The McKeesport Gas Pool, Allegheny County, Pennsylvania.

By

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Introductory Note to Second Edition.

This bulletin was originally issued early in 1920 when the drilling of new wells in the McKeesport district was actively going on. At that time it made available to the public a structure map of the Murrysville anticline near McKeesport and gave the evidence indicating the early exhaustion of the pool and probable financial loss incurred by wells begun after January 15. The report very definitely helped to stem the tide of over development and saved the taxpayers many times the biennial appropriation for this Bureau.

The first edition of this bulletin has long been exhausted and the continued demand has required this second edition. Minor corrections have been made. In the main, however, the bulletin is reissued in its original form in the belief that it has both technical and historical value.

Later studies have shown that the Murrysville sand is not the same as the Berea sand but lies between it and the "Hundred foot" sand.

The predictions made in January, 1920, were verified by subsequent events with almost mathematical precision. This is shown in part by Bulletin No. 19, "Production of the McKeesport Gas Pool", and its supplements.

Revised and stenciled June, 1922.
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Introduction.

This preliminary report tells briefly the story of the McKeesport gas pool, including some of its early history, lists the sands, describes the maps the position, extent and character, and discusses the probable future of the pool.

McKeesport, at the junction of the Youghiogheny and Monongahela rivers, 15 miles southeast of Pittsburgh, has been in the spotlight since August 1919, when probably the best paying gas well in the world, the Hamilton No. 3 drilled by Foster and Brendle (No. 8 of map 1) struck gas just south of the city at 2939 feet below the surface in the Speechley sand. Starting at 4 million cubic feet daily, this well quickly increased to 62 million cubic feet, and "coming in" where pipe lines are available, relatively little gas was lost before being turned into money. The well is said to have delivered an average of 50 million cubic feet a day for 100 days, a total of 5 billion cubic feet. As the gas had been contracted for at 17 cents or more a thousand cubic feet, it did not take long to net the owners a million dollars. Investments of $150 are said to have brought dividends of over $3,000 the first month.
Is it any wonder that other gas companies should have formed at once, obtained leases and begun drilling as soon as material could be gotten on the ground? Much of the land near the big well had recently been subdivided into building lots, and many of these had been sold at a very small price. Each became at once a potential lease-hold, so that by December, 1919, no less than 116 companies or corporations had been formed and 230 proposed wells located. By January 10, 1920, notwithstanding the advice of this office through the papers last December that "investments now being made for future drilling are almost certain to result in partial if not total losses," the number of companies had increased to 297, including fourteen new concerns granted permits on that day to issue stock. By January 15, 29 wells had reached the Speechley sand in this pool. Of these wells 17 are listed as having an initial production from the Speechley sand of over 1 million cubic feet, and 12 are listed as dry or small producers. Several wells dry or small in the Speechley sand have some production from the higher sands.

Drilling Operations.

Drilling for oil and gas in the Long Run or McKeesport district has been going on sporadically for 40 years and more. David Foster and Sam Brendle had drilled several wells to the higher sands (wells 2, 3, 4, 5 and 9 on map) and had gotten gas in the Murrysville or in the Elizabeth sands. Early in August the Philadelphia Company brought in a large well further up Snake Hollow (7), which had been drilled after their Storch well (6) had proved a disappointment. The gas was found in the Speechley sand.

Foster and Brendle began to deepen their old wells to the Speechley sand and on August 29 the Hamilton No. 3 came in as a gusher. The Philadelphia Company began wells on many leases scattered over the district. Scores of new companies were formed and by December 1st a dozen wells in or close to Snake Hollow were producing gas on a commercial scale, including a few such small producers as to be rated as "near dusters." These, except the big well were then reported as producing from 15 million cubic feet per day down to one million or less.

After November 15 wells reached one of the upper or lower sands in rapid succession. November 15th the Philadelphia Company's Wiggins No. 1 well (No. 12 on the map) with 5½ million cubic feet; on the 20th, the Sloan-Wally well (15) estimated at 8 million cubic feet; on the 25th the Foster "Stone house" well (13) estimated at 5 million cubic feet; on the 28th, the Pitts No. 1 well (14) with a very large flow. In December, the Lamp and Auld No. 1 (18) and Dutcher No. 1 (21) came in with flows estimated at 12 million cubic feet or more, but each of the latter caught fire before the gas could be turned into the pipes, burning its derrick and a nearby house. The fires were extinguished with steam a few days later.
Sale of leases and stock.

The financial side of the story has followed the usual course of such strikes. The earlier companies were partnerships economically managed and the first wells were put down at the minimum of expense for leasing and drilling. The big well is said to have cost less than $7,000. As the big well was followed by other large wells, lease-holds rose rapidly in value and soon more money was being made from the sale of leases than from the sale of gas. The price of gas went down to 10 cents a thousand cubic feet, but as winter came on and the demand increased, it rose and stabilized at 15 cents a thousand cubic feet. Owners of building lots in Snake Hollow nearby were able to sell or lease at increasingly fancy prices, until within four months, it was reported that leases were bringing as high as $25,000. Likewise the cost of drilling rose as the demand for men and material increased, until by January 1st, contracts were reported at $20,000 or higher.

