this purpose. It has been contended by some of the advocates for its use for the purpose mentioned that the product manufactured would realize more money per thousand feet for the gas than it could be sold for in domestic consumption, but this ignores the great value of the gas to the community itself. It seems to me that those charged with the administration of laws touching this question should keep in mind the value of the article to the community rather than to the individual. If gas could be utilized in the manufacture of diamonds, it might be worth, say two dollars per thousand feet, and a fair price for it in commercial use would be, say fifty cents. The advocates of its use in what may be termed wasteful processes have claimed that since it realized two dollars per thousand feet in the manufacture of diamonds, and only fifty cents for domestic use, it would not be a wasteful use of the gas to devote it to the first purpose. In my opinion it would be a wasteful utilization of the gas, since it would deprive practically all of the people of its use for the manufacture of a non-essential. . . . ."

C. W. Shannon, Director, Oklahoma Geological Survey:

". . . . In Oklahoma, the Corporation Commission has ruled against the use of gas for the manufacture of carbon black. There has never at any time been more than two or three plants in operation in the State to my knowledge and there is one plant operating at the present time. We have had numerous inquiries in regard to the establishing of carbon black plants, but as the ruling of the Corporation Commission is against such industries, we have not been in a position to recommend an attempt to establish additional plants.

"Personally I believe that under certain conditions carbon black plants should be permitted to use the surplus of gas in certain fields. There is no question but that the methods used by the plants in operation have been very wasteful of the natural gas supplies and from a conservation standpoint the industry cannot be encouraged. However, there are many areas where the gas is not being used for commercial purposes, and in such localities carbon black plants could readily secure all the gas needed without in any way decreasing the amount of fuel gas.

"It is the purpose of the Conservation Department of our Corporation Commission to 'shut in' any and all gas wells where gas is encountered so that in every way possible the gas may be conserved. During the past few years the recommendations



"BLOWING A GASSER"

This gas well is located on Bullskin Creek in Clay County. It is not commercialized at present.

of the Corporation Commission and the work of the U. S. Bureau of Mines has conserved millions of cubic feet of gas in Oklahoma, but on the other hand there are many localities where sufficient

gas is going to waste to run carbon black plants of considerable capacity. Under such conditions I would favor the establishing of carbon black plants under strict regulations as to the extent to which the gas could be used.

"While Oklahoma is still producing a large volume of gas it has been necessary during the past two years to take urgent action in regard to conserving the supply for domestic use, and industries in general have been very largely cut off from the use of natural gas. . . . . ."

I. C. White, State Geologist, West Virginia Geological Survey:

". . . . . The proposition is a difficult one to solve. My own opinion is, that where there is no market for the natural gas that has been developed through drilling and no prospect of any immediate market like the great Monroe field of Louisiana, State Public Service Commissions should not prevent the utilization of such natural gas for carbon black purposes. While it is true that all of the hydrogen and much of the carbon is lost in the manufacture of carbon black, yet the net result is a profit of several cents per thousand cubic feet to the manufacturer of carbon black. This latter substance also subserves many useful purposes and its field of utilization is constantly widening. So that from this point of view it has become one of our necessary industries. In our State there has never been any legislation on the subject, and the problem has practically solved itself, since when natural gas became too valuable to utilize in the carbon black industries, the latter have sold their gas production to natural gas pipe lines, and moved on to other states like Louisiana and other regions where natural gas could be secured cheaply. . . . . ."

Wilbur A. Nelson, State Geologist, Tennessee Geological Survey:

" . . . . . I have always felt that in a state that is thickly populated, or in a section where natural gas occurs in centers of population, that all natural gas should be conserved for use by public utilities. Such use would make your gas last for a longer period of time and be of more benefit to the people of your state, as natural gas generally decreases the cost of heating and the cost of living to the people living in the radius served.

"The use of natural gas for making carbon black does not benefit the individual people of the state except in a far fetched manner in what might be shown to be a slight decrease in the cost of printing newspapers, etc. From the standpoint of taxation I should think that all facts would be in favor of doing away with the carbon black interests and having all gas used by the public utility corporations, as this use would bring in a greater taxable return to the state on this natural resource.

"It seems to me that if carbon black interests are to exiss they must look to those areas where there are enormous gas poolt

like Homer, La., and where the population of the district is sparse as compared to the population existing along the Ohio River. . . . ."

R. C. Moore, State Geologist, State Geological Survey of Kansas:

" . . . . . the very large public interests of consumers of natural gas, particularly the domestic consumers, have higher interest, and right over any manufacturing interest. The policy guiding or tending to guide control of natural gas in Kansas is restricting industrial consumption, so as to conserve a supply for domestic use."

G. B. Morgan, State Geologist, State of Wyoming:

" . . . . . The so-called anti-carbon black law (of Wyoming), Chapter 275, page 60, declares that the consumption of natural gas in which the heat units are not fully utilized to be a wasteful use and to be unlawful where the sources of supply are located within 10 miles of an incorporated town or industrial plant. It was aimed solely at the manufacture of carbon black and is the only law that we have governing its manufacture. Carbon black, therefore, can be manufactured from gas outside of a 10 mile limit without violation of the law.

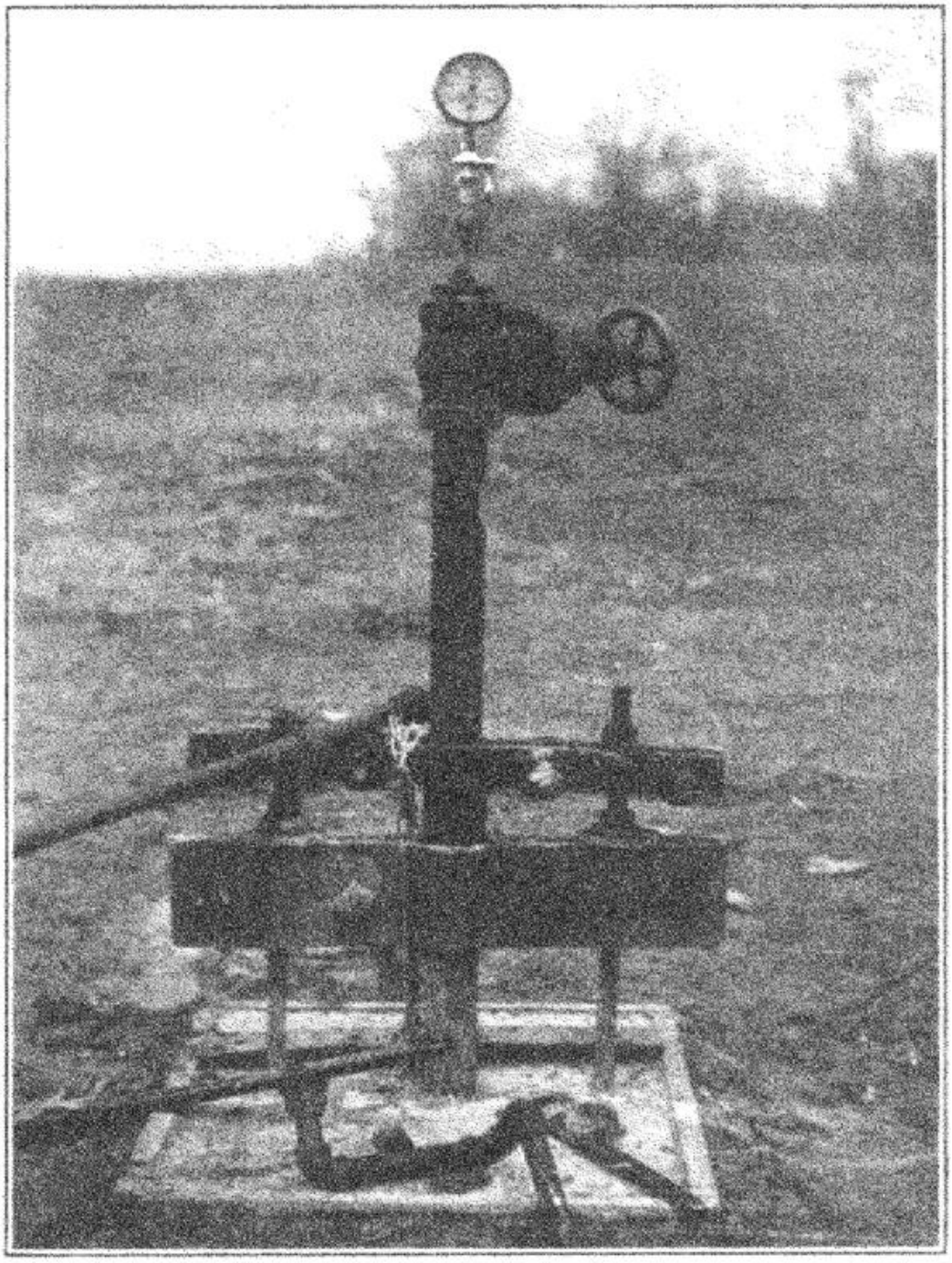
"The particular case which instigated the law was the carbon plant at Cowley, Wyoming, which took its gas from the Byron field, thereby endangering the future of the field and the interests of the private consumers and other industries.

"The position that this office is taking in regard to the carbon black industry is one of strict enforcement of the law as it stands for several reasons. First, the Midland Carbon Company in its operations in the Byron field wastefully used an immense quantity of gas that could have been put to better purposes and continued to do so a long time after the law was passed and even after the U. S. Supreme Court decided that the law was constitutional, they still ignored the statute until forced to close down by action of the Court. Their tactics were reprehensible both in their flagrant violation of the statute and in their conduct at legislative meetings.

"Personally, I believe that under certain conditions and circumstances carbon black may be manufactured from natural gas without injuring the resources of the commonwealth and in fact as a conservation measure. There are a number of fields in our State producing or capable of producing gas for which there is no market at the present time and probably will not be for a great many years. Wherever these fields have been drilled into by companies looking for oil, there has been a great waste of gas, and there will continue to be a waste of gas as long as the wells remain unplugged. There are several such fields in this State and it would be actually a conservation measure to put in a carbon plant together with a gasoline extraction plant to utilize the gas that is now going to waste. . . . ' ' .

J. A. Bownocker, State Geologist, Geological Survey of Ohio:

"Natural gas has not been used in Ohio for many years for the manufacture of lamp black and it is therefore not one of our



A TEMPLE HILL GASSER "CLOSED IN"

This Barren County gasser has been correctly closed, tubed and anchored. A blow cock is provided and a rock pressure gauge has been affixed.

troubles. In my judgment the states should forbid the use of natural gas for such a purpose. I believe that in West Virginia

the carbon black companies own their own gas territory and produce their own supply of fuel and I am not sure that they could be prevented from using the gas for this purpose. As you know, the Carnegie Steel Co. has obtained gas in a similar manner for many years and uses it in the manufacture of steel. These are great abuses, but our civilization does not seem to be far enough advanced to stop the practice.

