NATURAL GAS

By E. B. Swanson

The decline in the marketed production of natural gas, which began in 1931 after a decade of steady expansion, was continued in 1932, when, according to estimates, 1,518,000,000,000 cubic feet, valued at $357,000,000, were used or sold. Compared with 1931 the 1932 figures represent a decline of 10 percent in volume and 9 percent in value.

The demand for natural gas is divided into that sold for industrial and domestic fuel needs, that consumed as fuel directly in oil and gas operations, and that used in the manufacture of carbon black. The domestic and commercial market normally consumes slightly more than 20 percent of the national total, while industrial requirements (apart from those of the oil industry) take nearly 30 percent of the total. The requirements of the oil industry for natural gas as a fuel at refineries and gasoline plants and for drilling and other field purposes comprise about 40 percent of the total, and the remaining 10 percent is used as raw material in the manufacture of carbon black.

With industrial markets comprising approximately 80 percent of the demand for natural gas, fluctuations in industrial activity are reflected promptly by corresponding variations in demand. Because of its large share of the total demand, the oil industry undoubtedly influences the demand for natural gas more than do any of the other factors. The magnitude of the fluctuations in the larger items consequently tends to obscure the relative steadiness of the annual demand for natural gas to meet domestic needs in heating and cooking.

From data on natural-gas demand in 1932 it appears that gas sales for domestic and commercial purposes, while slightly lower than in 1931, held relatively close to the preceding levels, particularly during the closing months of the year. Some indication of the decline in industrial demand, on the other hand, is found in the records of natural-gas consumption in the generation of electricity at central power plants. Natural-gas consumption for this purpose during 1932, according to the United States Geological Survey, totaled 107,875,000,000 cubic feet, a decline of 22.6 percent from the 139,328,000,000 cubic feet recorded for 1931.

A somewhat similar decline was recorded in the carbon-black industry; the quantity of gas burned during 1932 amounted to 168,237,000,000 cubic feet, a decline of 12 percent from the 1931 consumption of 195,396,000,000 cubic feet.

The decline in demand, particularly for industrial purposes, retarded developments in a number of States and, in others, resulted in a reduction of output. The effect of the lowered demand was felt

particularly in some of the principal producing States, notably Louisiana, Kansas, West Virginia, and Pennsylvania.

In some of the smaller producing States, on the other hand, the 1932 output increased appreciably over that in 1931. Due to the development of the Jackson field, natural-gas production in Mississippi in 1932 was considerably larger than in 1931. Michigan also recorded a substantial increase. In the eastern fields interest in natural-gas developments was stimulated by the continued exploration which resulted from discovery of the Wayne-Tyrone field in New York and the Tioga and Hebron fields in Pennsylvania. Deeper drilling in West Virginia resulted in several gas shows in the Devonian shale above the Oriskany sand, indicating the possibility of further development of gas reserves in that State.

Particular attention was paid during the year to the problem of reducing gas wastage, especially in California and Oklahoma. In California the gas wasted during 1932 was only 6 percent of the recorded output compared with 44 percent in 1929. In Oklahoma a concerted effort was made to reduce the gas wastage in the Oklahoma City field.

The following review, by States, of natural-gas developments during 1932 is based primarily on information received from local authorities.

RECENT NATURAL-GAS DEVELOPMENTS

Arkansas.—Little progress was made in the development of new natural-gas fields in Arkansas during 1932, according to George C. Branner, State geologist. In western Arkansas one test each was completed in Franklin, Crawford, and Washington Counties, and a test was begun in Yell County. The Crawford and Washington County tests were dry holes. The Franklin County test, in sec. 13, T. 8 N., R. 29 W., near Vesta on the Vache Grasse anticline, was completed to a depth of 2,380 feet in the Atoka formation. Initial production was about 3,000,000 cubic feet, with a rock pressure of 400 pounds.

The Russellville field, which was discovered in October 1929, has not been drilled out or connected with a pipe line. Three gas wells in that field were shut in during 1932. It is estimated that leases on approximately 300,000 acres of potential gas territory in western Arkansas were held during 1932 by gas companies.

California.—Natural gas is produced in California from 35 oil and gas fields. Production during 1932 totaled 276,877,100,000 cubic feet, according to Claude C. Brown, gas and electric engineer, California Railroad Commission. Of the 1932 total, 144,106,500,000 cubic feet were sold to gas-utility companies and others; 53,697,100,000 cubic feet represented gasoline-plant fuel and shrinkage; 40,654,500,000 cubic feet were used as fuel in the field; 8,666,000,000 cubic feet were used as fuel at refineries; 12,242,100,000 cubic feet were returned to the formations for storage or for use in repressuring operations; and 17,510,900,000 cubic feet were blown into the air.

California is the outstanding example in the United States of reduction in natural-gas wastage. During 1929, 248,477,000,000 cubic feet, or nearly 700,000,000 cubic feet daily, were blown into the air (44 percent of the recorded output). During 1932 the quantity of gas so wasted averaged 48,000,000 cubic feet daily, only about 6 per-

cent of the recorded output and 93 percent less than in 1929. This material reduction in gas wastage has resulted from voluntary curtailment of both oil and gas production, expansion of natural-gas utilization, and vigorous administration of State conservation legislation.

The major part of the increase in natural-gas utilization has been due to the extension of distribution facilities into areas and communities formerly served with manufactured or mixed gas and those formerly having no gas service. A substantial part of the increase also is attributable to the greater use of natural gas by individual consumers, particularly for space heating.

The steady decline of production in the "town-lot" fields of the Los Angeles Basin has contributed materially to the decrease in gas wastage, as these fields were sources of prolific waste during their periods of peak production.

In fields where the greater part is controlled by a relatively small number of operators more reasonable and economical drilling programs have been followed, with the result that many such fields are still producing and will continue to produce for many years. The Kettleman Hills field, a principal source of natural gas supply, is regarded as the most noteworthy of this group.