At first, little publicity was given the big strike; but as the news spread, oil and gas men and promoters flocked to McKeesport and before Christmas a stock selling boom was in full swing. A Pittsburgh newspaper of December 21 carried almost four pages of advertisements of McKeesport gas stock; three gas dailies had sprung up in McKeesport, and a weekly in Pittsburgh. By the middle of December stock salesmen were soliciting subscriptions from the servant girls of Pittsburgh at the back doors.

Under these conditions the Survey has been flooded with requests for information - as to the location of the anticline, the exact position and extent of the pool, the depth and character of the sands, and especially as to the future yield and life of the pool.

Origin and Occurrence of Gas.

It is well known today that natural gas does not occur in an open reservoir, but in the pores of porous sandstones, the "sands" of the drillers. If the sandstone is close grained, or "tight", it may contain no gas, or will not yield the gas it contains. If it is open grained, it will yield gas, if it contains any. The gas is formed by the decomposition and natural distillation of bituminous matter, either plant or animal, laid down on the sea bottom when the containing rocks were being deposited there. The gas when once withdrawn is not stored.

Experience has shown that natural gas is commonly associated with anticlines, or roof-shaped folds of the containing rock. The central line of the fold is called the axis. A structure map of the gas fields of Pennsylvania will show that most of them are close to the axis of some anticline.

Murrysville Anticline.

The McKeesport gas pool is on the Murrysville anticline and is, therefore, a part of the Murrysville field. From its southern end at Monongahela City, the anticline extends northward across and parallel
with the Monongahela river, recrossing at Belle Bridge. Thence it extends northeastward, crossing Youghiogheny River at the mouth of Dead Man's Hollow, continuing northeast between Snake Hollow and Long Run, crossing the Lincoln Highway at the head of Jacks Run, then following about the line of Turtle Creek to and past Murrysville, crossing Kiskiminetas River a little southeast of Apollo; following Roaring Run along the southeast side of Armstrong County, and disappearing in Plumb Creek Township. The position of the anticline in Lincoln, Versailles and North Versailles townships of Allegheny County is shown on map #2.

Murrysville Field.

The Murrysville field has from the first been a great producer of gas. The first wells drilled in 1878, (the Beaver Valley well, a few miles from Apollo, coming in only a few days ahead of the Haymaker No. 1, at Murrysville,) were large gas wells. The Haymaker well has been estimated to have had a flow of 20-30 million cubic feet of gas a day for 5 years before being attached to a pipe line in 1883. During that year much drilling was done in the Murrysville field and it became recognized as the "phenomenal gas field" of the State. The first gas piped to Pittsburgh was from this field, and came from a sand 100 feet thick, since known as the Murrysville sand, lying 1900 feet below the Pittsburgh coal. As the flow in this first pool decreased, wells were renewed by deepening so that they maintained their flow for a long time.

Early history of McKeesport pool.

Lest anyone think that the McKeesport pool is a new one, it may be mentioned that prospecting for oil and gas began in the Long Run district before 1876. In that year the Bayard well near Ellrod Station, which had been drilled to 1030 feet and yielded only salt water, was deepened to 1486 feet. Enough gas was struck to throw the water as high as the top of the derrick, but all attempts to make a gas well of it failed. Another well had been drilled on Sixth Street in McKeesport. It was over 1640 feet deep and had a good show of gas at 1060 feet. The Wood well, 300 feet from the Bayard well, struck gas at 1401 feet, but was flooded with water and abandoned.

In 1882 Munhall and Smithman drilled a well a quarter of a mile east of Jacks Run school-house which went through 31 feet of Murrysville sand at 1487 feet and into the next sand below, known as the Hundred foot sand, which is a white, coarse grained, or pebbly sandstone carrying water. The Murrysville sand here was 1800 feet below the Pittsburgh bed, or 1170 feet below the Upper Freeport sandstone. The well flowed 3500 barrels of fresh water a day. Other wells were in drilled in April. In March, 1884, the Vandergrift or Erskine well was drilled 6000 feet west of the junction of Long Run and Jacks Run. At that depth, the same gas as Randwood entering the Hundred foot sand. In September, 1884, the Dossel well was drilled on Long Run, about one mile northwest of the Ellrod well. A good flow of gas which lasted only 60 days was struck in the Murrysville sand. The well was then deepened and struck salt water in the Hundred foot sand. In November, 1884 the Weston well,
750 feet southwest of the Vandergrift well, obtained a little gas, but not enough to be of value. Later the Black well was drilled one mile farther southwest but found nothing.

Recent development.

From that day to this drilling has been going on spasmodically, most of the holes going to the Murrysville sand, or into the water-bearing Hundred foot sand just below. During recent years a number of holes in this area have gone down to a sand nearly 3300 feet below the Pittsburgh coal, which is thought to be the same as the Speechley sand in the northern part of the State. The result of all this drilling has been variable. Many holes, drilled even into the Speechley sand have been dry. At least one gusher was drilled - Spiegle well - estimated by some to have had a flow of 100 million cubic feet (but soon drowned out by water), and at least one good pool was found at the head of Jacks Run just south of the Lincoln Highway. This pool was drilled during the last year and a half (1918-1919) several wells flowing from 1 to 5 million cubic feet a day from the Speechley sand. The rock pressure in this pool is now so low as to necessitate the building of a pump station to force the gas into the pipe line. Other wells have had an initial flow up to 8 million cubic feet.