"In Ohio the State is doing practically nothing to conserve the remaining gas supply. The companies, however, are working faithfully with that end in view. . . . ."

George H. Ashley, State Geologist, Bureau of Topographic & Geological Survey, Commonwealth of Pennsylvania:

"While a small amount of carbon black is made in this State, it is my impression that no question has been raised regarding the matter. In general however, I am inclined to believe that the position taken by many of the states is correct—that no gas should be used for the making of carbon black, except such gas as will not pay for piping to points of use—or in other words, such gas only for which there is no market.

"In this State (Pennsylvania), the price for gas for domestic use is increasing so rapidly, that that in itself is bound to solve the problem, as it is gradually approaching the price of manufactured gas. Wells which would therefore not pay for piping, would hardly be large enough to pay for establishing a carbon black plant. . . . ."

STATUS OF NATURAL GAS SHORTAGE IN CITIES

The pinch of natural gas hunger has already visited itself upon many of the largest municipalities of the Ohio Valley and adjacent regions. This is the case in Huntington, Cincinnati, Louisville, Columbus, Cleveland and many others less important cities. The aggregate urban population affected by this growing shortage totals in round numbers 2,750,000 people. Of these 610,000 are actual purchasing heads of families, the consuming unit, and have invested on the average $100 apiece in natural gas heating, cooking and lighting appliances. The total investment of the domestic consumer amounts to the

stupendous figure of $61,000,000.00, as may be gleaned from the following table:

Natural Gas Consumers and Investments.

	Domestic Consumers	Capital Invested
Ohio	385,000	$38,500,000
West Virginia	150,000	15,000,000
Kentucky	75,000	7,500,000
	610,000	$61,000,000

A single separate item of $325,000,000.00, may conservatively be taken as the investment in producing gas wells, pipe lines and plants by the several public utilities corporations supplying this large and scattered population. The total investment involved in supplying and consuming natural gas in this region amounts therefore to $386,000,000.00.

This large investment faces a rapid depreciation, as do all of the producing industries dependent upon it for their markets, if some effective measure of conservation of the supplies of natural gas remaining in the ground in the southern Appalachian region is not introduced to control the production and consumption. The tremendous waste of natural gas must be stopped, and stopped at once, at all points from the producing well to and including the consuming appliance.

That the natural gas situation is an acute one, that the shortage is real and widespread in its effect, and that any large replenishment of the supply is impossible, may be readily and authentically gathered from the excerpts of a number of letters recently received by the writer from mayors of cities, public service commissioners and others, well informed in these matters. These excerpts, which

have been taken from a large correspondence of similar trend, follow:

C. W. Campbell, Mayor, City of Huntington, West Virginia:

"I quite agree with you that the time is now ripe when the people of the cities using natural gas should agitate the question of conserving the supply for domestic use. So far the City of Huntington has taken no action in the matter, but the United Fuel Gas Company has been calling public attention to the fact that the supply is being rapidly depleted, and they are now asking an increase of rates because of that fact, and our Public Service Commission is hearing their petition, but our people are resisting their proposed increase. . . . ."

N. L. Pierson, Secretary to John Galvin, Mayor, City of Cincinnati, Ohio:

". . . . We Cincinnatians realize that the natural gas supply will very soon affect us greatly here, on account of a shortage of same. A movement is on foot now, that will doubtless raise the price that citizens will pay for gas. It is felt by some that if the price of gas is raised, a smaller amount will be used, and, therefore, the gas supply will be preserved for a certain length of time.

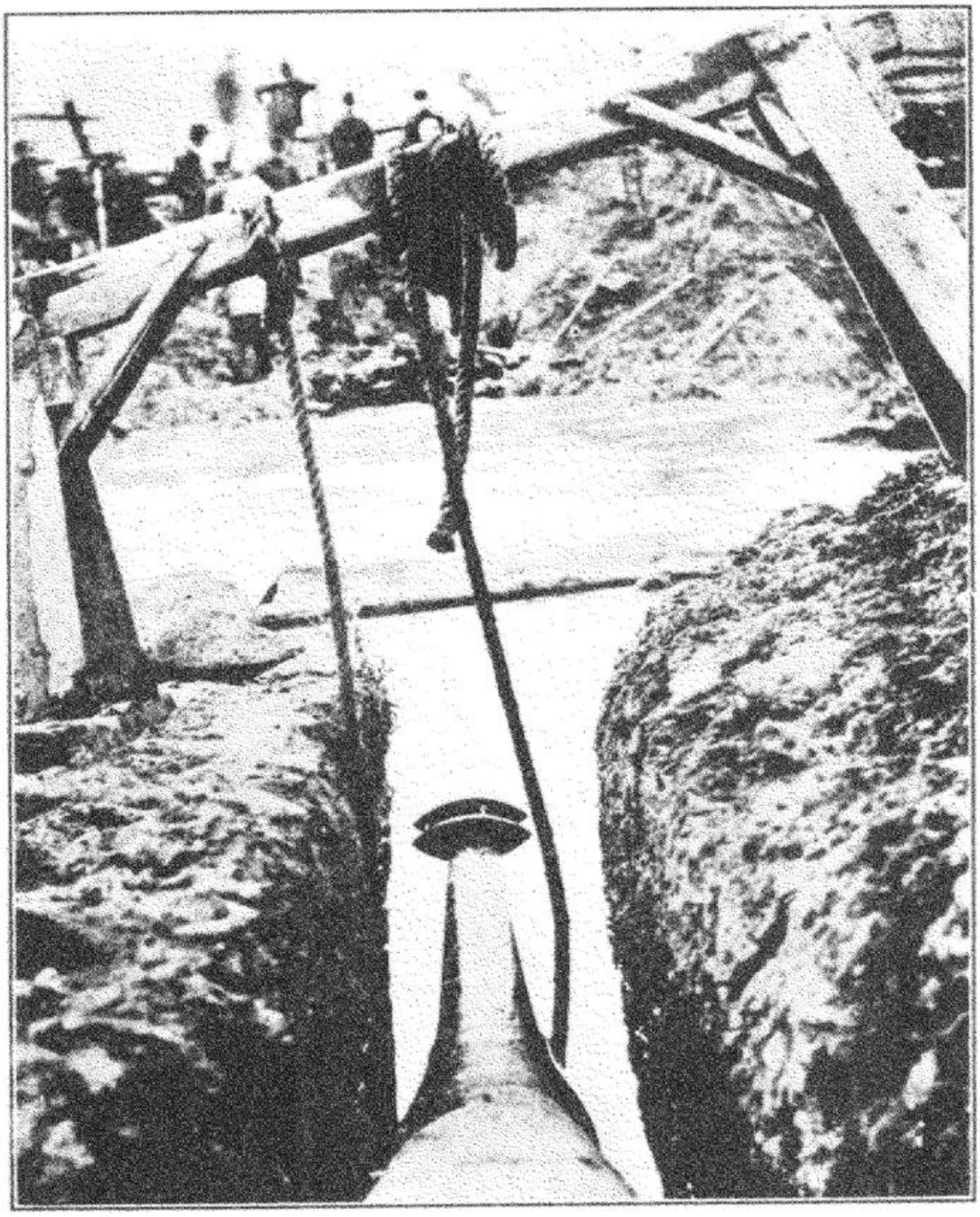
"I do not think much of this argument, but at the same time we have not the slightest doubt but that, in a few months, we will be paying a certain price for the first thousand feet of gas consumed, a slightly higher price for the second thousand feet, etc., for the third, fourth and fifth thousand feet used. . . . ."

W. H. Duffy, Director of Public Service, City of Columbus, Ohio:

" . . . . No steps have been taken by the City of Columbus toward conservation (of natural gas), except that the city council has granted an increased rate to the gas company, they having made the statement that the only method of conservancy was an increased rate which would cause users to install devices that would insure the use of less quantity than formerly consumed. . . . . "

John D. Marshall, Commissioner of Franchises, City of Cleveland, Ohio:

" . . . . Every one, I take it, is interested in the conservation not only of natural gas, but of all natural resources, and those cities which are using natural gas are, of course, par-



GAS PIPE LINES MUST CROSS CREEKS

One of the obstacles in pipe line construction is the large number of creeks of Eastern Kentucky. Here a twelve-inch line is being laid beneath the creek bed.

ticularly interested in the conservation of that fuel. In a rate ordinance which this city enacted on December 20, 1920, provisions have been made for conserving the natural gas by limiting industrial use during certain seasons of the year, and permitting the gas company to refuse service where improper appliances are used. The gas company, however, has refused to accept this ordinance, and on the contrary has attacked these provisions in the courts, claiming they are unfair and impracticable.

"The gas company in Cleveland claims the only conservation method which will prove effective is a sliding scale upward increase in price. To this proposition the City has not agreed. . . . ."

Huston Quin, Mayor, City of Louisville, Kentucky:

" . . . . . The conservation of our natural resources is a subject in which all good citizens are interested, and one of the most valuable of our resources is gas. Natural gas is the ideal fuel. It cannot be replaced by any artificial product, which even approximates it in quality or in price. Many natural gas fields are being rapidly depleted, and it behooves us all to conserve it in every way possible.

"We are doing everything we can to conserve the supply of natural gas in the city of Louisville. Every effort is being made to serve our citizens with gas at as near a uniform pressure as is possible, to avoid all leaks, and to advise the consumers as to the efficiency of their appliances. Furthermore, the mixing of artificial gas with our supply of natural gas at an increased rate for large consumers the past two winters served as a conservation measure, though it was primarily necessary to insure us an adequate supply. The pipe line which conveys gas from the field is in excellent condition, and the line loss is kept very low.

"The greatest opportunity for gas conservation at this time, therefore, is in the field. Gas is being wasted by oil well operators and oil drillers, but the greatest menace to the conservation and proper drainage of a gas field is the carbon plant. The process for obtaining carbon black is very wasteful, not more than 5 per cent of the carbon content of the gas being recovered. Furthermore, a carbon plant can utilize gas at a much lower pressure at the well than is necessary to make the gas available for pumping into a pipe line for transportation. Such a plant in a field, even though it has a very small acreage under lease, can soon destroy the field, and unless the utility company can procure every bit of acreage in the field, which is usually almost impossible, the company is constantly menaced by the possibility that any little tract in the field may become the site of a carbon black plant.