Colorado.—A discovery of considerable importance was made early in 1932 in the test of the Piceance Creek anticline, Rio Blanco County, Colo. A flow of gas, which gaged 13,000,000 cubic feet daily, was encountered in the sand, presumably of the lower Green River or the upper Wasatch formation of the Tertiary system, at a depth of 2,917 feet. Although the first discovery for the field was made in August 1929 the initial well had a daily open flow of only 2,000,000 cubic feet which was not sufficient to insure an outlet. The recent discovery, it is reported, may enable the towns along the Colorado River Valley, several miles south, to be served with natural gas, or the several small gas fields of northwestern Colorado may be linked to create a reserve great enough to justify connection with the Hiawatha-Salt Lake City line.

Gas was discovered on the Craig structure, Moffat County, on March 10, 1932. The gas was found in a sand of the Iles formation of the Mesa Verde group at a depth of 2,802 feet. The field is only 2½ miles from the town of Craig.

Illinois.—No new natural-gas areas were discovered in Illinois in 1932, according to Alfred H. Bell, geologist, head of the oil and gas division, Illinois State Geological Survey. In the two old producing areas 8 gas wells were drilled, of which 6 were in Morgan County 10 miles east of Jacksonville, and 2 on the Ayers anticline in Bond County.

The producing horizon in the Morgan County wells is a sandstone near the base of the Pennsylvanian system at depths ranging from 300 to 400 feet. One of these wells was reported to have an initial daily open-flow capacity of 1,500,000 cubic feet, the other 5 ranging from 50,000 to 200,000 cubic feet. Two wells are connected by a pipe line to the village of Alexander, which is 1 to 2 miles southeast of the wells. The remaining 4 are either capped or abandoned.

The two new wells in Bond County each had a reported initial open-flow capacity of 1,000,000 cubic feet. They are connected to a pipe line which supplies the town of Greenville 5 miles south. The

producing horizon is a sandstone in the lower part of the Chester series (Upper Mississippian), possibly the Yankeetown formation.

Indiana.—Natural-gas production in Indiana began in 1886, reached its peak about 1900, and has since declined gradually until, in recent years, the annual output has been relatively constant at slightly in excess of one billion cubic feet, according to William N. Logan, State geologist. Gas is being produced in two principal areas, northeast Indiana and southwest Indiana.

In northeast Indiana gas is obtained in the geanticlinal area, the northwestern extension of the Cincinnati arch. This structural feature passes northwesterly from the eastern part of Switzerland County to the vicinity of Logansport, Cass County, where the arch sags. The gas is obtained from minor structures on the surface of the geanticline. Gas is still being produced from the Trenton limestone horizon in a number of counties along this extension of the Cincinnati arch, among them Blackford, Decatur, Grant, Jay, Randolph, Rush, Shelby, and Switzerland. The wells in this area range in depth from 400 to 1,200 feet.

In recent years a large part of the natural-gas production in Indiana has been obtained in southwest Indiana. Gas has been obtained in Davies, Greene, Gibson, Knox, Martin, Perry, Pike, Sullivan, Vanderburgh, and Warrick Counties. The area is in general synclinal, but minor irregularities of deposition or folding have produced structural conditions that favor accumulation of gas. The production obtained in this area has come largely from the Chester division of the Mississippian. The wells range in depth from 500 to 1,600 feet. Devonian strata in Indiana have been the sources of natural-gas production in Greene and Harrison Counties. Most of the gas comes from the Devonian shales; very little, if any, comes from the Devonian limestone which underlies the shales. Gas from the Harrison County field is piped to Louisville, Ky.

Many wells have been drilled to the Trenton limestone in southwest Indiana, but no gas production has been obtained from that formation. In Gibson County, the upper surface of the Trenton limestone lies 4,500 feet below sea level. Although no wells have been drilled to the Trenton in the Gibson County area, wells that have reached it in neighboring counties have not produced natural gas.

It is reported that a number of counties in Indiana contain untested areas, some of which undoubtedly will be productive.

Kansas.—The lack of a market greatly retarded natural-gas developments in Kansas during 1932, according to the Geological Survey of Kansas. Only 30 gas-well completions were recorded for 1932 compared with 129 in 1931. No new wells were drilled in the Hugoton field in 1932, and in the McPherson County gas fields wells drilled fell from 58 to 7 for 1931 and 1932, respectively. Considerable gas is being produced and marketed in eastern Kansas, where small shallow wells are abundant, but the major gas fields in the State are not being drawn on by the large pipe lines. Many pipe lines running through Kansas are taking their gas from Oklahoma and Texas, with very little from the Kansas fields.

The 30 gas-well completions show an aggregate initial daily production of 613,000,000 cubic feet. The completion of 1 gas well each was was reported in Chautauqua, Ellsworth, Finney, Kingman, Morris, Sedgwick, and Woodson Counties; 2 each in Chase and Rush Coun-

ties; 3 in Butler County; 4 in Reno County; 5 in Cowley County; and 7 in McPherson County.

Several new gas developments are of interest. In December 1932 a well in sec. 16, T. 25 S., R. 34 W., Finney County, was completed with an initial flow of 5,500,000 cubic feet. This well is 60 miles north of the Hugoton gas field as now outlined, and some geologists believe that the Finney area is an extension of the Hugoton field. If so, it will greatly increase the already large Hugoton field.

In Kingman County a well in sec. 30, T. 27 S., R. 10 W., was completed in the Siliceous lime with an initial daily production of 38,000,000 cubic feet. The new Johnson pool in McPherson County has combination oil and gas wells which produce as much as 10,000,000 cubic feet of gas daily with the oil. In Rush County two gas wells with a total initial flow of 75,500,000 cubic feet were completed during the year but have been shut in awaiting a market outlet.

The largest gas well in Kansas was completed in April in Reno County. It is in sec. 25, T. 23 S., R. 4 W., and gaged 86,500,000 cubic feet of gas per day with a rock pressure of 1,170 pounds from the Mississippian "chat" at a depth of about 3,200 feet.