In continuation of their policy of gradually extending their prospecting southward, the Philadelphia Company had reached Snake Hollow in 1919 and drilled their first well just south of where the Russell well afterwards came in.

From this brief review we get these facts:

1 - This is not a newly discovered field.

2 - The sands are spotted, being gas bearing in one area and dry in another equally well situated with reference to the anticline; thus, a dry hole at one point is not proof that there is not gas nearby. The full extent of the gas resources of the field will only be known when all the field has been fully tested with the drill.

3 - Probably a majority of the holes drilled in the area just northeast of the Snake Hollow pool have been small producers, or dry. There is no reason to suppose that the proportion of dry holes and large producers will change in the future; therefore persons or corporations planning to drill in that area may anticipate a goodly number of dry holes and small producers.

4 - The discovery of the Jacks Run pool and the Snake Hollow pool shows that other yet undiscovered pools may exist.

5 - The gas occurs in unconnected pools, as evidenced by the fact that the decline of pressure in the Jacks Run pool had not affected the pressure in the Snake Hollow pool, when that pool was first tapped. On the other hand all of the wells in a pool should show nearly the same general reduction of pressure.
6 - The big pools, but not all of the big wells, have been found close to the axis of the anticline. The axis runs directly through the middle of the Jacks Run pool and the big wells of the Snake Hollow pool are on or close to the axis.

Geologic structure.

As a guide to future drilling, it is important therefore to know the position of the axis and the width of the anticline as nearly as may be determined, for its bearing on the width of the possible gas field. Map No. 2 shows the position and extent of the anticline in part of Allegheny County. It is offered as a preliminary map only, until the next field season will permit accurate mapping of the field with the plane table. It is based on a large number of hand level elevations on the coals, clays, limestones and sandstones of the region.

This gas pool is in the Pittsburgh coal field; but the uplift along the axis of the anticline has raised the Pittsburgh coal so high that it has been removed over most of the area in the center of the anticline. Where the Pittsburgh coal is gone its position is estimated from the elevation of some of the underlying rocks. Thirty feet below it is the Pittsburgh limestone that caps a number of hills where the Pittsburgh coal is gone. The Ames limestone can be seen at many places in that district about 300 feet below the Pittsburgh coal and 40 feet below the base of the massive Morgantown sandstone. This sandstone outcrops as cliffs in the hills facing Youghiogheny River and has been quarried back of Christy Park and on Long Run. At 132 feet below the Ames limestone is the Pine Creek limestone seen at the road level near the Snake Hollow schoolhouse and elsewhere. Just below that is the Buffalo sandstone that makes cliffs beside Long Run above and below the Walnut Street bridge. From 170 to 190 feet below the Pine Creek limestone is the Upper Freeport coal.

Geologic structure.

Most of the wells of the district start near the level of the Pine Creek limestone. All pass through the Upper Freeport coal, which thus becomes a good horizon marker. The elevation of most of the wells in the field was obtained by hand level and the depth to the Upper Freeport coal was used in determining the geologic structure. In part of Allegheny County, it is offered as a preliminary map only, until the next field season will permit accurate mapping. The structure of the field southeast of McKeesport is obvious by observing the rocks closely. The Morgantown sandstone makes a prominent cliff in the hill slope along Walnut Street between McKeesport and Christy Park. This sandstone is seen to incline or dip steeply towards McKeesport. The top of the sandstone goes below the level of the street about opposite the end of the Port Vue bridge. The bottom of it rises above the street where a car track formerly extended up the hill. If this sandstone is traced around the face of the hill north and northeast of Christy Park, it may be seen rising until its top reaches the top of the bluff facing the river, about 1,000 feet above sea level, a rise of about 200 feet in a mile. The rise can be measured more accurately by determining the elevation of the Ames limestone that lies about 40 feet above the sandstone. This sandstone outcrops as cliffs in the hills facing Youghiogheny River and has been quarried back of Christy Park and on Long Run, at 102 feet below the Ames limestone in the Pine Creek.
feet below the base of the sandstone. This limestone at the point where it passes under Walnut Street is represented only by some small nodules of limestone in a yellow clay. In general, however, it is one foot or more thick and can be seen at a number of places in the area of the McKeesport pool. The Pine Creek limestone may also be seen at many places in this district. Just over the Pine Creek limestone is a series of hard, sandy shales about 20 feet thick overlain with soft, red shales. These hard shales are exposed in continuous outcrop on the south side of Youghiogheny River opposite Versailles and on the north side of the river above Ellrod. The Pine Creek limestone, therefore, lies just below the railroad track northeast of Ellrod and continues so on the south side of the Youghiogheny almost to the mouth of Dead Man's Hollow, revealing a broad, extremely flat bench on the east side of the anticline. Just east or south of the mouth of Dead Man's Hollow the beds are raised so that the limestone and top of the sandstone are about 10 feet above the level of the railroad track; but those beds drop back to the track level at the northwest bank of the hollow, showing that the axis or center of the anticline crosses the Youghiogheny just opposite the mouth of the hollow. Northwest of Dead Man's Hollow the same hard shales may be seen along the railroad for some distance. Where crossed by Youghiogheny River the arch of the anticline is very flat and broad with just a slight up-turning at the middle. The same type of structure was found where the anticline crosses the ridge between the Youghiogheny and Monongahela rivers northeast of Belle Bridge, and where it crosses the Lincoln Highway. The structure across the two places mentioned can be determined quite accurately by tracing the position of the Pittsburgh coal, or the Pittsburgh limestone that lies about 30 feet lower.