"Carbon black has its uses in our industrial life, and in fact it is superior in some lines of manufacture to any other product. But there are many gas fields remote from our cities, or the pipe lines which convey gas to our cities, that could be used for the

manufacture of carbon black, and in my opinion the installation of carbon black plants should be restricted to such fields, and thus the conservation of our supply of natural gas for domestic use be given a decided impetus. . . . . "

D. D. Smith, Mayor, City of Frankfort, Kentucky.

" . . . . . our natural gas supplies are very limited in nature and are being rapidly drawn upon by both public utilities corporations and manufacturers of carbon black. I don't think the public utilities corporations waste much gas, but I understand the efficiency of the carbon black manufacturers is very low.

"The amount of gas now being used in Kentucky in the manufacture of carbon black would supply a city of considerable size and, if conserved, would put off the day when natural gas will have to be supplemented by artificial gas.

"The wasteful use of natural gas by domestic consumers is another great leak in the industry, and, although this is paid for by the consumer, it is nevertheless a great drain on natural gas reserves, and will accelerate their early depletion.

"The natural gas situation in Kentucky, from a standpoint of domestic consumers generally, is a serious one. Kentucky has never produced as much gas as it uses. West Virginia, which has given us its overproduction, is now beginning to feel her depletion rapidly, and in a short time we will be forced to supply all of our gas ourselves or go without it. . . . . "

Grant P. Hall, Mayor, City of Charleston, Charleston, West Virginia:

" . . . . . Up to the present time there has been nothing done in the city of Charleston looking towards the conservation of our natural gas. We have many large gas fields all around us and on account of it being so plentiful our people apparently have not fully realized the importance of the conservation of this resource.

"We have quite a number of carbon black factories near Charleston. A few years ago the State Legislature passed a law known as the Steptoe Bill, which imposed a tax on gas exported from this State. The gas companies of West Virginia attacked the constitutionality of this law and recently succeeded in their contentions.

"Personally I feel that it is highly important to do something to prevent the extravagant waste of our gas. . . . ."

F. O. Eichelberger, City Manager, Dayton, Ohio:

"The matter of gas consumption has been in the past one of considerable moment here in Dayton, due to the inability of The Dayton Gas Company to furnish an adequate supply to its consumers, or to maintain the required pressure. The question

first came up in 1920. After numerous conferences between the city officials and those of the gas company, Samuel S. Wyer, Consulting Engineer, of Columbus, Ohio, was engaged by the city to make an impartial investigation as to the reasons therefor.

"In summing up his report, we learn that Dayton was merely one of a large number of towns depending on the rapidly declining natural gas supply. It was recognized that the situation was acute, and will become worse each year; that there has been a marked decline in rock pressure and volume of old and new wells, the number of acres of natural gas land held, and the number of producing wells per domestic consumer.

"Simultaneous with this decline there has been a large increase in the number of domestic consumers, domestic consumers demands for gas service, compressing station capacity made necessary by rapidly declining rock pressure, purchase price of gas in field, compressing station operating cost, cost per million cubic feet of open flow capacity of new wells, and in well operating cost and taxes.

"The conclusions reached in this report were that the City should prohibit the use of natural gas in wasteful appliances; that the Dayton Gas Company should carry out Recommendation No. 17 of the National Committee on Natural Gas Conservation; that the names of all industrial consumers should be secured and made public so that they can be shut off during the peak load during the cold season; that all stove dealers should raise the burners on all cook stoves before sale, and to buy only approved stoves for the future; that an intensive campaign to teach the public how to curtail waste in their homes and get the most out of the gas they are receiving should be conducted.

"It was felt that after these recommendations were carried out the quality of the service would be greatly improved, and that unless strict attention was paid to all conservation recommendations, then, in so far as this city was concerned, the benefits of natural gas would be a thing of the past in a few years.

"This the city did, through propaganda over our own signature, as well as an educational campaign, indorsed and aided by us and carried on by the local gas company, and in addition, passed an ordinance fixing the price of gas at a rate over the previous ordinances, all of which we believe greatly benefited the local situation. The pressure required was reduced two ounces, so that this sums up in a few words our local experience.

"We believe the citizens are fully aware of the decreasing facilities of the natural gas companies and are conserving wherever possible its usage. This winter, as well as last, being open winters in this locality, aided in this conservation, and yet, we hesitate to state what conditions might be in the future. Seemingly, the only solution being the creation of an artificial supply when the natural gas has become exhausted. . . . . "

E. N. Jones, Secretary to W. A. Magee, Mayor, City of Pittsburgh, Pittsburgh, Pennsylvania:

" . . . . . the city of Pittsburgh has done nothing in the matter of the conservation of natural gas. What waste has taken place in the use of this commodity has occurred principally in the gas fields near which are located the wasteful carbon black plants.

"At the present time the rates for natural gas in the city of Pittsburgh have reached the point where it has become cheaper to use coal for household heating purposes than gas.

"Relative to the manufacture of carbon black, it may interest you to know that the Guffey-Gillespie Gas Products Corporation, of this city, has under way the construction of two plants in the South for the manufacture of carbon black under new methods which will allow them to obtain approximately ten pounds of carbon black per thousand cubic feet of gas as against one pound obtained under present methods."

Ralph Arnold, Consulting Geologist, New York City:

" . . . . . the oil and gas industry offers an illustration of two of our wasting assets that have been subject to a prodigal use and are still subject to much abuse in spite of the warnings sounded by those private and government geologists who have dared to face the ridicule of the operators and even some of their own profession. It is true that the quantitative estimates have varied and have as a rule been revised upward as more and more data became available, but still in the main the effort to bring home the limited character of our oil and gas deposits to both those who produce and utilize these substances, seems fully justified by the trend of events. In the case of the most prolific of the Mexican oil fields, a great saving of both oil and investments would have been accomplished had the warnings of the economic geologist been heeded.

"In view of the good that has been accomplished in the past through the work of experts in pointing out, either quantitatively or abstractly, the limits of our mineral or other natural resources, it seems almost superfluous to attempt a justification of these efforts or to suggest that it is not only the right of the economic geologist but his duty to make such estimates and statements as will safeguard the proper recovery and utilization of our wasting natural assets."*

W. H. Davis, Cons. Eng., Eastern Carbon Black Co., Charleston, West Virginia:

"We have been manufacturing carbon black at Osborne, Kentucky, for the last twelve months, and have a production at present of 3200 pounds per day, which will be increased to about

* "One Duty of the Economic Geologist," Economic Geology, Volume XVI, Number 8, December, 1921.

double that amount as soon as the additional units we are now putting in are in operation.

"We cannot say exactly the amount of gas required for each pound, as we are not metering the gas for that plant. We endeavor to waste as little gas as possible. Our factories are equipped with electric lighting system for both our plant and dwelling houses, and we do not use any steam boilers except in connection with the drilling. We use precaution in regard to line leaks, and do not blow our lines in the open as we have drips to take care of the water, and seldom open the tops of any of our wells. We are using the gas at Osborne, Kentucky, from two wells, either one of which will run our plant to its full capacity.

"There has always been considerable agitation in regard to the waste of gas in producing carbon black, as the carbon in the natural gas weighs many times as much as the product we take from it. This carbon, however, is not what is known to the trade as carbon black.

" . . . . . We could produce a great deal more weight with a thousand feet of gas than we are producing, but we have learned from experience that when we produce much more than two pounds to the thousand cubic feet the quality is so poor that it is almost unmarketable.

"While carbon gas black is used for paint, rubber compounds, phonograph records, shoe and stove polish, etc., seven-eighths of the black made by the Eastern Carbon Black Company for the last twenty years has been used for printer's ink. It seems strange to us that there would be such an adverse opinion to an industry that produces a product that has no substitute and is absolutely necessary for the welfare of humanity, as millions and millions of people receive a direct benefit of the products of carbon gas black, while only a few thousands receive benefits from gas where used for domestic consumption."

A. B. Koontz, General Consul, Associated Producers of Natural Gas Carbon Black, Charleston, West Virginia:

" . . . . there should be used the common sense methods of preventing waste such as flambeau lights, line and connection leakage, open flow of wells for indefinite periods, improper plugging of wells when abandoned, improper casing to prevent water from getting into producing sands, etc.

"In the States mentioned (Southern Appalachian Commonwealths) the statutes could be much improved. Indiana has some good laws as have Oklahoma and Texas. Yet in Texas there is now being wasted a great deal of natural gas. The law requiring the cementing of the hole at the top of the sand permitting it to stand for a number of days to "set" before drilling in, is in my judgment a very good law. In a formation such as they have there, it is impossible to safely anchor casing except in this way.

"While Ohio, Kentucky and West Virginia have some statutes for the purpose of preventing waste in connection with the drilling and operating of oil and gas wells, they are heeded, generally speaking, as the operator sees fit to heed them, and when not heeded there is no practical way to prosecute the violator. And besides this when the violation is made the field may be irreparably damaged and a punishment of the violator will avail nothing to the public in the way of gas conservation.

"The companies solely in the oil and gas business are very likely to take whatever steps necessary to protect the strata from which production comes, even though they may be lax about conserving the products above ground, but the wildcatter or promoter will take no steps, unless forced to do so, to protect the oil and gas strata, the coal seams or the surface. In the event of a strike the promoter handles his product in such a way as to get the most money in the shortest time, and with no regard to the effect upon the field in which he is operating.

"A State Inspector, such as is provided for in Indiana or a practical man as the representative of the Utilities Commission to see that the laws herein mentioned are enforced, would be welcomed by the substantial operators, should be provided for the promoters, and would be of untold service to the public in prolonging the life of gas fields.

"All of the above applies to the production and distribution of gas and is important, but just as important is some education to awaken the public to the fact that natural gas is being wasted by it, and to the fact that in order to have natural gas for any great number of years, it must 'pay the price.'

"Usually when natural gas is first furnished a community it is at such a low price that no attention whatever is paid to the amount used. If it is not sold on a flat or monthly rate it is sold at a few cents per M cubic feet, and in either event it is not too costly to have had burners, flambeau lights, etc. Various compilations of figures for different towns show that as the price of gas goes up the quantity used by each consumer diminishes.

"In order for a public service company to make a fair return on investment, consumers who will take gas during the entire year must be furnished and this means the furnishing of factories. Domestic consumers, who use a substantial amount only for three or four months during the year must either pay such a price that will justify conservation for domestic purposes only, or permit all-year consumers to rapidly exhaust the supply.