The largest gas field in Kansas and the second largest in the United States is the Hugoton, in southwestern Kansas, occupying all, or part, of Stevens, Morton, Seward, and Haskell Counties. It is estimated that there are close to 1,000,000 acres of proven gas territory in this field. At present there are 115 gas wells in the field, with an estimated open-flow capacity of 690,000,000 cubic feet per day or an average of 6,000,000 cubic feet per well. The field is not being drawn from to any extent.

Kentucky.—Most of Kentucky's natural gas comes from the eastern part of the State, where in 1932 production was between 26 and 27 billion feet, according to Arthur C. McFarlan, State geologist. The main production, comprising about 71 percent of the total, comes from the Black shale of Floyd County and vicinity. The Black shale here ranges in age from the Genesee into the lower Mississippian, a much thicker and more comprehensive section but not so rich in bitumen as the area of outcrop in the Knobs. Production apparently is not restricted to any one horizon. The Corniferous, including the Niagaran, which has been Kentucky's biggest producer of petroleum, ranks second with about 9 percent. This includes a number of pools scattered along the western margin of the eastern coal field.

In Knox and adjoining counties the production is mainly from the Big Lime and Maxon sands, next to the Shale region in activity. These produce about 7 and 6 percent, respectively. Other producing sands include the Salt sands (Pennsylvanian), 4 percent; the Weir (Waverly) of Magoffin, Johnson, and Lawrence Counties, 2 percent; the Big Injun (Waverly), 1 percent; and the Berea, a small quantity.

Trenton gas has been discovered within the past 2 years in Carroll and Gallatin Counties, but production has been small. Within the past year activities in the central Blue Grass resulted in a number of deep tests to the St. Peter and below. These and earlier attempts have not been encouraging.

Louisiana.—Natural-gas production in Louisiana during 1932 totaled 194,000,874,000 cubic feet, according to the report of J. A. Shaw, director, minerals division, Louisiana Department of Conservation. The production was divided by fields as follows: Monroe, in

Morehouse, Ouachita, and Union Parishes, 90,266,883,000 cubic feet; Richland, Richland Parish, 81,244,039,000 cubic feet; Sugar Creek, Claiborne Parish, 3,833,401,000 cubic feet; Rodessa, Caddo Parish, 1,272,839,000 cubic feet; and all others, 17,383,712,000 cubic feet.

The production reported for 1932 represents a decline of 14.6 percent from the output of the preceding year. An important part of the decline may be contributed to the Louisiana carbon-black plants, which used 40 billion cubic feet of natural gas for carbon-black manufacturing during 1932, or 11 billion less than the 51 billion consumed during 1931. The new Jackson (Miss.), gas field has contributed an additional supply to the pipeline extending to Birmingham and Atlanta and has lessened somewhat the demand for Louisiana gas to serve this line. Until the discovery of the Jackson gas field the Monroe and Richland fields supplied the demand for both domestic and industrial consumption in the area served by this pipe line. A mild winter in Louisiana and the adjoining Gulf coast area was partly responsible for the decline in local consumption, while an extremely cold winter in northern Arkansas and Missouri resulted in heavier demands on the 522-mile pipe line to St. Louis and intermediate points. It is reported that approximately 131 billion cubic feet of gas were put into pipe lines and transported to Texas, Missouri, Arkansas, Alabama, and Tennessee for industrial and domestic consumption.

The production of natural gas in the State is confined to northern Louisiana. The major producing fields are Monroe, Richland, Sugar Creek, Rodessa, Waskom, and Pine Island. Innumerable smaller fields are scattered throughout the area. The Monroe field, in Morehouse, Ouachita, and Union Parishes, comprises approximately 227,000 acres and was originally estimated to have a potential of 3,768 billion cubic feet. At the close of 1932 the field had produced a total of 1,392 billion cubic feet. According to the 1932 regage there were 850 producing wells in the field with a total open-flow capacity of 4½ billion cubic feet daily. Although 25 wells were drilled in the three parishes during the year little new production was added to the Monroe field, as the wells were drilled in widely separated areas in search of production apart from the Monroe field. Only 14 wells were abandoned during 1932, indicating that the field is withstanding water encroachment.

The Richland gas field, discovered in 1926, has been the second largest gas field in the State. At the close of the year it comprised 27,000 acres, with 239 producing wells capable of delivering 3,340,029,000 cubic feet daily. The Richland field had only three new drilling operations in 1932, while 30 permits were issued to abandon and pull casing. It is reported that much of the field's reserve was destroyed by numerous craters and that water encroachment is noticeable in the outer wells and those near the crater areas.

Sugar Creek and Rodessa, the next largest fields in the State, are very similar. Both are producing from the Trinity horizon and are exceedingly rich in gasoline. Heavy withdrawals are not being made from these fields because of insufficient gasoline-plant capacity. The limits of the fields have not been defined. Sugar Creek is producing from a depth of 4,300 to 4,400 feet, while Rodessa is producing from 5,600 to 5,700 feet. The latter field added a 62½ million cubic foot well to its production during 1932. While many of the less outstand-

ing fields of northern Louisiana are still capable of producing a great deal of gas they cannot be looked upon as a source of supply for any length of time, because the heavy withdrawals made upon them for the past several years have depleted their reserves, as shown by the number of wells abandoned during 1932.

There is still much undeveloped territory in northern Louisiana that undoubtedly is worthy of exploitation and will be developed as the need for additional supply increases, according to M. E. Nash, engineer, minerals division, Louisiana State Conservation Department. East Carroll, West Carroll, Madison, Franklin, Tensas, Concordia, and Catahoula Parishes, all in eastern and northeastern Louisiana, are potential gas territories and have received considerable attention. Several "wildcat" wells are being drilled at widely separated places in this area.

Central Louisiana, from the Texas State line to the Mississippi State line, is receiving the most attention. A belt approximately 30 miles wide, running northeast from De Ridder, La., to Jackson, Miss., known as the "Conroe Trend," is the center of leasing and drilling activities. Several new gas discoveries are expected along this trend, because of its relationship to the producing horizon at Jackson, Miss.