The structure is shown on map No. 2 by means of heavy lines that indicate the elevation of the Pittsburgh coal above mean sea level, or the position it would have had if not eroded. Such lines are known as structure contour lines. Unfortunately accurate bench marks from which to run level lines are few and far between in this immediate region. It was therefore not thought wise to attempt to show the elevations of the coal by lines closer than 50 feet until spirit levels can be run through the field from which the elevations of the rock beds can be more accurately determined.

Probable limits of pool.

It may be noted that along the axis of the anticline from Youghiogheny River to the Lincoln Highway the Pittsburgh coal would, if present, have an elevation of 1200 to 1265 feet above sea level, lying almost flat for a width of one or two miles. The heart of the field probably lies within the 1200 foot line as shown on the map. From that flat crest, the arch slopes gently downward to the northwest and southeast to the 1150 foot contour. The space between the 1200 and 1150 foot contours, covering from one quarter of a mile to a mile, should be included in the probable gas territory until drilling has shown this belt to be unproductive.

South of Youghiogheny River the anticline noses downward so that the Pittsburgh coal is 75 to 100 feet lower where the axis crosses
the Monongahela than at the crossing of the Youghiogheny. This means that south of Youghiogheny River the possible gas territory spreads out to the 1100 foot contour along the dividing ridge and possibly to the 1050 foot contour where the anticline crosses Monongahela River.

For the present, the writer feels that the territory outside the boundaries named is likely to prove outside of the gas pool, though it may prove that gas will be found extending one contour farther from the axis. But it must not be forgotten that much of the area within what is here classed as the gas pool, is certain to be non-productive. Many dry holes have already been drilled in the area enclosed within the 1200 foot contour. Mention has been made of the pool in the Speechley sand at the head of Jacks Run, south of the Lincoln Highway. North of the Lincoln Highway in the same region, drilling in the main has been unproductive. It may be expected that the gas will be found in pools where the sand is more open-grained, but that in much of the field the wells will be either small or dry. That another big pool like that near McKeesport may be found is possible, but not altogether probable. The Philadelphia and other large companies have been prospecting this field for many years. Yet their first hole in Snake Hollow proved unproductive while soon afterwards the Russell well (10) close by, came in big. The portion of the field south of Youghiogheny River has not yet been thoroughly tested for the lower sands, and the outlook in that area is problematical.

The fact that the Speechley sand in the Bedell well near West Elizabeth is only 3 feet thick is not encouraging. The Peoples' well (22) south of Youghiogheny River, found gas in the Speechley sand after getting 2 million cubic feet in the Elizabeth sand. The Benedum-Trees well nearby and other wells in Lincoln township were reported as small or dry. This may indicate that the edge of the pool lies not far south of the river. The fact that two holes up Long Run, the Bravo (27) and Riddle (5), are dry in the Speechley sand suggests that the limits of the pool may have been reached in that direction. On the other hand, the coming in of the Etna-Foundry well (24) with 4 million cubic feet from the Speechley suggests that the pool may extend southeastward as far as the river at Boston bridge and possibly over into Boston.

Gas Sands.

The character of this report does not permit a detailed description of the several gas-bearing sandstones. Measuring from the Upper Freeport coal, which is cut in most of the wells, the underlying sands are met in this area at about the following depths:
Depth of gas sands below Upper Freeport coal.

<table>
<thead>
<tr>
<th>Distance in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>475</td>
</tr>
<tr>
<td>950</td>
</tr>
<tr>
<td>1150</td>
</tr>
<tr>
<td>1275</td>
</tr>
<tr>
<td>1400</td>
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<tr>
<td>1550</td>
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<td>1625</td>
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<tr>
<td>1645</td>
</tr>
<tr>
<td>1720</td>
</tr>
<tr>
<td>1775</td>
</tr>
<tr>
<td>1825</td>
</tr>
<tr>
<td>1900</td>
</tr>
<tr>
<td>2640</td>
</tr>
</tbody>
</table>

The above names are used tentatively until a full set of records of drill holes between Murrysville and this area can be collected and studied in detail. The Murrysville sand at McKeesport is struck at about 1275 feet below the Upper Freeport coal.