"Our utility commissions, of course, can regulate the use of gas as between domestic and factory consumers. To this might be added the power, if it does not already exist (exer-

cised by Mr. Gregory during the war) to regulate the use of gas as between domestic consumers. (The legality of this might be questioned.)

"In summarizing I would say:

"Correct the present statutes so that waste in any substantial quantities will be made unlawful.

"Provide a practical way for the enforcement of the statutes.

"Educate the public so that it may appreciate the fact that natural gas will not last forever, and that there is a duty on it, as well as on the producing and distributing companies to conserve.

"The producing and distributing companies owe a duty to the public and the public likewise owes a duty to those companies."

T. J. Tonkin, Supt. Central Kentucky Natural Gas Company, Mt. Sterling, Ky.:

"As to the profligate use of gas, I have observed practices that, to me at least, seem criminal. All too frequent is the continuous use of open torches, or flambeaux, by farmers having wells on their premises, as a means of reducing the well pressure, millions of feet of gas going to waste when a twenty dollar regular would handle it properly and without waste. Free and unlimited use of gas as a part of the consideration to the land owner should not be permitted. Careless and indifferent ways of tubing and packing when wells are drilled in new territory seems not to be the exception, and enough gas is daily going to waste in this way in some of the small fields not as yet connected to pipe lines to supply a fairly good sized town."

Donald McDonald, Vice President and General Manager, Louisville Gas and Electric Company, Louisville, Ky.:

" . . . . The conservation of natural gas I consider an exceedingly important matter. Where communities have become accustomed to the use of natural gas, especially for cooking, the failure of it causes an amount of suffering and inconvenience which is truly surprising. Any steps which can be taken to prevent the waste of gas and the consequent hastening of the exhaustion of the fields, will be welcomed by this company. . . ."

George Otis Smith, Director, United States Geological Survey:

The largest degree of national usefulness will be won from our mineral resources only through the highest industrial efficiency, which is in turn secured by engineering advance and the linking up of mechanical power and man power. This means to the end is typically American, but too much emphasis cannot be put upon the importance of governmental action that is constructive in its cooperation with industry. While, unfortunately, public regulation seems to start usually with measures that are wholly restrictive in effect, because too often abuse of privilege has led to the legislative action, yet regulatory measures can be truly promotive, as has been shown in the recent cooperation of business and the Government. Public interest and private interest in the long run are less antagonistic than either the captain of industry or the public servant has suspected. It is true that the measure of economic worth must be the welfare of the individual, the community, and the people of the Nation, and not the dollar of profit to the corporation or the State, yet only a successful industry can be made to serve both owner and workman and the public as well.*

* "The Economic Limits to Domestic Independence in Minerals," George Otis Smith, Mineral Resources of the United States, 1917, Part I, p. 6a, pub. Dec. 28, 1918.

CHAPTER V

NATURAL GAS CONSERVATION

Problems involving the conservation of natural gas and mineral resources are intricate ones. Great difficulties confront the serious and impartial investigator at every turn, for although the general principles which should govern the situation are for the most part well defined, the special conditions which surround each problem are individual to it, and require a separate solution. What is true in principle of the conservation of natural resources as a whole, is also true in the same way of the conservation of natural gas, one of these resources, in particular.

It has been stated that, "in reference to natural gas, a great and pressing necessity is to stop its appalling waste by enacting and enforcing proper legislation. This ideal fuel should be used with the severest economy in order to prolong its life, which will be brief at best."* The study of existing conditions of supply and demand and their probable future trend of relationship, affords a basis for the consideration of the problems surrounding the conservation of natural gas. It is definitely known that the natural gas supplies once considered illimitable are in fact very limited, and rapidly approaching exhaustion. The word rapidly may be used in its fullest sense, for there is probably no other natural resource in all the world, certainly not in the United States, which is as near commercial exhaustion as is natural gas.

Regardless of what his special interest may be, whether consumer or non-consumer of natural gas, paid servant director of a public service corporation, or

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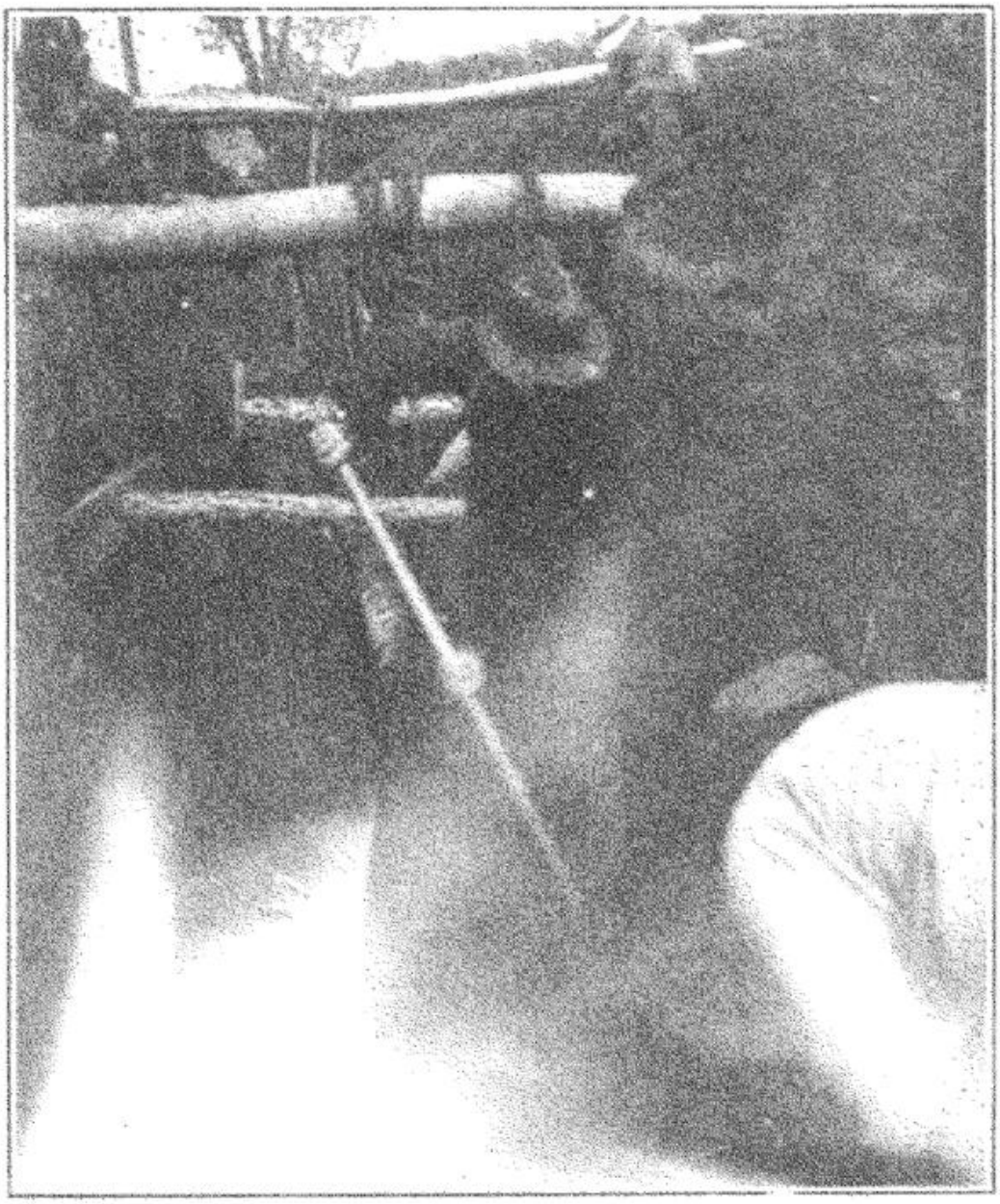
* Conservation of Natural Resources in the United States, by C. R. Van Hise.

owner of a carbon black factory, the man of broad judgment can have no fight with the principles of true conservation. The ideals of conservation do not allow of an idle



WHAT THE CONSUMER DOES NOT KNOW

Practically all of the gas main leaks are difficult and disagreeable to repair. Yet repairs should be made promptly to avoid great economic loss of natural gas.

hoarding of the volume of any natural resource, nor the perpetuation of capitalistic monopolies, under the cloak of future public interest. True conservation implies a wise and continuous use of natural resources, a use which will

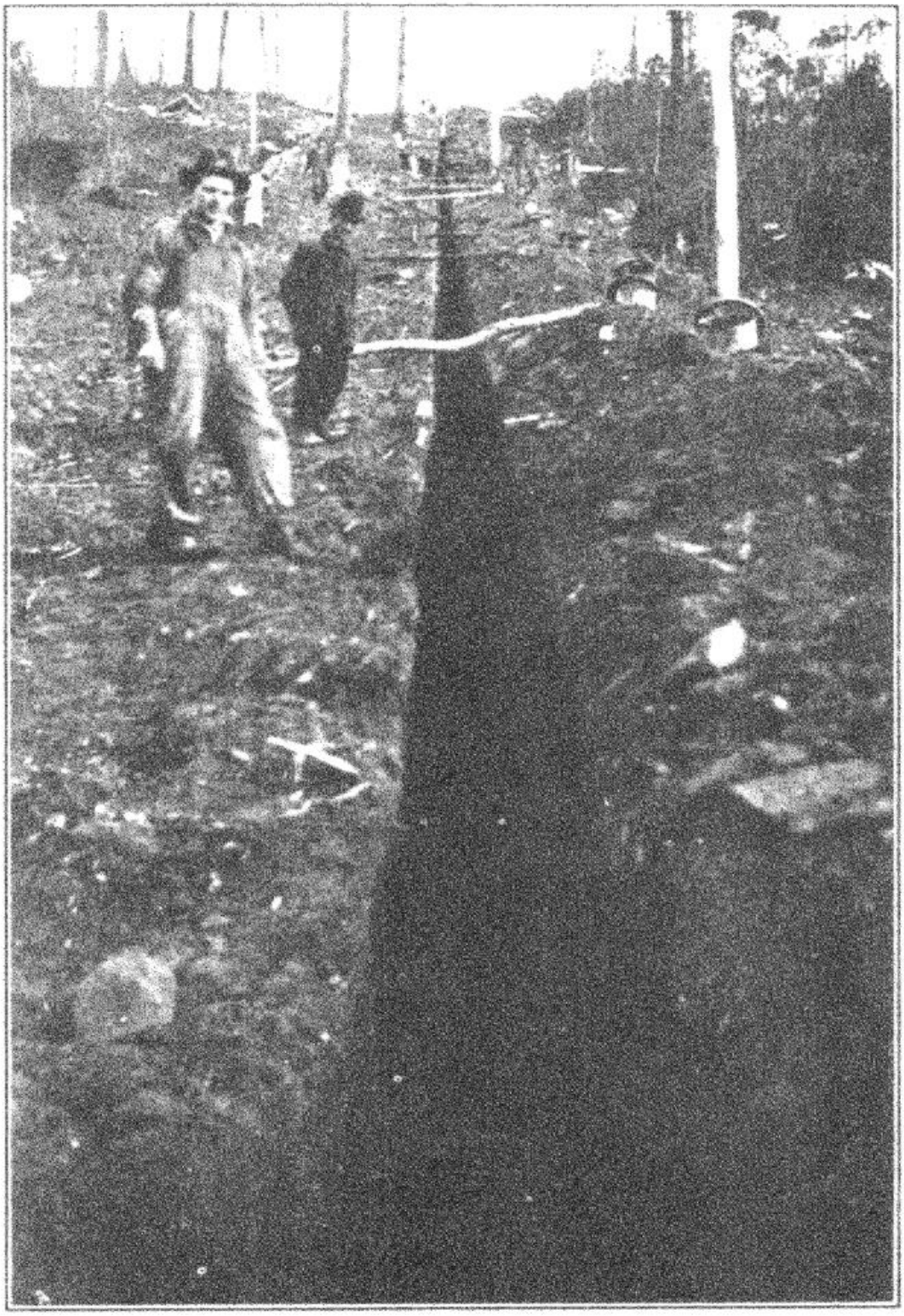
be efficient in the highest degree, while it extends far into the future the period of life of the resource involved. Conservation also implies the principle of equity—the greatest good for the greatest number—and it is along this last line that some of the most delicate and intricate questions of the whole problem of conservation arise.