Michigan.—The total reported production of natural gas in Michigan for 1932 was 1,405,880,000 cubic feet, according to F. R. Frye, petroleum engineer, geological survey division, Michigan Department of Conservation, compared with 472,000,000 cubic feet for 1931, reported by the Bureau of Mines. Of the 1932 production, 828,980,000 cubic feet were used for domestic and industrial purposes and 576,900,000 cubic feet in the field. A number of gas wells were completed during the year with initial productions ranging from 1,000,000 to 11,000,000 cubic feet, but no new producing areas were opened up. Natural gas was distributed for domestic purposes to Mount Pleasant, Midland, Clare, and Rosebush, while distribution for industrial purposes was continued in Muskegon.

In May the 8-inch line from the Broomfield area to Midland was connected with the 6-inch manufactured-gas line from Saginaw to Midland to conduct a heavy-duty test by burning natural gas at a power plant near Saginaw to determine the ability of the Broomfield gas pool to withstand sustained withdrawals for regular commercial service. After the test had been continued for 4 months proposals were presented to the city officials of Saginaw and Bay City to supply natural gas. Negotiations still were pending at the close of the year.

Early in January 1933 a small gas well was completed 2 miles southeast of the developed area in the Broomfield pool in Isabella County. The well was abandoned temporarily, but it is reported that the completion may indicate a considerable extension in the proved area of this pool. Shortly thereafter a well in Mecosta County, 14 miles west of the Broomfield area, encountered 4,120,000 cubic feet of gas in the same formation which is productive in the Broomfield area.

At the close of the year there were 62 producing gas wells in the State—30 in the Muskegon field, 14 in Broomfield, 7 in Clare, 6 in Vernon, and 5 in Ashley.

Mississippi.—Natural-gas production in Mississippi during 1932 totaled 9,847,907,000 cubic feet, according to George C. Swearingen, Mississippi State oil and gas supervisor. This represents an increase

of about 63 percent over the 1931 output of 6,048,000,000 cubic feet reported by the Bureau of Mines. Gas was produced and distributed from two fields. The older of these is the Amory gas field, which was discovered in 1926 and consists of three small wells in Monroe County. Gas from this field is being piped to Amory, Aberdeen, and Tupelo. During 1932, 152,972,000 cubic feet of gas were produced and marketed from this field. The gas has high B.t.u. content, and the rock pressure of the field is about 600 pounds.

The discovery well of the Jackson gas field was completed in February 1930, and since that date 152 wells have been drilled on the Jackson structure. Of these wells, 97 are now producing gas, 8 are abandoned producers, and 5 have made heavy oil, salt water, and some gas. Two of these wells are producing about 50 barrels per day of heavy oil each, and it is reported that a small refinery is being erected for making asphalt from the oil.

During 1932, 31 gas wells, 2 oil wells, and 5 dry holes were drilled on the Jackson structure. Production in 1932 was 9,694,935,000 cubic feet of gas. The greater part of this production has been distributed through the pipe line to Mobile, Ala., and Pensacola, Fla., and the line south of Jackson as far as McComb, Miss. From the line to Mobile a lateral runs down to Bogalousa, La., and from there gas is piped into a number of other Louisiana towns north of New Orleans. Some gas from the Jackson field also reaches Birmingham and Atlanta. The rest of the production, except that distributed locally, goes to Hattiesburg, Miss., and intervening towns.

The production from the Jackson field comes from the top of the Selma chalk of Upper Cretaceous age. This chalk is very porous and is overlain by a hard cap rock 1 to 3 feet thick. The cap rock in turn is overlain by 90 feet of Midway shale. The surface formations in the field are Jackson and Yegua. The average depth of the producing horizon is 2,300 to 2,500 feet, and the chalk is about 350 feet thick on the structure. The salt-water level is approximately 2,200 feet below sea level. The largest well in the field gaged 57 million cubic feet, and the average is about 40 million. The rock pressure is 978 pounds, and there has been very little decline from the original rock pressure. The gas is reported to average 940 B.t.u. per cubic foot.

Missouri.—The area producing natural gas in Missouri extends from southwestern Vernon County north through Vernon, Bates, Cass, Jackson, Clay, and Clinton Counties, with some production in Johnson, Ray, and Platte Counties, according to H. A. Buehler, State geologist. Within this area are approximately 40 pools. All the production is from sands and black shales of the Pennsylvanian series at depths ranging from 140 to 600 feet.

The pools range in size from less than 160 acres to 9 square miles, although the larger pools are interrupted by dry areas. The initial flow of the wells has ranged from a few thousand cubic feet daily, in wells saved for use in private houses, to as high as 2,500,000 cubic feet. The rock pressure is about normal, ranging from 20 pounds in shallow wells to 190 pounds in the deeper wells.

No entirely new and distinct pools were discovered during 1932. Drilling operations were quiet during the early part of the year but increased in the late summer and fall. It is believed that about 75 wells were completed during the year. The pool along Blue River

in the eastern part of Kansas City was extended into sec. 8, T. 49 N., R. 32 W., by a small group of new wells, the largest having an initial daily open flow of 475,280 cubic feet, with 130 pounds pressure. The Independence pool was extended into sec. 1, T. 49 N., R. 32 W., by the completion of a small number of wells, the largest having an initial open flow of 150,000 cubic feet daily.

Montana.—No new gas fields were discovered in Montana during 1932, according to Francis A. Thomson, director, Montana Bureau of Mines and Geology, and Eugene S. Perry. Two gas wells were added to the list of 18 in the Cut Bank field. Five wells in the Dry Creek field near Red Lodge found gas in sands of the Middle Cretaceous, above the oil horizon, which is of Lower Cretaceous age. One of these wells is reported to have had a flow of 45,000,000 cubic feet daily, with a pressure of 1,400 pounds.

A new development during 1932 was the completion of 12 oil wells near Cut Bank. The oil area lies adjacent to the gas area on the western, or down-dip, side. The oil was found in the Lower Cretaceous, the same sands which produce gas.