Gas has been found at McKeesport chiefly in three sands - Murrysville, Elizabeth and Speechley. As a rule not much gas has been found in the Murrysville, but in at least one well, the Doctor Matthew well (17), enough gas was found in this sand to warrant stopping the drill at that point. Most of the wells have found some gas in the Elizabeth sand. Later wells appear to have found a very large quantity of gas in that sand. Among the later wells reporting a large flow from the Elizabeth sand, is the Philadelphia Company's Storch No. 1 well (16) which struck such an unexpectedly large flow, that it was not possible to put out all of the fires and the gas was ignited and burned the derrick down. The Stewart well (19) of Foster & Company obtained a flow estimated at 2 to 5 million feet, and the Peoples' Natural Gas Company is reported to have struck 2 million cubic feet of gas in the Elizabeth sand on the south side of Youghiogheny River.

"Secondary enrichment" in Elizabeth sand.

The explanation offered by Mr. Tonkin of the Peoples' Natural Gas Company seems a reasonable one but, if true, is an unique example of a secondary enrichment of a gas sand. At first only a 6 inch pipe line was laid to the big Foster well. This proved insufficient to carry the gas; and to prevent damage to the pipes, a valve was set into the pipe, which allowed the gas to escape until the pressure was reduced to about 430 pounds. The big well had been cased only to 1700 feet to shut off the water in the Hundred foot sand. The face of the Elizabeth sand in the well was exposed and it is assumed that the high back pressure in the big well drove a large volume of gas coming from the Speechley sand into the Elizabeth sand.
higher up in the well, resulting in the large flows obtained from that sand in later wells. As tending to confirm that theory, Mr. Tonkin cited the Riddle farm well (5) which had an estimated flow of 200,000 cubic feet from the Elizabeth sand, which later increased to a flow of about 400,000 cubic feet.

Probable life of pool.

The two questions of greatest interest to the largest number of people regarding the gas pool near McKeesport are: "What is the future supply of gas in this pool and in the field as a whole; and, what will be the life of the field." On the one side are those who declare that the pool has hardly been scratched and who believe that the big well will be paying good dividends five years from now. On the other are those who believe with the Oil City Derrick, which says "to the practical oil and gas man, the fiasco at McKeesport would be amusing if it did not have an assured pathetic ending. Within 6 months that portion of the field now under development will be as dead as the proverbial herring."

As between these two points of view what is the driller or investor to think? Are there any facts from which one may be warranted in drawing fairly definite conclusions?

In discussing this question there must be kept clearly in mind the difference between a pool, such as that in the Speechley sand surrounding the big well, tributary to it, and sharing its life history, and a field such as the Murrysville field which, as in this instance, may consist of many pools. Again, it must be remembered that a well at any point may enter a number of pools in as many sands, each having a different extent, a different initial pressure, a different life history. One sand may be open-grained and the pool short-lived; another sand may be fairly close-grained and yield gas slowly but for a long period. Where, as in the McKeesport region, three or more sands are gas bearing, the problem appears confusing because of the fact that the same well may be drawing largely from two sands and the gas from one sand may be playing out rapidly, while that from the other is holding up well.

There are two ways of attacking the problem: one may be called practical and the other theoretical. The practical problem may be stated in dollars and cents. If it cost $30,000 to promote, lease and drill a well, and gas sells at 15 cents a thousand cubic feet at the well mouth, how many million cubic feet must the well produce to return its cost and yield a return of 10 per cent, or of 1,000 per cent? It must yield 200 million cubic feet to return its cost; 220 million cubic feet within a year to yield 10 per cent; 400 million cubic feet to yield 100 per cent; 2,200 million cubic feet to yield 1,000 per cent and return one's original capital. What is the chance of a well yielding these amounts: 1st, in the Long Run or Snake Hollow pool; 2nd, outside of that pool but in the Murrysville field.

Many years ago Mr. J. F. Oarll, of the Second Pennsylvania Geological Survey, after years of practical experience and study in the Pennsylvania gas fields, announced three principles:
"1 - That gas wells have a life just as oil wells have".

"2 - That one well left alone without other wells around will continue to yield a regular supply of gas for a long time; but when numerous wells are put down around it the gas supply is soon entirely exhausted.

"3 - That when an oil well ceases to yield, a second well in the vicinity may and frequently does find oil; but when a well ceases to flow gas, new wells in the vicinity find no gas".

Since that time very detailed studies have been made by the United States Geological Survey, the United States Bureau of Mines, many State Surveys and others, of the life history of many gas fields. Everywhere the story is the same — a large initial flow and high rock pressure, steadily declining (unless water chokes the flow of gas) until both flow and pressure disappear. The rate at which the flow and pressure decline depends entirely on the rate at which the original supply of gas is exhausted. This in turn depends on three elements: the grain of the rock, the original quantity of gas, and the size and number of holes drilled into the pool. A 1/4-inch gimlet hole may require some time to drain a tank. A 3-inch auger hole may drain it quickly. Some gas wells in fine-grained rocks will flow only when a powerful suction is exerted in the drill hole. Other rocks are so open-grained that when pierced a gusher is bound to result. Wells of the first kind may last a score of years. Those of the gusher type may exhaust themselves in a few weeks. A well is often reported to flow a long time without any diminution, but no records of such a well have been published.

Cleveland, Ohio, gas field.