In the natural gas industry, the fiercely competing interests, recognizing in many cases the validity and merits of their opponents' contentions, present their cases much as do opposing counsel. The endeavor is made to offer the most plausible reasons for their own position and at the same time to belittle and depreciate that of their opponents. The actuating motives thus unfortunately become selfish ones, backed by monetary consideration. Little thought is given to a fair and impartial solution of the problem from the standpoint of the best interests of the general public.

The producer of natural gas on leased property is not concerned, does not want to be concerned, at all in the matter of the most efficient present and extended use of the supplies which he controls. His interest is based on that unsound yet widely popular principle of American business which requires the largest possible return in the shortest possible period. Naturally, to gain his ends he cannot consider any broad principle of conservation, as his selfish motives necessarily imply a disregard of true conservation.

OWNERSHIP OF NATURAL RESOURCES

It is a nice question as to whom the stores of natural gas really belong. Just how far the principle of public interest, based on ultimate consumption, may enter, as compared with that of individual ownership, based on discovery and exploitation, is at the present stage of our social development, uncertain. If we follow the statutes,



READY FOR THE GAS MAIN

A twelve-foot ditch in Eastern Kentucky prepared for the laying of the large transmission line of a Central Kentucky city.

we cannot do much more than recognize the right of the discoverer and owner, though we may plead quite properly the sound principles of public interest. Having produced natural gas, in Kentucky it is the owner's full and legal right to dispose of it or use it in almost any way that he chooses. In fact there is nothing to prevent a 100 per cent waste of the natural gas under any lease in Kentucky, if the owner chooses to allow it. While the regulations governing natural gas production are plainly stated in the statutes, it may be said in truth that they are easily circumvented in the field.

In spite of our inelastic intellectual and legal inheritances, there are many signs of an awakening consciousness among the people of Kentucky as to the ultimate ownership of the limited natural resources. Various items in the current press, speakers before public audiences and legislators in our General Assembly are gradually developing and popularizing the idea of a fundamental social interest in all irreplaceable natural resources of Kentucky. The trend of this new conception is much higher and its ultimate possibilities are vastly greater than that which until yesterday was defined as personal ownership. Quite recently a representative from a great oil producing county in Kentucky stood in the House at Frankfort and proposed a small tonnage tax on coal, giving as his reason the fact that the men who chiefly profited by it did not produce it; they simply mined it, sold it, and left nothing in its place. A contemporaneous writer discussing the great rock asphalt deposits of Kentucky has recently said that the people of this state have a right to have *their* rock asphalt developed so that *they* may use it more widely.

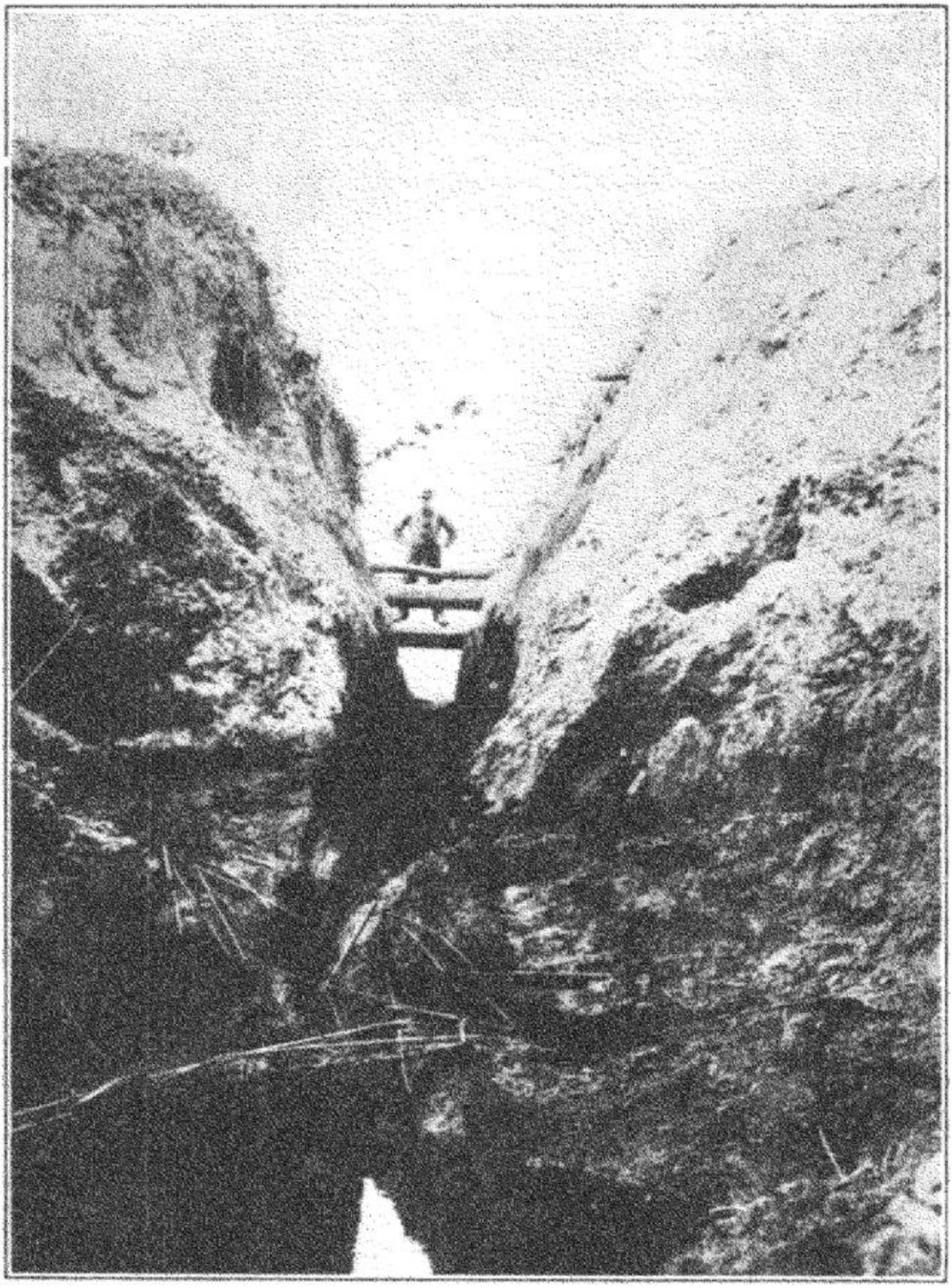
There is much in the growing public opinion of today which indicates a tendency to regard the personal ownership of mineral resources much in the light of custodian-

ship. It is pointed out that the value of all mineral resources is created by society in general. The ultimate consumer of every ton of coal, every gallon of oil and every pound of metal is the one who makes the mining of these mineral resources possible and profitable. A ton of coal may not always be sold as coal. A ton of iron ore has not reached the ultimate purchaser when it is dumped out at the smelter. Each may re-appear as a jack-knife or a hinge or an automobile. Taken collectively, the countless individual consumers of these manufactured products are known as society. It is the great social demand which makes possible and profitable the mining of coal and the production of the iron ore. It is the social demand, now rapidly increasing, which has created the profound interest in the intelligent and efficient use of these and all other mineral resources of our country.

DOMESTIC AND INDUSTRIAL GAS WASTES

In the use of natural gas it is easier to see in the domestic consumer, the ultimate consumer, than it is in many other natural resources. In this same proportion it should be easier to see the principle involved. The use of natural gas in all of the large industries is more or less wasteful. In fact, waste attaches to every form of use of natural gas, but it is a fact that the domestic consumer undoubtedly represents a higher degree of efficiency of use than any other. Great industrial waste in natural gas consumption attaches to the glass manufacturing industry, the zinc smelting industry, and the carbon black manufacturing industry. Of these three the greatest waste attaches to the last, for carbon black manufacture is considerably less than 5 per cent efficient.