New Mexico.—Natural-gas production in New Mexico has advanced rapidly during the past few years. In the northwestern part of the State commercial-gas production has been developed on the Barker and Ute Domes and in the Aztec and Kutz Canyon areas. Gas from the latter area is transported to Albuquerque, Santa Fe, and Farmington. The town of Aztec gets its gas from the wells nearby, while gas from the Ute Dome is taken to Durango, Colo. Gas is produced from the Pictured Cliff sandstone (Upper Cretaceous) in the Kutz Canyon area and from the Dakota sandstone on the Barker and Ute Domes.

In southeastern New Mexico gas is produced, either directly or in conjunction with oil, in the Artesia, Maljamar, Hobbs, Eunice, and Jal areas. Gas is transported from the latter area to El Paso, to towns in southwestern New Mexico and southeastern Arizona, and across the border into Mexico.

No oil or gas has been discovered in New Mexico west of the Pecos River. Although shows of both oil and hydrocarbon gas have been reported at a number of places in northeastern New Mexico no oil or gas of commercial importance, except carbon dioxide gas, has been found.

New York.—Exploration for natural gas, which was stimulated by the discovery of the Wayne-Tyrone field in 1930, was still apparent during 1932 in central and western New York, particularly in the area embraced by the first two tiers of counties north of the Pennsylvania border, according to D. H. Newland, State geologist. Outside of this area the interest shown was more moderate, but exploration was still noticeable over the territory north to Lake Ontario. A few tests have been reported from outlying districts. Notable in the recent exploration has been the tendency to rely upon close geological study of the ground preliminary to a drilling campaign and, where this does not give the desired information, to apply geophysical tests. These methods were not practiced to any great extent in New York until recent years.

The Wayne-Tyrone field has been delimited by border drilling and put into production with about 115 tributary wells. The gas is transported by trunk lines, east as far as Binghamton and west to Buffalo,

and by a local pipe line to several communities lying north of the field. The results of overdrilling in the Wayne Village area are manifested by a substantial falling off of pressure. A curious feature is the fact that the latter area produces sweet gas whereas in the eastern or Tyrone tract the gas is sour and has to be treated before it is run into pipe lines. It is reported that, with the accentuated drain upon the Wayne wells, some of them have turned sour.

In Steuben County, beyond the limits of Wayne Township, tests have been made of various structures to the horizon of the Oriskany sandstone, but so far no definite pools have been established. Most of the wells for exploring the sandstone have encountered salt water and no gas in quantity. Two wells in Greenwood Township may have considerable significance; one shows a large flow and the other a moderate yield, both being on or near structure.

A shallow pool in the basal part of the Chemung beds has been opened in Rathbone Township, where some 20 producers are reported. Their volume ranges from a few thousand to 2 or 3 million cubic feet. Outlet is by a newly built pipe line to the village of Bath. The Oriskany horizon is not reached in any of the wells.

In Allegany County the occurrence of the Oriskany has been established locally by some deep tests, but thus far no important field has been discovered. In the town of Allen the sandstone was drilled into at about 3,000 feet for a reported yield of 2,000,000 cubic feet, besides 8 or 10 barrels of high-grade oil. Most of the oil and gas production of this county is from the Chemung beds, usually less than 1,500 feet from the surface.

In Ontario County a good deal of interest was aroused by the bringing in of several gas wells near Geneva, 30 miles northeast of the Wayne-Tyrone field. Their sites are on the outcrop of the Onondaga limestone, and the gas comes from a depth of about 1,000 feet from what appears to be the Niagara or Lockport dolomite. This formation has not been found productive elsewhere. The first well was completed in August 1932 to a depth of 1,079 feet and showed a rock pressure of 640 pounds. The initial flow was given as 5,000,000 cubic feet, but later the figure was reduced considerably. A second test at essentially the same horizon was reported as showing a rock pressure of 920 pounds. A third well, less than 1½ miles from the first two, was estimated at 5,000,000 cubic feet, with 640 pounds pressure. Three or four other tests failed to get any substantial results from the Lockport horizon and were drilled to the upper Medina, resulting in small yields only. Additional wells proved to be dry, one being drilled to 2,800 feet. Plans have been discussed for drilling one or more tests to the Trenton limestone, about 3,500 feet below the surface.

Figures for production in 1932 probably will show a good gain over the State totals in 1931. It is certain that more natural gas is now available for local consumption from sources outside of the State than in previous years. The most notable recent additions to the potential supplies are the Tioga and Potter County fields in Pennsylvania, not far south of the State boundary. From the Tioga field a 20-inch pipe line has been laid to Syracuse to supply that city, as well as Ithaca and Cortland. The Potter County field doubtless will be tapped by the trunk lines already in existence to supply Buffalo and other points in western New York. The outlook is for a much increased use of

natural gas in central and western New York, but it is not certain that the market will be extended into the populous districts of eastern New York.

Ohio.—Natural-gas developments in Ohio during 1932 were not extensive, according to Wilbur Stout, State geologist. In the old Clinton area additional pools have been brought in along the eastern margin of the main field. The outstanding new pools have been in the townships of Springfield, Franklin, and Coventry, in Summit County, and Lawrence and Jackson, in Stark County. Initial production has ranged from 1,000,000 to 20,000,000 cubic feet daily, with rock pressures from 1,000 to 1,300 pounds. Exploratory work is being continued northeast of the old Clinton area.

The production of shale gas is gaining in importance. This new development is confined mainly to Union and Rome Townships of Lawrence County. Wells have been completed with an initial production ranging from 300,000 to 2,000,000 cubic feet daily and rock pressures from 700 to 900 pounds. The area to the north is regarded as promising, and it is expected that the field will be extended into Gallia and possibly Meigs County. Prospecting for shale gas is also under way in other areas as the belt in which gas may be obtained crosses the State from the Ohio River to Lake Erie.

Oklahoma.—Although primarily an oil field, the Oklahoma City field during 1932 was the center of interest in natural-gas developments in Oklahoma, because of the attention directed toward the problem of gas wastage and the endeavor to conserve natural gas, both because of its relationship to the production of oil and its value as an industrial and domestic fuel.