Figures to show these facts might be given from almost any of the gas fields in the country, or a comparison may be made with a single field in which conditions are fairly similar to those in the McKeesport pool. The Cleveland, Ohio, gas field in which the wells get gas at 2600 to 2800 feet and in which the original rock pressure in the different pools was from 800 to 1100 pounds per square inch, may be selected. The initial open flow in many wells in that field was between 3,000,000 and 10,000,000 cubic feet. The gas was found to be in distinct pools, all of which, however, had identical histories after being developed. One pool for example, had one well starting at nearly 13 million cubic feet, 4 at about 10½ million, 8 at about 5 million and 8 at about 3 million, which compare favorably with the wells near McKeesport except for the big well. This field also resembled the McKeesport pool in the closeness of drilling, as it was in the midst of town lots in the suburbs of Cleveland.

A study of the flow of the wells shows that the average for the first month was from 15 to 68 per cent of the initial flow of the first day. Comparing the flow for the first month with that for succeeding months, there is found: third month, 56 per cent of first month; fifth month, 41 per cent; ninth month, 21 per cent; twelfth month, 7 per cent. These selected figures are the average of the measuring stations. The life of wells in the more thickly drilled pools was about 12 months; the average of all the pools about 18
months. Some wells became exhausted in 2 or 3 months while one or two lasted for more than 3 years. Curves drawn to show the decline of production of individual wells indicate that the larger wells were longer lived, but declined more rapidly in actual production. All of the curves are nearly straight lines, indicating a fairly uniform falling off. A study of the rock pressure in a single pool shows as follows:

Rock pressure in a single pool at Cleveland, Ohio.

<table>
<thead>
<tr>
<th></th>
<th>pounds</th>
<th>pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 16</td>
<td>950</td>
<td>October 19</td>
</tr>
<tr>
<td>June 25</td>
<td>890</td>
<td>November 10</td>
</tr>
<tr>
<td>August 5</td>
<td>650</td>
<td>December 11</td>
</tr>
<tr>
<td>September 16</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>

Compared with these pressures the initial production of wells may be grouped as follows:

Initial production of wells at Cleveland, Ohio.

<table>
<thead>
<tr>
<th>Brought in</th>
<th>Number of wells</th>
<th>Average production (cubic feet)</th>
<th>Average initial pressure (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Aug. 31</td>
<td>7</td>
<td>3,150,000</td>
<td>731</td>
</tr>
<tr>
<td>Sept. 1 to Oct. 31</td>
<td>16</td>
<td>1,970,000</td>
<td>483</td>
</tr>
<tr>
<td>After Nov. 1</td>
<td>13</td>
<td>600,000</td>
<td>205</td>
</tr>
</tbody>
</table>

In this pool it required five months for the rock pressure to be lowered one-half, though in two months more it had been cut in half again. How do these conditions compare with the conditions in the McKeesport pool?

Rock pressure in McKeesport pool.

Rock pressure is measured by a gauge after a well has been closed for 24 hours. The approximate pressure can be learned without stopping the flow of gas for so long by noting the rate at which the pressure rises after the valve is closed. The exact rock pressure of the new gusher at McKeesport was not measured last August. An attempt was made to determine the rock pressure at the Philadelphia Company's second well. When a pressure of 1280 pounds to the square inch was recorded the casing began to rise and the test was discontinued. Judging by the rate at which the pressure was rising before the gas was released it was thought that the gauge would have stopped rising at about 1400 pounds.

A number of tests of rock pressures made during December were reported to show 800 pounds, 745 pounds, and the last one 730 pounds per square inch. In January the pressure continued to fall, the last measurement obtained as this is written being 450 pounds, equivalent to about 500 or 550 pounds if the whole field were closed. This
would agree with the rate at which the pressure had been falling previously, that is, 5 to 6 pounds a day. (According to a later report (unauthoritative) the pressure at the big well and the new Foster well nearby was 375 pounds. If true, the gas in this field is more than two-thirds exhausted). It would thus appear that the pressure had fallen off one-half in about 4 months or in less time than in the Cleveland pool. Accurate figures are not at hand concerning the flow of all the wells, but such figures as are at hand indicate that the pressure in individual wells is falling off at much the same average rate as in the pool at Cleveland, Ohio.

Decline in production.

One well at McKeesport is reported by its owner as giving at the end of the first month only 21 per cent of the first day's run. Another early well was reported by the owner in December as yielding about one-sixth of the initial production. That the average production today is only a fraction of that reported in some advertisements is well known to every person acquainted with the facts. A well advertised as yielding 10 million cubic feet, was yielding in mid-December only 1,200,000 cubic feet. Another quoted at 7 million cubic feet in January, was down to 300,000 cubic feet in mid-December, and so on. The yield of the whole pool January 8 was estimated at 65 million cubic feet a day.

The big well has fallen off on the average 1 million cubic feet every 3 days, more slowly at first when it had the pool to itself, and faster in recent weeks. As this is written, the flow is below 30 million cubic feet a day (reported in papers of January 22 as 14 million feet).