While great waste attaches to the use of natural gas in the glass industry, the relative stability of plants manufacturing glass requires them to be more or less sub-



WHERE A PIPE LINE WITHSTOOD A WASHOUT

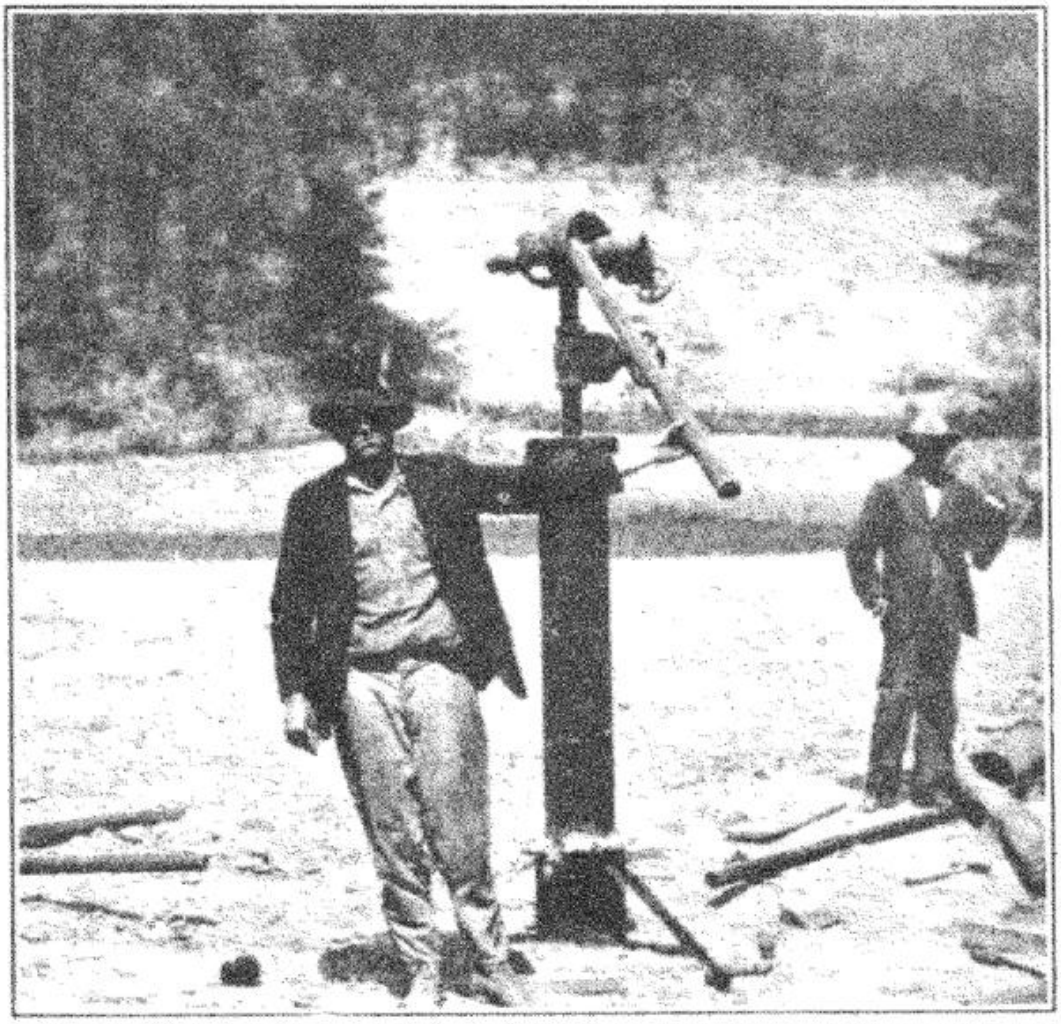
Through the long distances which the gas pipe lines in Kentucky come, many strange and unexpected things happen. Gas companies must be careful to watch for leaks. Here a bad washout did not interrupt the service.

servient to public service corporations, which in turn now properly require each industrial consumer to reduce his waste by the imposition of a sliding scale upward of purchase. Economic laws, therefore, operate in this, as they do in the zinc smelting industry, to eliminate some degree of waste. Such laws do not operate for the carbon black manufacturer. In most cases he produces his own natural gas, and in those cases where he does not, he is an almost direct producer. He generally secures his supplies of natural gas without competition or impost of penalty for such large wastes as may creep advisedly or unadvisedly into his operations.

A thoughtful consideration of the several problems involved in the conservation of natural gas indicates clearly that all industries using natural gas where other fuel can be substituted are opposing the principles of true conservation. A review of many of the practices inherent in the several natural gas industries discloses great extravagance in the use of natural gas and justifiably provokes the most severe criticism. The production of carbon black by any commercial method now known must be regarded as a very wasteful use of natural gas, although the product which is thus obtained is at the same time recognized as an important semi-necessary industrial mineral resource by-product. Since the importance of carbon black may be thus justifiably stressed, it becomes necessary to find a way whereby this industry may thrive and be rendered more efficient in its principles of production, rather than mercilessly obstructed and rendered commercially extinct.

There is little justification for the wasteful consumption of natural gas to produce carbon black for export. The citizens of Kentucky, who are the ones vitally interested in the conservancy of their own limited supplies

of natural gas, will do well to look ahead but a few years and see a time when natural gas will be a very rare and much more costly fuel resource in Kentucky cities than it is today. The time is not far distant when many of our small towns will be unable to secure adequate supplies



A "CLOSED IN" KENTUCKY GASSER

All gas wells should be tubed and packed and "closed in" immediately after drilling. It is an economic crime to let gas wells "blow open."

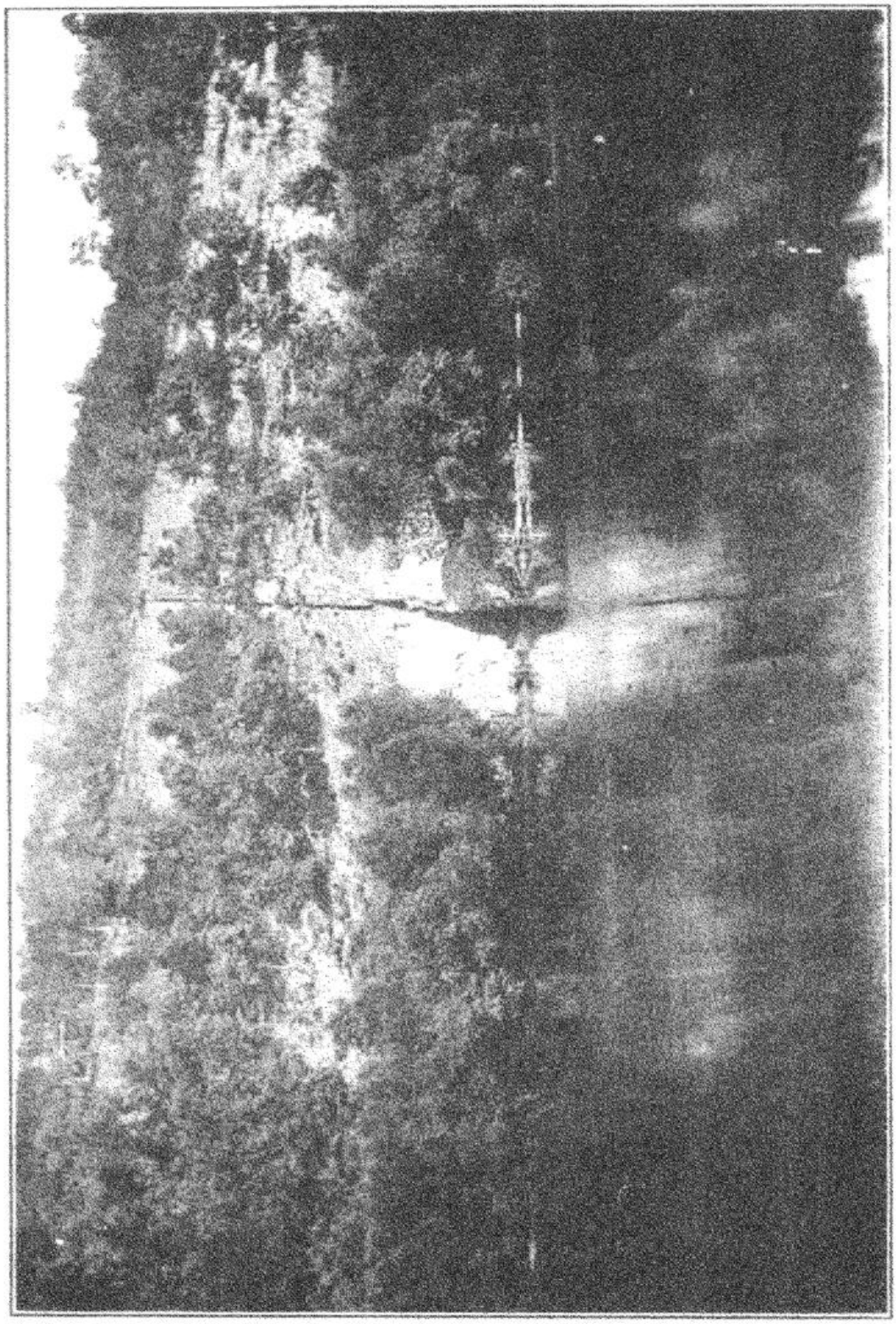
of natural gas at any price. Since it is impracticable to produce artificial gas for towns under 5,000 in population, the question as to what the small town in Kentucky will do then is an open one. The seriousness of the situation for all the States now using natural gas is shown in the following table, which indicates that of the 2,180 towns in

the United States that have natural gas, 1,944 are under 5,000 population and are, therefore, too small for manufactured gas and must go without gas service when natural gas is gone. These towns represent about one-half of the natural gas consumers in the United States. Kentucky has 51 such small towns.

Natural Gas Consuming Towns and Cities of the United States. 1921

STATE	Number of Towns Over 5,000.	Towns too Small.	Domestic Consumers in Towns Over 5,000.	Domestic Consumers in Towns too Small for Manufactured Gas.
Alabama	0	2	0	102
Arkansas	6	25	21,000	742
California	13	57	96,200	164,567
Illinois	5	23	8,600	69
Indiana	15	106	25,000	6,032
Kansas	22	113	78,000	52,350
Kentucky	11	51	77,800	13,049
Louisiana	2	17	7,600	16,770
Maryland	2	13	5,400	
Missouri	6	9	76,800	3,238
Montana	0	3	0	1,198
New York	13	134	131,200	38,108
North Dakota	0	1	0	6
Ohio	68	459	455,200	430,676
Oklahoma	12	110	38,200	82,307
Pennsylvania	39	505	242,600	238,675
South Dakota	0	2	0	391
Texas	11	49	55,200	24,655
West Virginia	10	267	31,600	95,568
Wyoming	0	5	0	999
	235	1,944	1,350,400	1,169,512

A review of the natural gas rates now in effect in twenty-five representative Kentucky cities and small towns shows an average domestic flat rate of 40½ cents per M cubic feet. A comparison with the maximum



A TWELVE-INCH GAS PIPE LINE CROSSING THE KENTUCKY RIVER

The view shows the construction of the Kentucky Pipe Line Company's large gas main passing into Woodford County. The line runs from Eastern Kentucky to Louisville.

rate of $1.90 per M cubic feet and the minimum rate of $0.95 per M cubic feet paid by domestic consumers in cities surrounding Kentucky for the use of artificial gas, is at once illustrative of the great advantage enjoyed by domestic consumers of natural gas in Kentucky. Once the natural gas reserves of this State are depleted, the installation of artificial gas in our cities is the next step. When this time comes, gas rates somewhat comparable to those of the second following table (page 136) may be expected:

REPRESENTATIVE KENTUCKY CITIES USING NATURAL GAS

Rates in effect January 1, 1922.