Some constructive measures directed toward the conservation of natural gas have been put into effect in the Oklahoma City field. Gas losses from the pre-Pennsylvanian zones have been reduced appreciably by classifying wells with high gas-oil ratios as gas wells instead of oil wells. An order issued by the Corporation Commission permitted operators to transfer allowable oil production from wells with high gas-oil ratios to those with lower ratios.

On May 1, 1933, there were 967 completed oil wells and 58 completed gas wells in the Oklahoma City field. In December 1932 there were 14 natural-gasoline plants in the field, with an aggregate daily capacity of 636,000,000 cubic feet. The average daily volume treated during 1932 was 442,000,000 cubic feet. The estimated daily demand for gas during the fall of 1932, including field operations and sales to pipe-line companies, was over 100,000,000 cubic feet.

There was no expansion of distribution properties during 1932, according to local reports. Pipe-line construction was nominal and consisted of one 12-mile line from the Bebee field to Stratford and a 16-mile extension in Le Flore County to Red Oak.

Pennsylvania.—No new gas fields were discovered in Pennsylvania during 1932, as the decline in industrial consumption discouraged both exploration and development, according to George H. Ashley, State geologist. Production of 63,286,242,000 cubic feet of natural gas from 16,426 wells in 22 counties was reported for 1932 by the State Bureau of Statistics compared with 74,797,000,000 cubic feet reported by the United States Bureau of Mines for 1931.

Interest in gas-field development centered in the Hebron and Tioga fields, Potter and Tioga Counties, where important discoveries were

made in the Oriskany sand in 1931 and 1930, and in the region adjacent to the new fields where prospecting of the Oriskany sand has been in progress or is contemplated.

In the Tioga field 18 wells were completed during 1932, of which 15 were gas wells having a total initial daily production of about 135,000,000 cubic feet. It is reported that development work has proceeded slowly, only a few locations being active at any one time, as the shut-in production at present far exceeds the demand for the gas. As now outlined, the probable productive area of this field is about 6,000 acres. At the close of 1932 there were 41 wells with initial daily outputs ranging from 100,000 to 70,000,000 cubic feet, and averaging about 15,000,000 cubic feet. The initial rock pressures ranged from 1,450 to 1,675 pounds, and the aggregate initial daily production of all wells was about 620,000,000 cubic feet. The producing sand averages about 50 feet thick and the porosity of extruded fragments a little more than 9 percent. Wells average about 4,100 feet in depth and cost about $20,000 each to complete. The gas is dry and sweet and has a heat value of 1,030 B.t.u.

The Hebron field, Hebron Township, Potter County, was discovered in November 1931. During 1932, 8 wells were drilled in the field, of which 6 were producers ranging from 3,600,000 to 20,000,000 cubic feet in initial daily production and totaling 73,240,000 cubic feet. Rock pressures ranged from 1,950 to 2,200 pounds. One of the dry holes is well up on structure 7 miles southwest of production but did not find the Oriskany sand; the other dry hole, 7 miles northeast of production, was off apparent closure and brought in salt water. At the close of 1932, 9 wells had been completed, of which 7 were productive and had an aggregate initial daily flow of about 81,500,000 cubic feet. All the producing wells are within an area 2 miles long by 1½ miles wide; however, nothing definite is known as yet about the extent of the field. Thickness of the sand has not been determined. The porosity of fragments blown from wells averages about 9 percent. The gas is dry and sweet and has a heat value of 1,020 B.t.u.

All wells producing from the Oriskany sand are in the Tioga and Hebron fields. Thirteen wildcat wells have been completed and are dry. In addition to the 41 gas wells completed in Tioga County at the close of 1932, 37 dry holes and 5 abandoned holes above the sand are on the Sabinsville anticline and represent the effort to define the Tioga field. Fifteen or more of these 37 failures are located where, according to surface geology, production was expected, and the lack of gas is reported to be due to faulting. One dry hole is on the Harrison anticline and 1 on the Towanda anticline, and 6 dry holes and 1 abandoned hole are on the Wellsboro anticline. In Bradford County 4 holes were completed and 5 abandoned above the sand. One hole in Susquehanna and 1 in Lycoming County were abandoned above the sand, and in Erie County 1 well to the Medina was dry.

Two wells were drilled during 1932 in the Texas School field, Quemahoning and adjacent townships, Somerset County; 1 was dry, and 1 had an initial daily flow of 1,500,000 cubic feet. Fourteen wells have been drilled in this field since its discovery in 1930, 3 being gas wells with initial daily outputs of 200,000, 900,000, and 1,500,000 cubic feet. Rock pressure ranges from 725 to 800 pounds. The producing sand is near the middle of the Catskill formation. Development work was suspended in 1932.

The 20-inch pipe line from the Tioga field to Syracuse, N.Y., was completed during 1932 and placed in operation at part capacity late in the year. It is reported that the line may be extended during 1933 40 miles west to connect with the Hebron field. Gas from the Tioga field also is being supplied to towns in the Susquehanna Valley through the 14-inch line completed in 1931. Williamsport and near-by towns are being served. Local Pennsylvania and New York markets are served through lines existing when the field was discovered. A small line was built into the Hebron field during 1932, and gas from that field is being marketed in New York State.

South Dakota.—Natural-gas production in South Dakota during 1932 was approximately 16,400,000 cubic feet. There were no new developments during the year, according to E. P. Rothrock, State geologist.

Tennessee.—There was very little natural-gas development in Tennessee during 1932, according to Walter F. Pond, State geologist. The completion of a well with an initial daily capacity of 300,000 cubic feet was reported in the Sunbright field. The small fields near Sunbright, Morgan County, and Glenmary, Scott County, continued to supply gas locally. The small field at McMinnville continued to produce a limited amount of gas.