In this connection some will point to the Lamp and Auld (18), Dutcher No. 1 (21), Pitts No. 2 (25), and Foster's Impong well (30), all of which "came in big" late in December or early in January, as evidence that the pool is holding up. It is probable, however, that these wells struck the same type of sand as the Hamilton No. 3 well and that had they come in last August they might have been as large as the big well. While rock pressure and flow have much to do with each other, it is the rock pressure that tells the story, just as it is the water level in a cistern that tells how fast the cistern is being emptied. A 3-inch auger hole emptying a cistern gives a large flow until the water level actually reaches the hole. A gas well in very open-grained sand may give a large flow until the pressure becomes almost as low as the back pressure in the mains, when it may shut off suddenly. That the Dutcher, Pitts, and Impong wells mentioned above would start with productions as large as that was anticipated as soon as the Lamp and Auld well came in; just as it may be anticipated that wells Nos. 31 to 34 on the map stand about an even chance of coming in dry or small.

Relation of total to initial production and cost.

The decline in production of 350 wells in the Cleveland field was plotted and showed that on the average the production per month was as follows:
<table>
<thead>
<tr>
<th>Month</th>
<th>Per cent of first month's production</th>
<th>Month</th>
<th>Per cent of first month's production</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd</td>
<td>- - - - - - 70</td>
<td>12th</td>
<td>- - - - - - 9</td>
</tr>
<tr>
<td>4th</td>
<td>- - - - - - 45</td>
<td>14th</td>
<td>- - - - - - 5</td>
</tr>
<tr>
<td>6th</td>
<td>- - - - - - 31</td>
<td>16th</td>
<td>- - - - - - 3</td>
</tr>
<tr>
<td>8th</td>
<td>- - - - - - 20</td>
<td>18th</td>
<td>- - - - - - 0</td>
</tr>
<tr>
<td>10th</td>
<td>- - - - - - 14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At the eighteenth month the average well had stopped flowing.

Figured out this gives each well an average total production of less than one hundred times its initial production. In other words, a well that started at 1 million cubic feet could be counted on to yield less than 100 million cubic feet. A well that started at 10 million cubic feet should have a total production of nearly one billion cubic feet. If the same ratio holds true at McKeesport, a well that cost $30,000 must have an initial production of 2 million cubic feet to pay for itself; all above that will go toward dividends. A $15,000 well should pay for itself if its initial production is above one million cubic feet. Probably the big well at McKeesport will do better than this ratio, but figures from the other wells suggest that the above method of computing the yield of a well may prove useful in the McKeesport pool. The sand struck by the big well was so loose grained and the initial pressure so high that the flow of gas steadily enlarged either the well or the channels leading to it. Sand was still being blown into the pipes from this well in mid-December.

The earlier wells cost $15,000 or less. It is obvious therefore that most of them not only pay for themselves but will pay handsome dividends. By January; most of the wells were being capitalized at $25,000 or more apiece, and therefore must have not less than 2 million cubic feet initial flow to pay any dividends.

What chance have wells starting to drill January, and requiring 60 days to reach the gas, of coming in with a production of two million or more cubic feet? In the pool at Cleveland, Ohio, the wells brought in from the middle of the third month to the middle of the fifth month averaged less than two-thirds as large as those brought in during the first 2½ months. Those brought in after the middle of the fifth month averaged less than one-fifth the size of those of the first 2½ months. Leaving out of account the big well, the first ten wells drilled in the McKeesport pool in the first three months averaged, according to conservative reports, about 4 million cubic feet initial production. If the McKeesport pool were to follow the Cleveland pool it would mean that the wells brought in between the middle of November and the middle of January, 1920, would have an average of 2,600,000 cubic feet initial production, and that 'therefore', all or nearly all would pay dividends, while those brought in after January 15 would average less than one million cubic feet and therefore would not pay. It was estimated that in the Cleveland field as a whole the net financial return from the sale of gas fell
$100,000 short of paying the cost of drilling the wells. Those first in the field made money, while those last to come lost more than the first-comers made. If the McKeesport pool runs true to form, while the pool may last two years as previously stated by the writer, it is doubtful if the average well started after January 1st will pay any dividends. At the prices most wells were then being contracted for and with the high cost of leases, they will do well to pay for themselves. This does not mean that none of the wells will pay. Many of the wells put down after January 1st will be on old leases, or on leases obtained before the rush began, and it is the experience in the Cleveland and other fields, that occasionally a large well comes in even late in the life of a pool. For example, at Cleveland one 2 million foot well came in during the sixth month when all of the other wells around it were coming in at 350 thousand to 650 thousand cubic feet.

Comparison has been made with only one field - the Cleveland - because conditions there are fairly similar to those at McKeesport and because the figures, only a few of which have been quoted, are unusually complete; but the general history of that field might be repeated from every gas producing State in the Union. The results given are not opinions, but hard, cold facts.

Theoretical computation of gas supply.

A theoretical study of known facts leads to the same general conclusion. An acre of land contains 43,560 square feet. The Speechley sand is reported as 3 to 50 feet thick. Not all of it is gas-bearing. Some wells go through it without getting gas and some go into it 10 or 15 feet before striking a pay streak. Probably 25 feet would be a liberal assumption of the average thickness of gas-yielding rock. The rock, where struck in the big well, is a hard, gray quartz sandstone with a pore space estimated--not tested--at not over one-fifth of its volume. On that basis, one acre of Speechley sand would contain about 200,000 cubic feet of pore space full of gas.