	Name	Rate Per M Cu.Ft	Company Supplying
1	Ashland	30c	United Fuel Gas Company.
2	Barbourville	38–80c	Barbourville Supply Co.
3	Campbellsville	38c	Green River Gas Co.
4	Catlettsburg	35c	United Fuel Gas Company.
5	Central City	90c	Central Gas Co.
6	Clintonville	50c	Blue Grass Natural Gas Co.
7	Cloverport	54c	Cloverport Gas Co.
8	Covington	45–60c	Union Light, Heat & Power Co.
9	Frankfort	50c	Frankfort Natural Gas Co.
10	Greensburg	38c	Green River Gas Co.
11	Greenup	35c	United Fuel Gas Company.
12	Inez	35c	United Fuel Gas Company.
13	Lexington	40c	Cent. Ky. Natural Gas Co.
14	Louisa	35c	United Fuel Gas Co.
15	Louisville	35c	Lou. Gas and Electric Co.
16	Maysville	35c	Maysville Gas Co.
17	Midway	40c	Cent. Ky. Natural Gas Co.
18	Mt. Sterling	40c	Cent. Ky. Natural Gas Co.
19	Paintsville	40c	Johnson Co. Natural Gas Co.
20	Paris	40c	Paris Gas & Electric Co.
21	Russell	35c	United Fuel Gas Co.
22	Versailles	40c	Cent. Ky. Natural Gas Co.
23	Warfield	35c	United Fuel Gas Co.
24	West Liberty	20c	Collier Oil & Gas Co.
25	Winchester	40c	Cent. Ky. Natural Gas Co.

General average rate 40.5 cents.

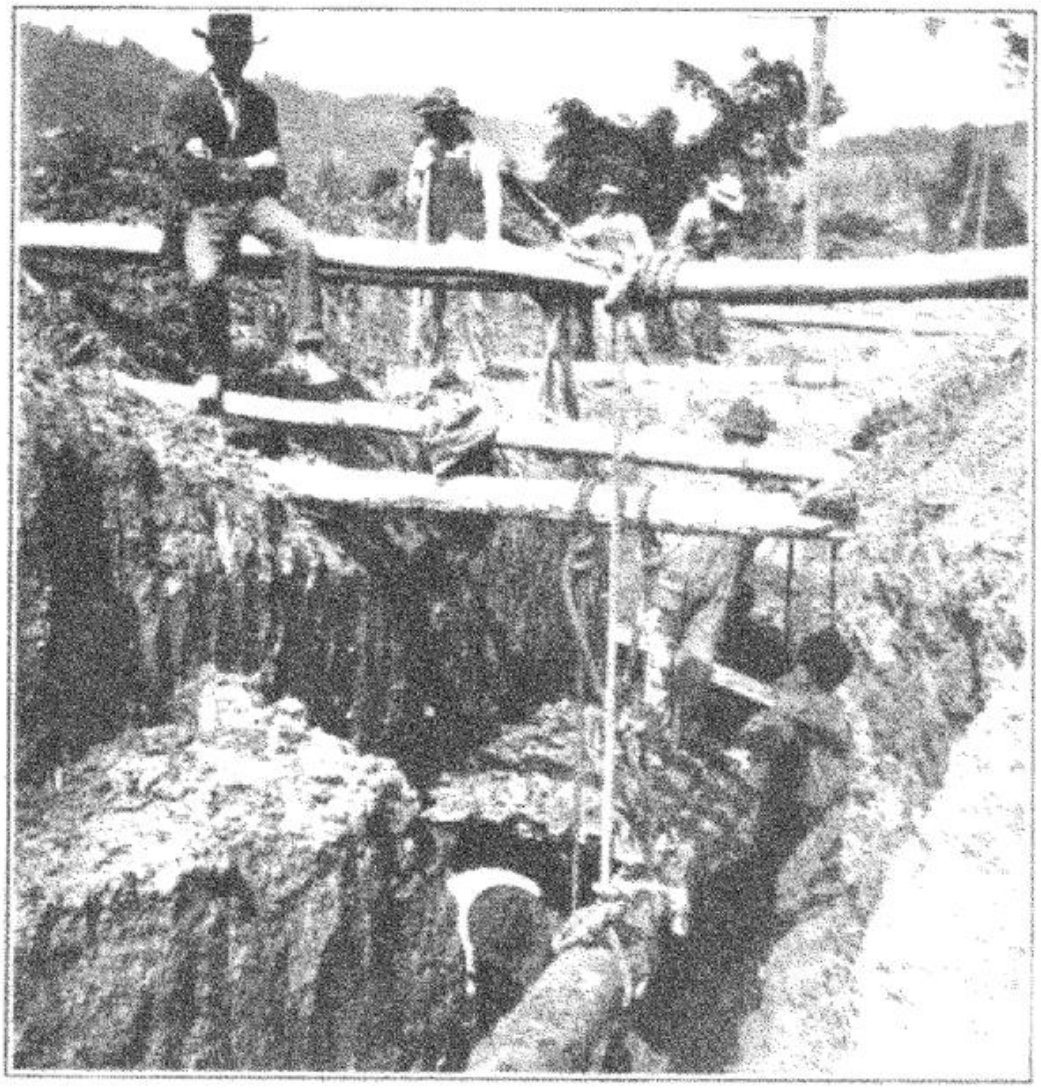
NOTE—Gas for local companies supplying Clintonville, Frankfort, Maysville, Paintsville and Paris is furnished by Central Kentucky Natural Gas Company.

Representative Cities of the Eastern United States Consuming Artificial Gas and Flat Rate to Domestic Consumer, Effective January 1, 1922.

	Per 1000 Cu. Ft.
Brooklyn, N. Y.	
Brooklyn Borough Gas Co	$1.35
Brooklyn Union Gas Co	1.25
Flatbush Gas Co	1.25
Kings County Lighting Co	1.50
Chattanooga.	
Chattanooga Gas Co	1.75
Chicago, Ill.	
Peoples Gas, Light and Coke Co	1.15
Far Rockaway.	
Queens Borough Gas and Electric Co	1.40
Flushing.	
New York and Queens Gas Co	1.60
Memphis.	
National Power and Light Co	1.35
Nashville.	
Nashville Gas and Heating Co	1.90
New York City.	
New Amsterdam Gas Co	1.20
Bronx Gas and Electric Co., et al	1.50
Central Union Gas Co	1.25
Consolidated Gas Co	1.25
New York Mutual Gas Light Co	1.20
Northern Union Gas Co	1.25
Jamaica Gas Light Co	1.20
Philadelphia.	
Northern Liberties Gas Co	1.10
Philadelphia Gas Works	1.00
St. Louis.	
Laclede Gas Light Co	.95
Washington.	
Georgetown Gas Light Co	1.25
Washington Gas Light Co	1.25

Since there can be no doubt but that the best and most intelligent use of the natural gas resources of this State would be one directed toward the benefit of the largest number of our own people and our posterity, it may be wise for us to think seriously of drawing a line between the carbon black manufacturer who produces for domestic consumption only, and he who produces

either in part or in whole for foreign trade or export. This suggestion is made in all seriousness, since it must be evident that there is no way by which the citizenship of this State can ever be adequately recompensed for the great loss of natural gas sustained. From a domestic



DRAINAGE VS. A GAS PIPE LINE

In order to avoid obstructing a farm drainage ditch a twelve-inch gas line was here lowered eighteen feet. In the neighborhood of large cities natural gas transmission line construction is beset by many obstacles.

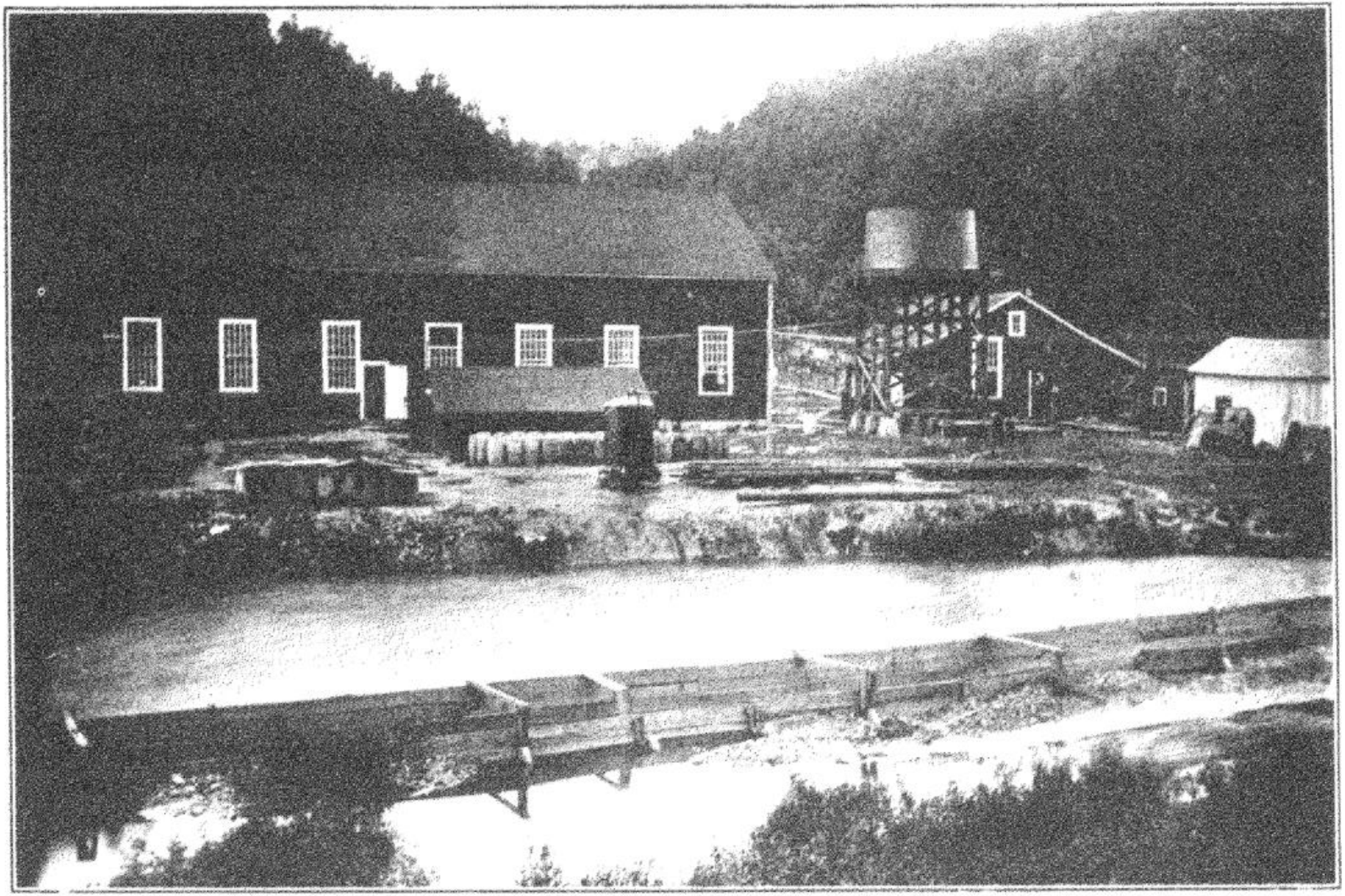
standpoint, the total benefits derived from such a traffic are shared by a very few selfish individuals. The foreign aspects are the improvement to a small degree of international commerce and the advancement of the inter-

ests of competitive industries in other countries. To rapidly dissipate in Kentucky so important and limited a natural resource as natural gas in the interest of such small returns, is not merely profligate negligence, it is an economic crime.