The completion of a well in Macon County in the Northern Highland Rim area was reported from local sources; also the completion of some small wells in Robertson County. A deep test is being drilled in the extreme northwestern part of Tennessee, in Obion County, and has apparently found an unexpectedly great depth of the Cretaceous. An examination by Dr. J. A. Cushman, Tennessee Division of Geology, indicated that the top of the Cretaceous was at 2,100 feet. The well is shut down temporarily at 2,500 feet. It was stated that no commercial development has taken place in the Dickinson County fields. Pipe lines from the Morgan County area to Knoxville and eastern Tennessee and from the Dickinson County fields to Nashville have been projected, but no construction has been begun.

Texas.—Natural-gas developments in Texas during 1932 were concentrated mainly in the Panhandle section and in the south and south-central section, according to W. F. Knode, chief petroleum engineer, Railroad Commission of Texas. In the Panhandle section, 24 gas wells were completed in Carson, Gray, Moore, and Potter Counties with an aggregate initial open flow daily of 707,000,000 cubic feet. These wells were classified as dry-gas wells, as the gasoline content in this general section averages less than one half gallon per 1,000 cubic feet. In view of the vast drainage area assignable to each gas well completed in the Panhandle area the 24 wells completed during 1932 are estimated to have proved approximately 100,000 acres of gas production.

The area known as south and south-central Texas comprises approximately 50 counties lying in the extreme southern tip of the State. Natural-gas developments during 1932 were confined largely to Zapata, Webb, Victoria, Nueces, and Refugio Counties, being incidental, for the most part, to the development of the various oil pools and to exploratory drilling.

In south and south-central Texas the Railroad Commission of Texas has instituted a new method of regulating gas production from a field which has oil and gas in the same pay sand. In Duval

and Nueces Counties the commission has issued conservation rules governing the production of oil and gas based on an allowance of equal displacement to both the oil and gas wells. These orders are predicated on the belief that the owners in a common reservoir should be given the same privilege to produce, as it was judged unfair to shut in the gas wells to protect the oil-producing properties, and to protect the interest of both types of producers it was necessary to give each the same amount of displacement from the producing formation.

In the development of other oil fields the commission has found it necessary to regulate the spacing of the wells and the settling of casing in such manner as to best bring about conservative conditions of production. As an example, in the Conroe field in Montgomery County it was found that there was an immense gas cap overlying the oil. Here it was deemed necessary to require the operators to establish the oil-gas contact by coring before setting the producing string of casing. It was shown that by this method the over-all gas oil ratio could be reduced from approximately 4,000 cubic feet per barrel to as low as 400 cubic feet per barrel. This results in a distinct saving in gas energy and will in all probability result in a longer flowing life and increase the ultimate recovery of the pool.

During 1932, 134 wells were completed in Texas which were classified as gas wells. These 134 wells had a daily initial open flow of 1,940,500,000 cubic feet. In addition to this a quantity of gas amounting to 175,000,000 cubic feet per day was developed with oil production. Also, during 1932 the commission shut in 1,364,750,000 cubic feet due to lack of market outlet.

One gas well was completed in the North Texas district, with initial daily production of 6,500,000 cubic feet. The output is being used for domestic and industrial purposes. In West Texas, four wells were completed with an aggregate daily initial flow of 39,000,000 cubic feet, of which 30,000,000 cubic feet are being utilized. In West Central Texas, 49 wells were completed with a total initial daily production of 132,250,000 cubic feet, of which 61,250,000 cubic feet are being utilized and 71,000,000 cubic feet shut in. In East Texas, 12 wells were completed with total initial daily flow of 46,000,000 cubic feet, of which 26,000,000 cubic feet are being used for domestic purposes, 6,000,000 cubic feet processed for gasoline and the residue vented to the air, and 14,000,000 cubic feet shut in. One well in East Central Texas, with initial open flow of 42,000,000 cubic feet daily, is shut in. In the Texas Gulf coast, seven wells were completed with aggregate initial open flow daily of 175,000,000 cubic feet, of which 123,000,000 cubic feet were shut in and 52,000,000 cubic feet, produced with oil, used for domestic and industrial purposes. In South and South Central Texas 39 wells were completed with aggregate initial open flow daily of 792,750,000 cubic feet, of which 583,750,000 cubic feet were shut in and 171,000,000 cubic feet used for domestic and industrial purposes.

Utah.—The Cisco gas field remained shut in as a result of the overproduction of carbon black, the only market for gas produced in this field. Gas wells at Ashley Valley and Farnham Dome operated below capacity due to lack of a market.

Washington.—The only commercial natural-gas development in Washington is in the Rattlesnake Hills, Benton County, where 15

wells had a measured production of 132,320,000 cubic feet during 1932, according to a summary prepared by Harold E. Culver, supervisor of geology, Washington Department of Conservation and Development.[1] Additional quantities, unmetered, were utilized for lease operations, compressors, and minor uses. Seven towns in the Yakima Valley—Grandview, Prosser, Sunnyside, Mabton, Toppenish, Granger, and Zillah—are served from this field.

The Rattlesnake Hills field lies in the midst of the vast plateau of Columbia River lavas. It is regarded as a freak field in that production is from basalt, an igneous rock. Although gas has been withdrawn from the field for more than 20 years and withdrawals have increased greatly during recent commercial development of the area, there has been no appreciable decline in the flow of gas. A feature of special interest is the low pressure of the gas, the authentic maximum being 32 ounces. Because of the known occurrence of natural gas and the results of structural and stratigraphic studies one of the producing wells is being deepened in an attempt to locate source beds of the gas, which may lie below the igneous rocks.

Another test, also within the area of the Columbia basalts, is that at Union Gap just south of Yakima. Here a hole, already down 3,000 feet, is soon to be deepened in an attempt to complete a conclusive test of the structure, which is well-defined in the Columbia basalt formation. Gas showings indicate the possibility that this area may become a commercial producer.

The occurrence of natural gas is also considered a possibility in the lower Wenatchee Valley. Here the top covering of glacial drift and river alluvium is underlain by a thick series of presumably continental sediments called the Swauk formation. This is of Tertiary age, antedating the great basalt flows of the Columbia Plateau. Careful geologic work has resulted in the discovery of structures which are soon to be tested in the hope of obtaining natural gas. The petroliferous content of the rocks is indicated by the presence of several natural oil seeps. Besides considerable folding, the series has been slightly faulted, but these fractures are held of little consequence as far as the prospect for gas is concerned.