But the gas is under high pressure. It is a law of nature that doubling the pressure on a gas decreases its volume one-half; that is, the volume is inversely proportional to the pressure. At the high pressure found originally in this field certain gases, which may occur in this natural gas, would be liquefied. Allowing for this and other deviations from the law it is probable that each foot of pore space in the rock contained 100 cubic feet of gas as delivered to the consumer, a little above atmospheric pressure. If so, one acre of Speechley sandstone may have originally contained 20 million cubic feet of gas. It might contain anything less than this and some few acres might contain double that quantity. If this pool has been producing an average of 60 million cubic feet daily it has been exhausting 3 acres a day, or in 150 days it would have completely exhausted 450 acres. Natural gas, however, is not exhausted like coal in a bed, but rather as water is drawn from a reservoir with an ever lowering water level. The gas is drawn from all parts of the pool though not so quickly or readily as water from a reservoir, because of the small spaces in which it occurs. The exhaustion is registered by reduced rock pressure rather than lowered water level (this is true only in a dry sand.) Because the porosity of the sand
is not regular, the reduction of pressure is not uniform or instantaneous over the whole pool. Wells in dense rock or at some distance from producing wells may lag behind in pressure reduction. In general, however, when the pressure in a pool (not a field) has been reduced one-half it may be assumed that more than one-half of the gas in that pool is gone. The relation of rock pressure at any time to the initial pressure will indicate what percentage of the gas originally in the pool has been taken and how much is left. With these facts in mind and the figures already given the reader may draw his own conclusions as to the future of this pool.

**Extent of pool and number of wells per acre.**

It must be borne strictly in mind that the comparison made with the Cleveland field refers only to the Long Run or Snake Hollow pool. The extent of that pool can be determined only as it is outlined by dry holes. If it is as wide as the anticline it should extend from the southeast part of Christy Park to the river between Ellrod and Boston. Its length along the anticline can be determined only by the drill. Outside of the pool is territory that has already been explored and found to vary in its yield of gas. This field invites exploration. It is hardly likely to have any more pools like the Long Run pool now being developed and it will probably reveal many dry spots, but it may contain many smaller pools that will pay well if properly drilled, that is, if 80 acres or more is allowed for each hole. To drill four holes on a 10 acre lot is like boring four holes in a barrel of cider; the cider may come out quicker, but no more comes in the end and when holes cost $15,000 or $25,000 apiece, a difference between one hole or 16 holes on an 80 acre lease may make some difference in the financial return. Gas companies in the business of drilling for and supplying gas allow not less than 80 acres for each well.

**Conclusions.**

The question has been asked: "Is this, as claimed by some, the largest gas field in the world?" No. It has been stated by well informed gas men that Foster's Hamilton No. 3 well has paid better financially than any other well in the world, partly because it came in close to pipe lines and an eager market when gas was bringing a good price. There have been many larger wells. A well near Taft, California, was reported as yielding 480 million cubic feet of gas every 24 hours. Wells giving a measured yield of 100 million cubic feet or over, have been reported from Louisiana, Texas and Oklahoma.

It is estimated that the Long Run pool did not contain at the beginning over 15 or 20 billion cubic feet of gas. The Bartlesville Oklahoma, field is estimated to have wasted 500 million cubic feet a day during 1913-1914. The estimated waste in the Cushing, Oklahoma, field was 250 billion cubic feet. In 1916, 43 wells in the Cushing field were claimed to have a combined initial production of 1 billion cubic feet a day. The Cleveland field yielded over 31 billion cubic feet in 1915 alone.
Will oil follow the gas? At present there are no indications of oil in this pool. Two wells have had a show of oil from the Hundred foot sand. Some oil may be found low down on the northwest flank of the anticline.

Is gas likely to be found below the Speechley sand? Many of the wells that failed to find a satisfactory flow of gas in the Speechley sand have been drilled down to the Bradford sand. So far as learned, gas has not been found in paying quantity below the Speechley sand. Experience to date would therefore seem to indicate that there is little gas in this field below the Speechley sand.

The obvious conclusion of all this is that, though this pool may yield gas under the stimulus of the pumps for another year or two, the pressure and average flow are decreasing so fast that the wells will stop delivering gas into the mains within two or at the most three months, and that at present prices, the average well drilled after January 1st in the McKeesport or Long Run pool will not return its cost. (A pipe line pressure of 150 pounds is here assumed.)

The total volume of gas in the Long Run pool at the start may be closely estimated at 15 billion cubic feet, which, at 15 cents a thousand, was worth about $2,250,000.

The State Geological Survey has no legal authority to stop drilling. It can only offer advice based on volumes of records of what has happened in other fields and on the known laws of physics and geology. That is and must continue one of its principal functions. Last December it advised through the newspapers that "further drilling in the McKeesport pool must result in serious financial losses." It can only repeat that advice today, as the McKeesport pool is "running true to form."
RECONNAISSANCE MAP OF PART OF MURRYSVILLE ANTICLINE IN ALLEGHENY COUNTY, PENNSYLVANIA

BY GEO. H. ASHLEY AND ROLAND W. BROWN

50 Foot contour lines represent elevation of Pittsburgh coal above sea level