Besides the export phase of the carbon black industry, which to a State like Kentucky is positively without recommendation, there are other angles of the business that deserve inspection and criticism from the standpoint of conservancy. Foremost among these is the manufacture and sale of carbon black to such industries as might well provide a substitute. A splendid instance for this class would be the automobile rubber tire industry, where adequate substitutes for fillers, such as oxide of zinc, which was used in the pre-war period, may now be brought back into service. The inexpediency of stifling the carbon black industry in so far as it produces carbon black for the printing ink industry of this country is at once manifest. Here is an instance where there is no known "just as good" materials or reliable substitutes. Newspaper inks equal to those made from pigments of carbon black are not known. The great waste of natural gas is here, to some degree at least, justified, for we must have newspapers, and we must have inks with which to print them, in Kentucky as well as everywhere else in this country.

COMPETING INTERESTS VS. CONSERVANCY

The relationship of the carbon black producer and the public utilities corporation in the field has not been clearly defined. The principles of fair play demand that both should have the same right to search or prospect for natural gas. When the natural gas has been discovered, the principles of conservation enter into the



A MENIFEE COUNTY "BOOSTER"

This is the Central Kentucky Natural Gas Co.'s Pressure Plant in Menifee County, Ky. "Booster Stations" are vital to long distance gas pipe lines. From the Kermit, W. Va. station to this pressure plant is an air-line distance of about seventy-five miles.

problem. It now appears that each should be guaranteed an unmolested prosecution of its business so long as neither one nor the other endangers the best interests of the general public in the conservancy of the remaining supplies of natural gas. Since it is widely recognized that natural gas supplying public utilities corporations approach nearer to a strictly efficient use of this natural resource than any other, and since through them greater regulation of the conservation of natural gas may be obtained through the rules of State Conservation Commissions than in any other way, their operation is recommended, while the use of natural gas for all wasteful industrial enterprises must be condemned. This final interpretation has been arrived at generally by all conservancy commissions and scientific bodies that have found it necessary to give the matter careful consideration.

In the light of these interpretations, the operation of carbon black plants within any large proven gas field which is serving through a public utilities corporation a large group of domestic consumers, must be considered as a serious menace to true conservation. Isolated gas pools not fundamentally necessary to public service demands, either present or future, are without doubt the rightful field for the manufacture of carbon black, and it is held that the carbon black industry should not only be directed to such pools, but once established here should be as carefully protected as possible. Carbon black's best interest, from the standpoint of the conservation of its available resources, may even here be safe-guarded by proper legislative restriction which will insure for it a longer lease on the life of its rapidly depleting supplies of natural gas. Projecting the present uncontrolled volume of the carbon black industry

A GAS PIPE LINE NEAR THE BIG SANDY

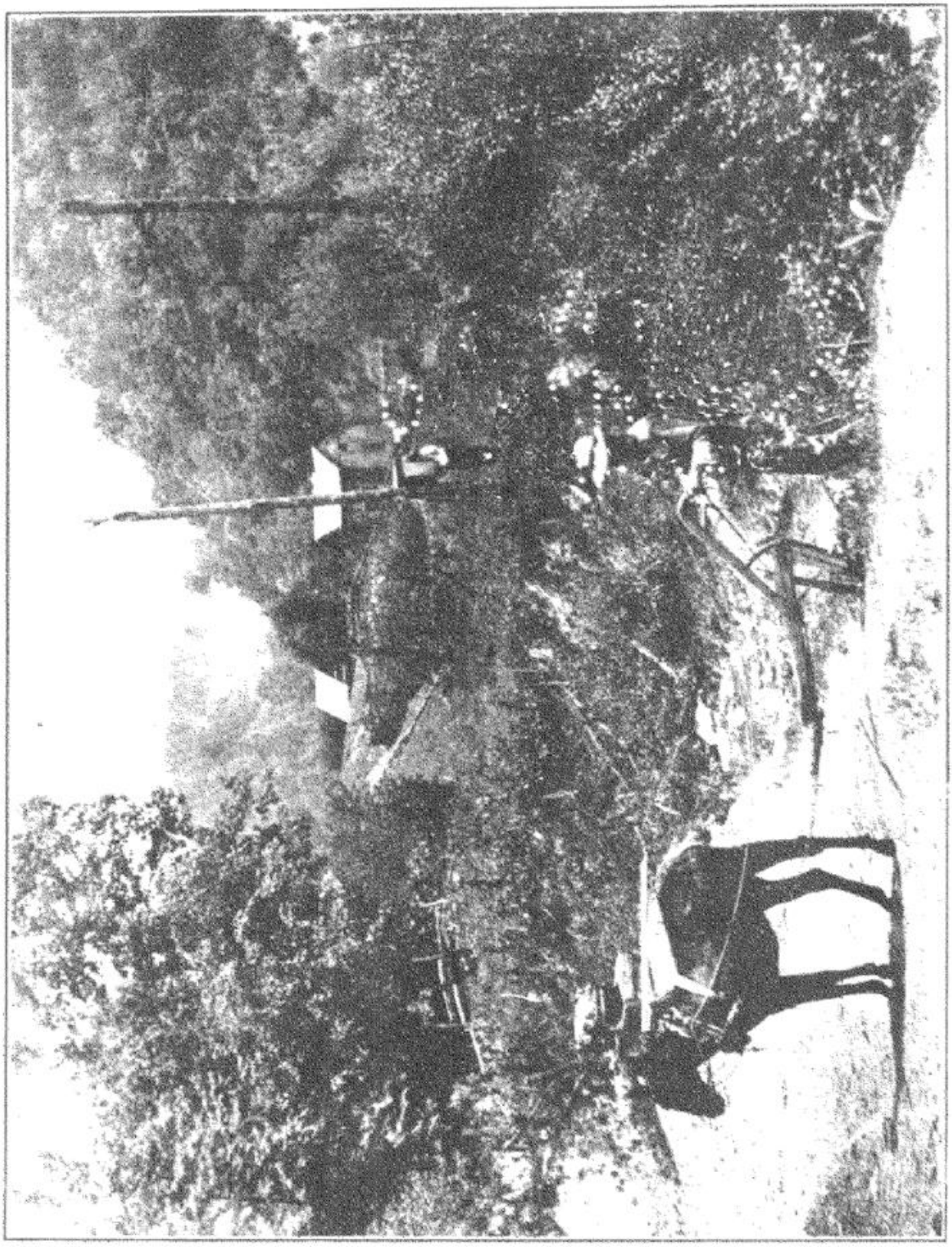
In the construction of this line, here shown in progress, all the bare area was a large slip and had to be tile drained to prevent further movement.

into the future, the interested public may be assured that within a few decades carbon black as a natural gas by-product will be an industrial relic in all of the Eastern States, including Kentucky. American carbon black will then be produced only in those isolated sections of this country where newly discovered supplies of natural gas are far beyond the reach of the public utilities pipe ines.

NATURAL GAS CONSERVATION MEASURES

As measures of natural gas conservation the following principles are recommended for gas field operation: (1) the prompt closing of gas wells; (2) the proper casing of gas wells to prevent underground waste; (3) the proper casing and tubing and packing of gas wells to prevent waste; (4) regulation of the amount of gas which may be used in firing well, drilling boilers and the method of burning such gas; (5) outlawing of the use of the gas flambeaux or torch; (6) the drilling of fewer offset wells; (7) the proper plugging of oil, gas and salt water sands; (8) outlawing of the practice of blowing gas wells to secure oil; (9) the outlawing of extensive blowing of gas wells in order to free them from water; (10) proper regulation of the lowering of rock pressure in order to avoid too rapid a diminution of natural gas flow.

To further promote the conservation of natural gas, the following principles are recommended for the guidance of public service corporations, domestic consumers, and the interested public: (1) regulation of inspection, covering the leakage, gathering, transmission and distributing lines; (2) the installation of leak proof measuring devices by the ultimate consumer; (3) the drying of natural gas where necessary to avoid blowing drips; (4) the abolition



TELEPHONE LINE AND NATURAL GAS PIPE LINE

The Kentucky Pipe Line Co. maintains a private telephone line along its gas main for the rapid reporting of leaks. This view is in Johnson County. Every important natural gas transmission line should be so equipped in the interest of natural gas conservation.

of free gas and flat gas rates; (5) the abolition of cheap gas for manufacturing, and in its place the institution of a sliding scale upward; (6) a proper regulation and limitation of the carbon black industry and all other wasteful natural gas industries so that they will conform as nearly as possible or practicable to the best principles of conservation; (7) the outlawing of exports to foreign countries of carbon black manufactured in Kentucky; (8) the standardization of heating, lighting and cooking appliances using mixers so as to produce the most efficient use of natural gas; (9) the compulsory installation of thermostats regulating large natural gas heating devices, such as furnaces, etc.; (10) a discontinuance of discount practices by natural gas companies for low pressure or peak periods; (11) the adoption by municipalities generally of franchise regulations providing for the mixing of artificial gas with natural gas during periods of increased demand or peak load; (12) the education of the public in general and the domestic consumer in particular concerning the rigidly limited and rapidly diminishing natural gas reserves of Kentucky and adjoining States; (13) the adoption by every one of the most efficient methods and appliances for handling and consuming natural gas, and the strictest enforcement throughout of the principles of true conservation.

The End.

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