In addition to these operations on the eastern side of Cascade Mountains, there are several tests in progress on the western side which may prove of value in the production of natural gas. One regarded as promising on the basis of advanced showings is in western Clallam County. Here a test, now below 1,800 feet, is being pushed to determine the possible gas production of the sands of the Hoh formation, or of other Tertiary zones. The stratigraphy in the Olympic Peninsula is not completely worked out, but it is probable that a rather thick series of Tertiary marine sediments underlies a belt bordering the Pacific.

Other tests which warrant consideration in a survey of the gas possibilities of Washington are in Grays Harbor, Clallam, and in Whatcom Counties. From present information all of these tests, although widely separated, lie within areas of marine Tertiary beds.

West Virginia.—Production of natural gas in West Virginia for domestic purposes has been light owing to the mild winters of the

[1] In the preparation of the summary, Culver acknowledges the cooperation of R. B. Newbern, president Northwestern Natural Gas Corporation, T. A. Rogers, president Northwest Oil Research Corporation, and M. S. Hurwitz, secretary Northwest Oil and Gas Association.

past 2 years, according to Rietz C. Tucker, assistant geologist, West Virginia Geological Survey, who has stated that a larger production would have been possible in 1932 had there been a larger demand. Productive gas wells were drilled in 25 counties during 1932, and 163 gas wells were completed, with an initial production of approximately 106,000,000 cubic feet daily.

The deepest well ever drilled in West Virginia was completed in Roane County on May 11, 1932. This was the J. W. Heinzman No. 4053, on which the final report showed a depth of 9,104 feet. Three gas shows and 2 oil shows were found at depths below the Berea sand. This and upper sands had previously been productive of gas. Completions in the county totaled 17 gas wells with an aggregate initial daily production of 16,250,000 cubic feet. Three wells were estimated at 2,000,000 cubic feet each, while others ranged from 250,000 to 1,500,000 cubic feet. Depths ranged from 1,497 to 2,556 feet.

In Kanawha County 4 gas wells were completed, with a total initial production of 1,500,000 cubic feet. Depths ranged from 960 to 4,755 feet. This deep well has since been deepened further according to reports. Another deep well in Kanawha County, completed since the close of 1932, found some gas in the Devonian shale above the Oriskany sand at a depth of 4,848 feet. A strong show of gas in the Devonian shale above the Oriskany sand was reported late in the fall of 1932 in a well drilling on the Dry Fork anticline in McDowell County. The tools were blown up the hole and bridged. The well has recently been cleared and drilling resumed at a depth of over 6,600 feet. It is stated that the finding of these deep gas horizons may lead to further development.

In Boone County 19 gas wells were completed, averaging 1,000,000 cubic feet daily. One large well has an estimated production of 6,000,000 cubic feet. The others ranged from 250,000 to 1,500,000 cubic feet. Depths ranged from 1,242 to 2,978 feet. In Cabell County 9 gas wells were completed, with a total initial production of 12,500,000 cubic feet; depths ranged from 1,366 to 3,690 feet. In Calhoun County 26 gas wells were completed, with a total initial production of 17,500,000 cubic feet, depths ranging from 1,830 to 2,987 feet. In Gilmer County 7 gas wells were completed, with a total daily production of 3,750,000 cubic feet, depths ranging from 1,734 to 2,054 feet.

In Lincoln County 22 gas wells were completed, with a total initial production of 7,500,000 cubic feet daily; depths ranged from 1,945 to 3,441 feet. In Logan County 4 gas wells were completed, with a total initial production of 2,000,000 cubic feet daily and depths ranging from 1,247 to 2,981 feet. In Marian County 5 gas wells were completed, with a total initial production of 4,000,000 cubic feet daily and depths ranging from 2,030 to 3,624 feet. In Mingo County 3 gas wells were completed, the largest having a capacity of 500,000 cubic feet daily and the others of 250,000 cubic feet each, the depths ranging from 3,854 to 4,095 feet. In Monongalia County 4 gas wells were completed, the largest having a capacity of 750,000 cubic feet and the others of 250,000 cubic feet each, depths ranging from 3,072 to 3,633 feet. In Putnam County 5 gas wells were completed, with a total daily initial production of 4,250,000 cubic feet, the largest being 2,000,000 cubic feet and the others ranging from 250,000 to 1,000,000

cubic feet. Depths ranged from 1,090 to 2,107 feet. In Ritchie County 7 gas wells were completed, with a total initial daily production of 2,500,000 cubic feet, the largest having a capacity of 750,000 cubic feet while the others ranged from 250,000 to 500,000 cubic feet each. Depths were 1,880 to 2,330 feet. In Wayne County 9 gas wells were completed, with a total initial daily production of 5,750,000 cubic feet, the largest being 1,500,000 cubic feet, while the others ranged from 250,000 to 1,250,000 cubic feet. Depths were from 1,720 to 3,791 feet. In Wetzel County 3 gas wells were completed, each with a daily initial production of 250,000 cubic feet. Depths ranged from 3,213 to 3,643 feet.

One gas well each was completed in Doddridge, Harrison, Marshall, Mason, Nicholas, Pleasants, Raleigh, Tyler, Wirt, and Wood Counties. Initial productions ranged from 250,000 to 1,000,000 cubic feet daily with an average of 500,000 cubic feet. Depths were from 1,794 to 4,375 feet.

Wyoming.—Production of natural gas in Wyoming during 1932 was slightly greater than in 1931, according to local reports, approximately half being obtained with oil. A large proportion of the gas produced was returned to the sands in gas-drive projects.

The gas-drive project in the Salt Creek field was continued, residue gas from natural-gasoline plants being recycled to the producing sands. On June 30, 1932 there were 194 gas-injection wells in the field taking a daily aggregate of 20,000,000 cubic feet. The second Wall Creek sand has been found to be most adaptable for gas-drive operations and has participated to the extent of about 96 percent of the total gas recycled.